

## Ecological and socioeconomic impacts of trochus introductions to Samoa – A project of the Australian Centre for International Agricultural Research

Steven Purcell,<sup>1\*</sup> Sapeti Tiitii,<sup>2</sup> Justin Aiafi,<sup>2</sup> Audrey Tone,<sup>2</sup> Atapana Tony,<sup>2</sup> Moso Lesa,<sup>2</sup> Catherine Esau,<sup>2</sup> Brian Cullis,<sup>3</sup> Beverley Gogel,<sup>3</sup> Kate Seiner,<sup>1</sup> Daniela Ceccarelli<sup>1</sup> and Alejandro Tagliafico<sup>1</sup>

*Trochus* were introduced to Samoa from 2003 to 2006 with the goal of creating a new fishery that would diversify seafood supply for local communities. It took at least 10–15 years for trochus populations to become established on Samoa's reefs. Underwater visual censuses in 2018 showed that populations are now established around both main islands, Upolu and Savai'i, although they are spatially variable. The project estimated that over 1000 fishers now harvest trochus in Samoa, and 300 of them sell the flesh in villages, roadside stalls and markets. Informal networks are used to sell and distribute the seafood in villages. Analyses found the benefits to be inclusive and gender equitable. For a majority of fishers surveyed, trochus is now one of the most harvested reef resources by volume. The project found significant positive impacts to income, local diets and satisfaction of fishers. Further income from trochus could be made through handicrafts from the shells or shell exports. Permitting exports would need to be accompanied by the implementation of a fishery management plan and a robust system of monitoring, control and surveillance. The fishery is a welcomed success story in an era when seafood supply in the Pacific is under threat.

### Background

Trochus, which now goes by the scientific name *Rochia nilotica* (Linnaeus, 1767) (World Register of Marine Species), is an herbivorous marine snail that is commercially important in the Pacific Islands region. A century ago, the distribution of trochus was restricted to the western Pacific and Southeast Asia. Starting in the 1920s, trochus broodstock were translocated to reefs of central Pacific Island countries (Gillett 1993). Sometimes, populations failed to colonise naturally, while in other cases, the translocated broodstock bred successfully and created populations on reefs that later yielded lucrative fisheries for Pacific Islanders (Bell et al. 2005). Until recently, trochus did not naturally occur in Samoa (Fig. 1).

Introductions of species from one country to another come with a risk to native populations of fauna and flora and reef systems. This is especially serious when foreign stock from one country is introduced to "enhance" or "restock" populations already native in another country, as the foreign stock can alter the genetic diversity of native stocks in detrimental ways. Alternatively, foreign stock might be introduced to a country where the species does not occur or has never existed. In such cases involving introductions to new

localities beyond geographic ranges ("assisted migration"), the risks to other native species and ecosystems need to be weighed against potential benefits to livelihoods. These considerations are especially pertinent today given that Pacific Island countries have been urged to diversify the supply of seafood in the future (Bell et al. 2009).

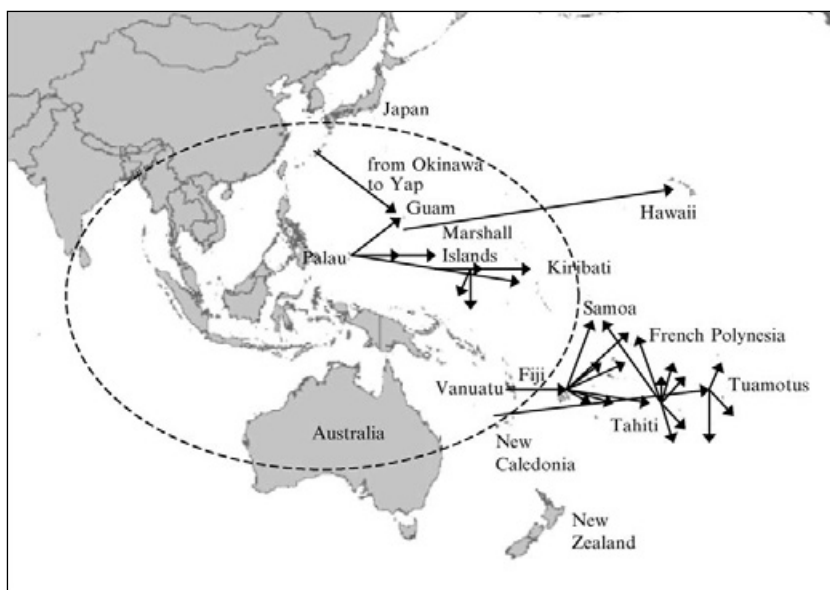


Figure 1. Translocations of trochus among Pacific Island countries. Source: Bell et al. 2005

<sup>1</sup> National Marine Science Centre, Southern Cross University, PO Box 4321, Coffs Harbour NSW 2450, Australia

<sup>2</sup> Fisheries Division, Ministry of Agriculture and Fisheries, PO Box 1874 Savalolo, Apia, Samoa

<sup>3</sup> School of Mathematics and Applied Statistics, National Institute for Applied Statistics Research Australia, Faculty of Engineering and Information Sciences, University of Wollongong, Wollongong, Australia

\* Author for correspondence: steven.purcell@scu.edu.au

An introduction of trochus to Samoa in 1990 was unsuccessful. From 2003 to 2006, a project by Samoa's Ministry of Agriculture and Fisheries (MAF), with expertise and funding from the Australian Centre for International Agricultural Research (ACIAR), introduced trochus from Fiji and Vanuatu to several sites in Samoa. The aim was for the animals to breed naturally to colonise neighbouring reefs and diversify the marine resources available to coastal villages. That project was unable to show that any new populations had been created, although the timeframe was too short to prove ecological success.

The broodstock eventually bred successfully on Samoa's reefs, as evidenced by fishers collecting animals and selling the flesh some years later (Tiitii and Aiafi 2016). Monitoring of local trade by MAF shows a rapid increase in the sales of trochus flesh over the following years (Fig. 2), and underwater surveys at some sites on Upolu Island showed that new populations were establishing one decade after the introductions (Tiitii and Aiafi 2016).

The extent to which wild populations have become established, and the socioeconomic impacts resulting from this, were still uncertain. In addition, fishers are currently benefiting almost solely from the sale of the flesh and are not profiting much from value-adding that could be done to the shells. MAF has not yet allowed exports of trochus, in part because information about the fishery was incomplete; therefore, the full economic value of the animal in Samoa has been largely underutilised.

## Project objectives

Encouraged by the reported success of trochus introductions to Samoa, ACIAR funded a project (2018–2019) coordinated by Southern Cross University (SCU) and MAF. Its four objectives were to: 1) build capacity in value-adding of trochus shells in Samoa; 2) assess the extent of colonisation on Samoan reefs; 3) determine the socioeconomic impacts of the trochus fishery in Samoa; and 4) appraise the potential for exporting trochus sustainably.

## Activities

Underwater visual censuses were undertaken at 14 sites around Upolu and 14 sites around Savai'i (Fig. 3). The team counted and measured trochus and other reef gastropods (snails) on belt transects on the reef-front habitat at each site (Fig. 4). An SCU graduate student also studied the association of trochus with habitat features to aid future site selection.

Two capacity-building workshops were held on Upolu and two on Savai'i to train people from neighbouring villages in how to polish trochus shells and make trochus shell jewellery. Equipment from Australia was set up and left in Samoa for further workshops and use by artisans.



Figure 2. Fisher with bottles of trochus flesh near Fusi, Savai'i. (image: S.W. Purcell)

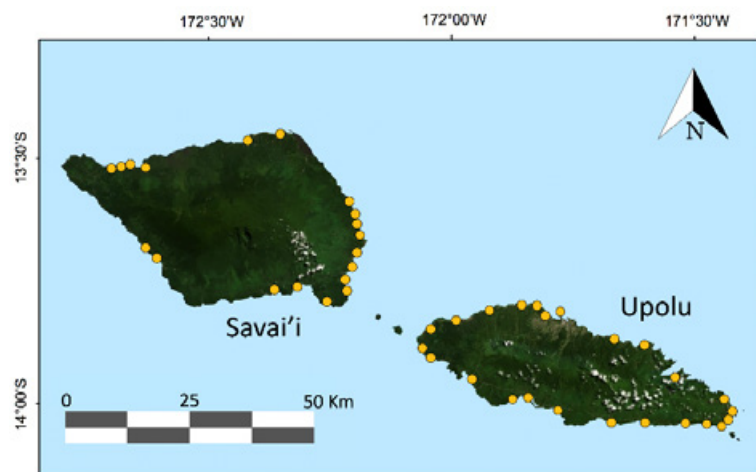


Figure 3. Study sites (yellow dots) in Samoa showing where the underwater survey and socioeconomic surveys occurred.

Socioeconomic surveys of 303 fishers using questionnaire interviews were conducted in 34 villages (Fig. 6). The surveys collected data on the fishing, consumption, sale and trade of trochus in Samoa. Modelling analyses of the data tested gender disparities in these variables and other factors potentially influencing socioeconomic impacts. Lastly, project data were used to assess the

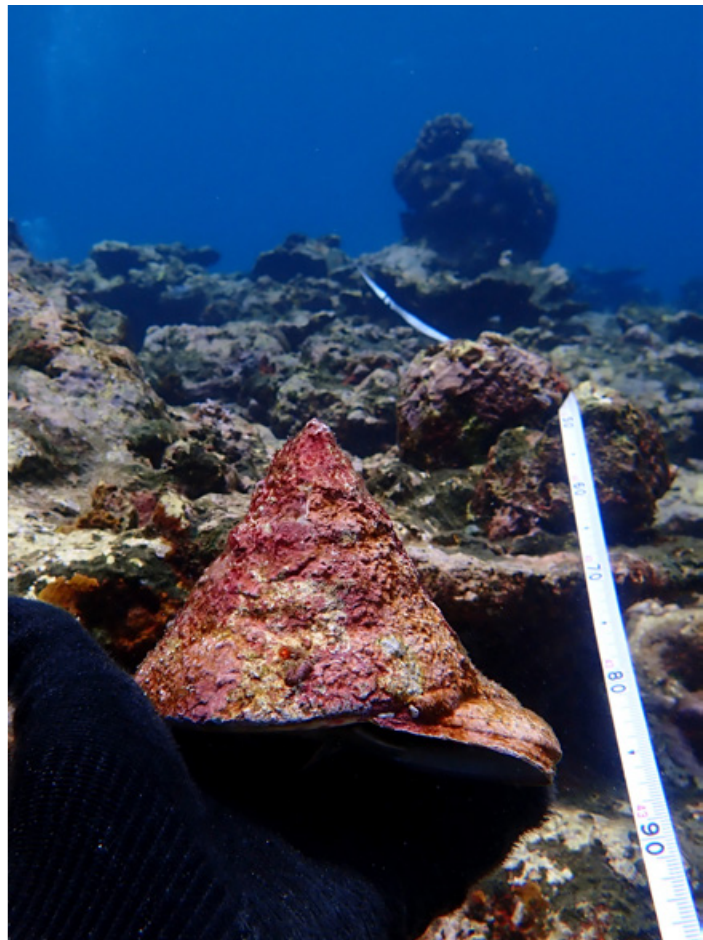


Figure 4. Underwater visual census surveys of trochus in Samoa. (images: S.W. Purcell)

potential volume and value of trochus shell that could be sustainably exported from Samoa, and the management plan for the fishery was reviewed.

## Outcomes

Underwater surveys showed that trochus had colonised beyond the initial translocation sites. Two of the three initial translocation sites were not ideal for these populations to thrive. Future translocation and restocking programmes need a better understanding of the habitat requirements of species to be translocated or restocked. The graduate student project determined the specific habitat preferences of trochus, and that it is a generalist species. Reefs in Samoa have been heavily impacted by coral bleaching in the past decade (Fig. 6). Densities of trochus were very high ( $>500$  ind  $\text{ha}^{-1}$ ) at a few sites, and all of the populations contained some large individuals that could be used for jewellery making or shell exports. Large variations in colonisation among sites imply that we should anticipate that the benefits of such translocations will not be even across villages.



Figure 5. Catherine Esau interviewing a young trochus fisher for the socioeconomic survey. (image: S.W. Purcell)



Figure 6. An adult trochus in Samoa next to dead plate corals that have been covered by algae. (images: S.W. Purcell)



Figure 7. A young Samoan fisher with trochus he caught for household consumption. (image: S.W. Purcell)

Our study shows that abundant, exploitable stocks can develop within 15 years, although trochus populations at some sites seem to still be developing. Our analyses did not indicate any negative impacts on native marine snails in Samoa. Trochus are food for a variety of fish and invertebrate species (e.g. wrasses, rays, crabs, octopus, triton and bailer shells), some of which are important for fisheries (Nash 1993). Trochus are grazers, keeping the growth of macroalgae (seaweeds) down to a short turf, and creating space for corals to settle and grow. These translocations of trochus could, therefore, support food webs and the resilience of reefs impacted by coral bleaching.

The fishery is now contributing to livelihood diversification and food security. Young and older fishers and both men and women collect trochus in Samoa, and most of the fishers retained or gave away a majority of their catch for

consumption within their villages (Fig. 7). One-third of fishers (both men and women) sold part of their catch using informal markets (mostly roadside stalls). The extra cash resulting from the fishery was spent mainly on other food, school fees and church tithing.

The majority of fishers were satisfied with the income they earned from the new fishery. Most fishers believe that the trochus population is still increasing on the reefs. More than two-thirds of fishers ranked trochus as their top three (out of 15) harvested resources. Fishing was done mainly from paddle canoes or swimming and wading from shore. Our calculations of annual fuel consumption by fishers using motor boats to collect trochus reveal a small carbon footprint for the fishery.

In many respects, the fishery was gender equitable because women and men had similar catch rates, income, satisfaction and perceptions about the fishery. Most fishers agreed with a minimum legal size limit being imposed on the fishery, but some were against the idea of seasonal closures. Finally, we observed an underutilisation of the trochus shells, showing that fishers could significantly increase the income they make from harvesting trochus if opportunities arise for selling the large shells either for handicrafts or for export. Project data showed that around 7 million trochus were harvested across Samoan villages in 2018, including approximately 260 tonnes of trochus legal-sized shell, which could serve in exports to increase the value of the fishery.

Shell jewellery and handicrafts are already popular in Samoa, and products from trochus shells offer a promising new niche. The four one-week-long workshops trained participants from numerous villages on Upolu and Savai'i. Participants learned how to safely use the machines and to grind off the outer layers of the trochus shells to expose and polish the inner pearly nacre (Fig. 8). They made necklaces, earrings and key chains from pieces of trochus. Many of them later sold the jewellery and shells, and were keen to continue making these handicrafts as an alternative livelihood activity. MAF has set up one station at the village of Asau (Savai'i) and is preparing to set up machines at two other stations so that artisans can use them for making handicrafts.

## Future activities

The Samoan trochus fishery management plan was reviewed, under the activities of the project, and is set to be implemented soon. Regulations include a “slot” size limit of 90–120 mm shell diameter<sup>4</sup>, daytime collection only, the option of a harvest season, and export licences (if exports are allowed).

<sup>4</sup> The shell diameter of trochus is measured across the base of the shell, taking the distance from the outermost tip of the whorl to the farthest edge on the opposite side of the shell. The measurement is also known as the maximum basal shell width.



Figure 8. Participants polishing trochus shells and making jewellery on Savai'i. (image: S.W. Purcell)

MAF has planned to coordinate further training workshops for value-adding of trochus shells. The stations being set up for shell polishing equipment will be managed by MAF, and artisans will pay a small fee that will contribute to maintenance costs and materials.

The success of trochus introductions in Samoa provide yet another example of fishery development of this species. Trochus could offer an important food and income source for other islands yet to have the species, such as the Gilbert Islands in Kiribati. This project gives clearer guidelines for habitat features needed at translocation sites. Further research should use controlled experiments to examine potential ecological effects of trochus, as the introduction of foreign animals to ecosystems is usually scorned by the scientific community.

Even for species with relatively strong potential for local colonisation, such as trochus (Bell et al. 2005), the Samoan case shows that fishable stocks might take at least 15 years to populate. Even longer timeframes could be expected for species with lower rates of productivity (e.g. giant clams and sea cucumbers). Careful judgement and a review of available data should precede any introductions. From a pragmatic viewpoint, resource managers must weigh the potential ecological risks with the potential benefits to livelihoods. The data, thus far, from Samoa suggest that livelihood benefits have been significant, with minimal negative ecological impacts.

## Acknowledgements

The work was funded by the Australian Centre for International Agricultural Research through project FIS/2016/128. Support was also provided by Southern Cross University, Australia, and Samoa's Ministry of Agriculture and Fisheries.

## References

- Bell J.D., Rothlisberg P.C., Munro J.L., Loneragan N.R., Nash W.J., Ward R.D. and Andrew N.L. 2005. Restocking and stock enhancement of marine invertebrate fisheries. *Advances in Marine Biology* 49:1–370.
- Bell J.D., Kronen M., Vunisea A., Nash W.J., Keeble G., Demmke A. and Andréfouët S. 2009. Planning the use of fish for food security in the Pacific. *Marine Policy* 33:64–76.
- Gillett R. 1993. Pacific Islands trochus introductions. *SPC Trochus Information Bulletin* 2:13–16.
- Nash W.J. 1993. Trochus. P. 451–495. In: Wright A. and Hill L. (eds). *Nearshore marine resources of the South Pacific*. Honiara, Solomon Islands: Forum Fisheries Agency and Institute of Pacific Studies. 707 p.
- Tiitii U. and Aiafi J. 2016. Assessment of Samoa's trochus (*Tectus niloticus*) fishery: History, status and recommendations for management. Samoa: the Pacific Community (SPC) and the Samoa Ministry of Agriculture and Fisheries of Samoa. 25 p.

### For more information:

**Steven Purcell**  
Associate-Professor, Fisheries and Marine Ecology  
National Marine Science Centre, Southern Cross  
University, Australia  
steven.purcell@scu.edu.au

**Sapeti Tiitii**  
Principal Fisheries Officer  
Ministry of Agriculture and Fisheries, Samoa  
sapeti.tiitii@gmail.com