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Editor's note

This edition contains two articles that are both centred on Melanesian topics. The first, 'Catching names: Folk taxonomy of marine fauna on Takuu Atoll, Papua New Guinea', by Anke Moesinger, describes and analyses how the islanders of Takuu Atoll perceive and make use of their marine environment. This article also presents an analysis of the Takuu residents' descriptions and classifications of 200 local marine vertebrates and invertebrates.

The second article 'A field survey of the green snail (*Turbo marmoratus*) in Vanuatu: Habitat density, effects of transplantation, and villagers' motives for participation in transplantation and conservation activities', is authored by H. Terashima and colleagues. This article describes a field survey that was conducted by the authors in Vanuatu in 2017 for estimating the density of green snail on transplantation sites and surrounding areas. It then describes the procedures and gives results of a questionnaire survey that was conducted in order to understand the motives of villagers who participated in the green snail transplantation and conservation activities in selected villages in north-western Efate Island and eastern Malakula Island. An awareness survey was also conducted in villages with no experience of these transplantation and conservation activities. Information was collected from target villagers using a questionnaire based on 'Scheffe's pairwise comparisons test' to understand the most important motive for managing and conserving the green snail.

Kenneth Ruddle

Note:
In line with a worldwide trend to limit the impact of producing printed publications on the environment, SPC has decided to stop the production and distribution of printed copies of this and other information bulletins. The *SPC Traditional Marine Resource Management and Knowledge Information Bulletin* is only available in digital format since issue #36. All issues remain accessible from SPC's website at:

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Catching names: Folk taxonomy of marine fauna on Takuu Atoll, Papua New Guinea

Anke Moesinger[1]

Abstract

Folk taxonomies are a critical component for understanding resource use patterns and cultural, social and economic preferences on geographically remote Pacific atolls. To understand how people perceive and make use of their environment, 200 local names for marine vertebrates and invertebrates were collected and the hierarchical classification system was documented on Takuu Atoll in Papua New Guinea. The local nomenclature of the marine fauna of Takuu is based largely on shared fundamental morphological characteristics. Furthermore, all fish (*Te ika*) in the ocean are placed into one of five distinct groups in the hierarchical classification system. These include three functional groups that are categorised by ecological niche, whereas another group encompasses all fish that possess a certain behavioural trait. The fifth group is unique in that it is solely made up of fish that were previously targeted during local *Sii* fishing expeditions. This article presents an analysis of Takuu residents' descriptions and classifications of local fish and marine invertebrates.

Keywords

Folk taxonomy, Takuu Atoll, local knowledge, Polynesian outlier, folk hierarchical classification

Introduction

Takuu Atoll islanders are dependent on and inextricably linked to the marine environment that surrounds them, and fishing permeates almost every aspect of their lives. To gain an understanding of how the people of Takuu observe and make use of their environment, I collected local names for marine vertebrates and invertebrates. As has been shown throughout much of the Pacific region and beyond, folk taxa not only must be established as a baseline for further studies of local knowledge but can significantly aid in participatory monitoring and other conservation measures (Foale 1998; May 2005). This paper provides an examination of local nomenclature and the hierarchical classification system currently in use on Takuu Atoll.

Study area

At 157°E and 4.5°S, Takuu Atoll, also known as Mortlock, lies 273 km northeast of Buka, Bougainville, Papua New Guinea (PNG). Although politically part of PNG, Takuu Atoll is geographically and ecologically part of the Solomon Islands archipelago. The atoll is one of only three Polynesian outliers found in PNG. The others include Nukuria, also known as Fead Island, which is located 160 km to the northwest of the atoll, and Nukumanu, or Tasman, which is situated 315 km to the east. The islanders reside on the small village island of Nukutoa, although the largest island of the atoll ring is Takuu, from which the atoll derives its name. Takuu is uninhabited and serves as a garden plot for the atoll's population. The total land area covers around 90 ha.

The population has decreased markedly over the last few decades. Although the atoll recovered after an unknown ailment that reduced the number of people to 64 in the 1880s, the population steadily increased over the next century, reaching 508 by the time of the 1980 census (Churchill 1909; National Statistical Office of Papua New Guinea 2003). The current population is 316. A variety of factors such as employment opportunities and secondary education on the mainland, lack of adequate shipping services and health concerns are motivating people to relocate from the atoll. All the elders who were interviewed for this paper claimed that this has had a tremendous negative impact on local knowledge

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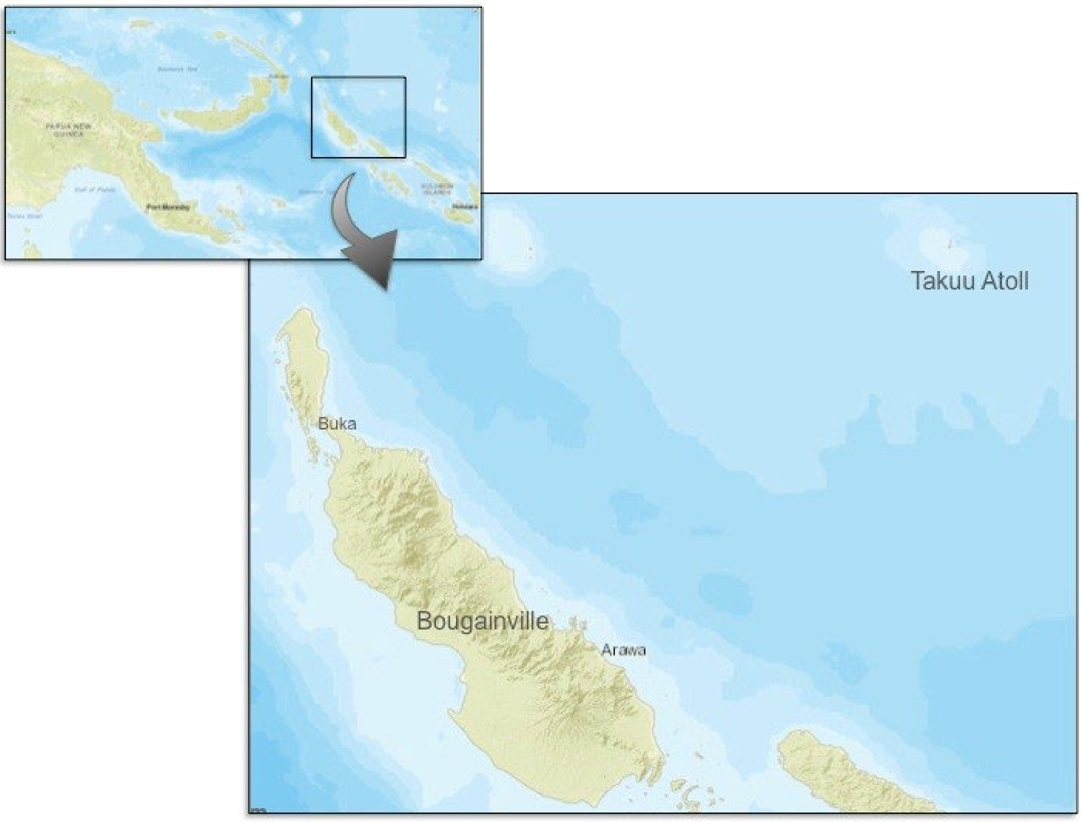

Figure 1. Takuu Atoll, Autonomous Region of Bougainville, Papua New Guinea.

systems that are critical for survival on the atoll. Despite being prominently featured in the film *There once was an Island*, from which the atoll gained international attention as being on the front lines of climate change, Takuu islanders are not at present relocating due to any negative effects of environmental change.

The Takuu language is Polynesian and belongs to the Ellicean group (Moyle 2011). It comprises 11 consonants, namely f, h, k, l, m, n, p, r, s, t, and v, as well as the vowels a, e, i, o, and u. In addition to the atoll's residents, there are an estimated 1750 Takuu speakers worldwide and the language is not considered endangered.

A combination of methods was used to ascertain local names of the marine fauna. Examining fresh specimens caught and brought back by fishers after their daily trips provided many of the names that are included in Appendix 1. When I was uncertain about the correct scientific name, I took photographs and documented meristic features, such as the number of scale rows and dorsal rays. Interviews with village elders and fishers also yielded many of the local names. Reef fish and reef creature identification guides were used for informal interviews and discussions, and the names that were provided by the locals were cross-checked with a minimum of eight people to ensure accuracy (Allen et al. 2012; Humann and Deloach 2010). There was much debate about the names of certain fish – especially those that are rarely caught or observed, thereby the names of marine fish and invertebrates are only included in Appendix 1 if a consensus was reached. After most the names were documented, I conducted focus groups to discuss the hierarchy and relationships of the marine fauna. Two focus group discussions were held with eight participants and a further two were conducted with seven different participants. Due to the shallow nature of *mee ttai* (literally (lit.) sea thing) taxonomy, we focused largely on the groupings of fish. We were thus able to create the hierarchical graph, which is depicted in Figure 2.

Results

Takuu nomenclature

Humans think in highly structured ways, and the habit of organising and classifying surroundings is claimed to be universal (Brown 1991; Atran 1998). In order to interact with and make extensive use of their environment, Takuu islanders have an established lexicon to distinguish disparate types of marine fauna. As in most cultures, the system for nomenclature on Takuu is based on shared, fundamental characteristics (Foale 1998; Ono and Addison 2009). The classification of organisms that are found is based on salient morphological attributes such as colour and shape and also on behavioural patterns and habitat. Appendix 1 provides 200 distinct Takuu marine taxa combined with the corresponding English and scientific name(s).

The Takuu system is based on shared basic characteristics between organisms, and there is an extensive overlap with the system that is employed by scientific biological classification. However, unlike scientific classification, if something does not fulfil a biologic, economic, or socio-cultural need or purpose, it is far less likely to possess a name in Takuu. This trend is seen in the various species of Holithuridae (sea cucumbers). Takuu remains, in part, a subsistence economy as it is geographically remote and shipping services are intermittent. Prior to the moratorium that was enacted by the PNG National Fisheries Authority (NFA) in 2009 on the harvesting of sea cucumbers, one of the few ways to benefit economically from their atoll environment was to gather, dry and sell sea cucumbers (beche-de-mer) to Asian markets. Although most marine invertebrates are referred to by a local family name such as *Siakorokoro* (various species of cuttlefish) and *Te ura* (lobsters), sea cucumbers are collectively termed *Naa* (multiple) *lori* and are further divided into seven distinct species; these are *Kavatuitui*, *Lori sarau*, *Saratea*, *Tikava*, *Takusana*, *Kukupo* and *Muripata*.

Fish often possess two names. The first is a generic term that often denotes the family to which an organism belongs whereas the second refers to a descriptive qualifier. *Simu moana* or *Simu kanae* are both classified in the Linnaean system as belonging to the family Balistidae, or Triggerfish (Allen et al. 2012). *Simu* denotes a group of pelagic marine vertebrates, namely fish, that all have a compact, oval-shaped body, a large head, small eyes and strong jaws with large teeth. *Naa simu* have a set of spines on top of their head to deter predators or lock themselves into crevices in the reef. These spines are the reason why they are colloquially referred to as triggerfish, as the spines may pop up or trigger when sensing danger, often inflicting painful injuries to fishers. *Simu moana* is so named because it is blue, large and found deeper on the reef or slightly offshore in the ocean (*Moana*). *Simu kanae* carries its name due to a slight yet obvious physical similarity to the flathead grey mullet (*Mugil cephalus*). In English-language speaking countries, *Simu moana* and *Simu kanae* are classified as the Oceanic Triggerfish (*Canthidermis maculatus*) and the Blue Triggerfish (*Pseudobalistes fuscus*), respectively. While the Linnaean system has identified a collective 40 species of Triggerfish in the family Balistidae, there are 18 types of *Simu* known on Takuu today.

Table 1. Fish and cephalopod names for various developmental phases.

Growth stages for marine vertebrates

Family	Scientific name	Juveniles	Small size	Adult size	Extra-large size adult
Balistidae	*Balistoides viridescens*		Pareparekaina	Simu taia uri	
Balistidae	*Pseudobalistes flavimarginatus*		Pareparekaina	Simu taia mmea	
Carangidae	*Caranx lugubris*		Lluhe	Tahauri	Sukimana
Carangidae	*Caranx sexfasciatus*	Kainarupo	Taahaki > kaipaa	Matapuku	Paratoko
Carangidae	*Elegatis bipinnulata*			Kamai	Nanauri
Carcharhinidae	*Galeocerdo cuvier*		Riinapa	Kauaerua	Urupou
Cheloniidae	*Chelonia mydas*		Romu	Una mea	Te peva
Exocoetidae	various spp.		Ssipa	Ssahe	
Lutjanidae	*Aprion virescens*		Kamautu	(Te) Utu	
Lutjanidae	*Lutjanus bohar*		Tahanamea	Hanamea	
Lutjanidae	*Lutjanus gibbus*		Rupaia	Taea	
Mugilidae	*Liza vaigiensis*		Kokotarina	Tarina	
Mugilidae	*Mugil cephalus*	Aua	Kokoaua	Kanae	
Mullidae	*Mulloidichthys vanicolensis*	Karokilla	Karo	(Te) Vete	
Scrombidae	*Thunnus albacares*		(Te) atu lliki	(Te) Atu	Lamaoto > Maraorao

Growth stages for marine invertebrates

Family	Scientific name	Juveniles	Small size	Adult size	Extra-large size adult
Octopodidae	various spp.	Piripiri	Sinavere	Toka	
Sepiidae	*Sepia latimanus*		Pukuoho	Siakorukoru	

Identifying the growth or developmental stages of fish on Takuu is more open to interpretation and is not as static as individual fish nomenclature. Fish sizes, or stages of growth, were indicated to me by a fisher who extended out his arm, hand opened, and showed sizes corresponding to the length between one of his fingertips and his chest or beyond using the other hand. A fish, such as the yellowfin tuna (*Te atu*), that is brought back and agreed on as measuring more than 1 m in length is considered to be a *Lamaoto* (an extra-large adult) and especially valuable. The fisher who catches one wins respect among the other fishers and community as a whole. A list of growth stages is shown below in Table 1.

The presumption among Takuu elders is that there were many more types of classified marine vertebrates and invertebrates in past generations. However, due to increased inter-island mobility and migration of locals to urban centres in Papua New Guinea, many of the names that were once employed on the atoll are no longer being widely used or shared. As the village elders pass away and certain factors drive residents from Takuu, much of the folk taxonomy appears to be fading from the collective memory.

The Takuu hierarchical classification system

Naa mee tipu ttai literally means 'everything that can be found in the ocean'. The hierarchical classification system is depicted in Figure 2, on next page. Takuu islanders distinguish between *Te ika* (fish) and *Mee ttai* (sea thing), and all marine organisms can be divided into one of these two groups. A *Mee ttai* is anything not deemed to be a fish, such as sea cucumbers, brittle stars and corals. Stony corals, or *Harero*, are thought to be non-living rocks that simply grow. This is a common belief throughout much of Melanesia and Polynesia (S. Foale, pers. comm.) The only distinction made is between stony corals (*Harero*) and branching corals, referred to as *Harero mananamana* (lit. coral with fingers). Takuu islanders do, however, refer to coral fragments on land as *Te hatu* (stone). Although I noticed *Harero* and *Te hatu* being used interchangeably at times, the discrepancy seemed to be mainly based on where the coral was located. Most *Mee ttai* do not have extensive hierarchical classifications or distinctive names. Sea stars, for example, are collectively classified as *Te hetuu*.

Te ika, or fish, are further classified into five groups of shared characteristics: *Te ika te akau* (lit. reef fish), *Te ika hatu* (lit. stone fish), *Te ika te moana* (lit. ocean fish), *Te ika ttoro* (lit. crawling fish), and *Ika ttea* (fish targeted during *Sii* fishing expeditions). As discussed below, the first three are functional groups consisting of fauna that share an ecological niche, whereas the *Te ika toro* is grouped based on its behavioural traits. *Ika ttea* has the exception that this group consists solely of fish targeted during a ceremonial type of fishing known as *Sii*, which is conducted on extremely large (7 m or more) carved wooden canoes known as *Vakasii* (Figure 3). The aim of this group fishing method is to catch prestigious fish such as *Te atu* (yellowfin tuna), *Kamai* (rainbow runners) and various other large pelagic game fish. It is this functional group that contains many *Ika ttea* without family names. These fish are of such great cultural importance to the community that the majority of these fish names stand on their own. *Sii* fishing is not currently in practice on Takuu, but many schooling fish caught by other means, such as *Paataki* (trolling), are nevertheless still commonly referred to as *Ika ttea*.

Te ika te akau consists solely of reef fish. These fish are shallow water reef fish found on the patch, fore and back reefs of the atoll. Some *Ika te akau*, such as the *Tikuu* (Damselfishes) and *Tipitipi* (Butterflyfishes) are ornamental and not consumed on Takuu. Women and children target other families like *Parani* (Rabbitfishes and Sergeant Majors) as they cast their lines from the beach or off the seawall. *Te ika hatu* (lit. stone fish) refers to a functional group of reef fish that are able to hide in coral. They are distinguished from *Te ika te akau* because they are generally larger and live deeper along the reef slope. Women or children do not commonly catch these types of fish, unless a male fisher takes his wife or teenage son on a fishing trip. These include *Te ume* (Unicornfishes), *Hiloa* (Emperors) and *Natara* and *Tai ava* (Groupers).

Oceanic pelagic fish are collectively referred to as *Te ika te moana*. It includes the families *Manoo* (sharks), *Te paru* (deep sea groupers), *Te hai* (stingrays) and *Tahoraa* (whales). Several members of this functional group do not belong to a family, as they are distinctive in character and appearance. Many are also considered prestigious fish that are only caught by highly skilled fishers. Three members of sharks, *Manoo tea*, *Manoo ava* and *Moemoeatu* (the blacktip reef shark *Carcharhinus melanopterus*, the whitetip reef shark *Triaenodon obesus* and the tawny Nurse shark *Nebrius ferrugineaus*, respectively) fall into the functional group of *Te ika te akau* because they are always found in shallow reef areas and never in the open ocean. *Kimaota*, or Dolphinfish (*Coryphaena hippurus*) and *Sakuraa*, colloquially known in English-speaking countries as Swordfish (*Xiphias gladius*) are two such distinctive *Tka te moana* without family names. Sea turtles, like *Una mea* (the Green Turtle *Chelonia mydas*) and the critically endangered *Masana* (the Hawksbill Turtle *Eretmochelys imbricata*), are also placed into this hierarchical level owing to their migration patterns.

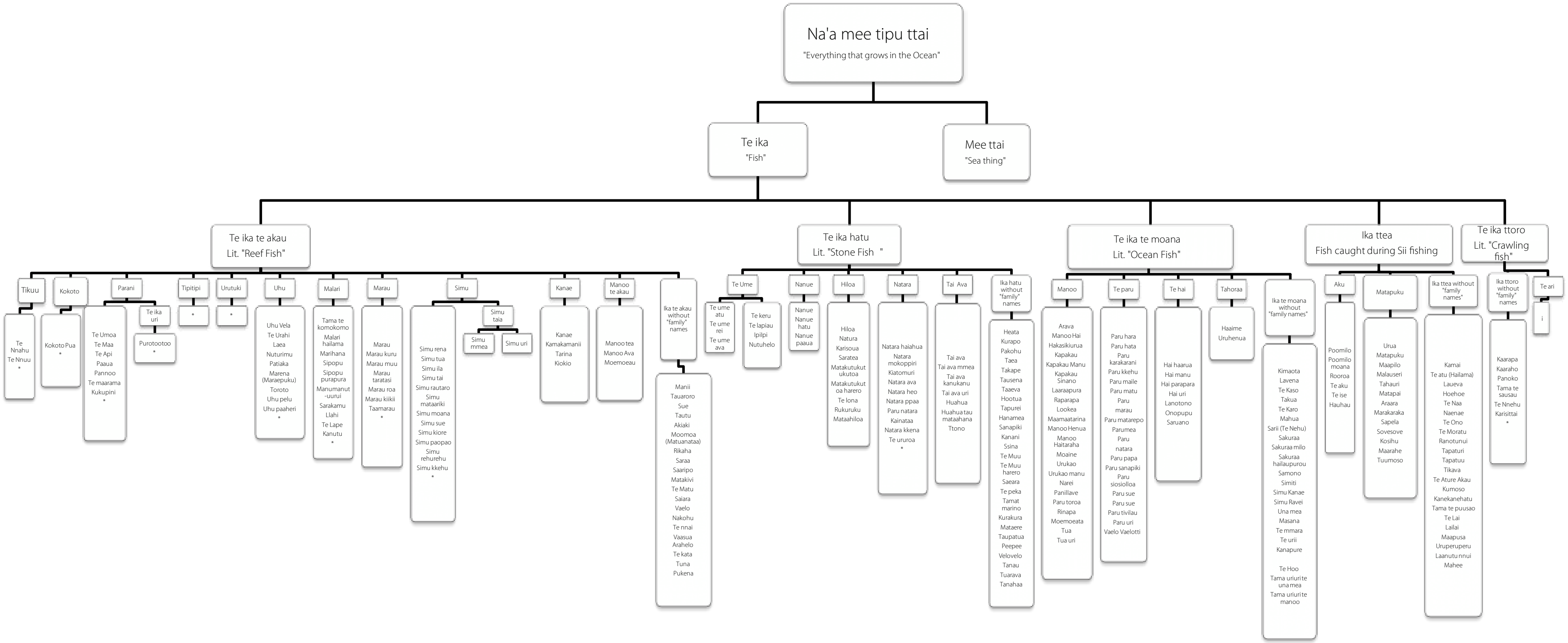

Figure 2. Schematic depiction of the hierarchical classification system of fish. The asterisk below the individual names denotes that all other fish belonging to the family, but not individually identified, are simply referred to by their family name.

Figure 3. Takuu elder carving a new large fishing canoe (*Vakasii*) used to target *ika tte*a during *Sii* expeditions on the southern tip of Nukutoa Island.

Te ika ttoro are the functional group consisting of 'crawling fish'. *Te ari* (flounders and soles) are both thought to crawl along the seafloor and are the only family of *Te ika ttoro* that are consumed on Takuu. The rest of this functional group does not have family names; they are thought to taste bitter and are often simply referred to by their group name. *Karaho*, *Kaarapa* and *Panoko* are types of blennies and gobies that perch themselves on corals with their large pectoral fins and appear to crawl rather than swim.

Interestingly, three of the four species of giant clam regularly consumed on the atoll are considered to be *Te ika te akau* (reef fish). Giant clams, particularly *Nakohu* (*Tridacna gigas*) feature prominently in Takuu mythology. It was believed that *Nakohu*, along with *Vaasua* (*Hippopus hippopus*) and *Te nie* (*Tridacna squamosa*) are capable of separating themselves from their shell and swimming to and settling in another shell at a more desirable location. *Nakohu*, *Vaasua* and *Te nie* are highly prized and are farmed in family plots belonging to female community members in designated areas of the lagoon (Moir 1989). As giant clams also play a prominent role in various ceremonies on the atoll, this elevates them to the status of prestigious fish. The smallest version of the giant clam that is consumed, *Te kunu* (*Tridacna crocea*) is curiously placed into the *mee ttai*, or sea thing, category. A possible explanation for this is that *Te kunu* is the only giant clam gathered solely by woman and teenagers, often together in groups. Fishing is predominately the role of the men, so *Te kunu* is simply thought of as a 'sea thing' that is gleaned from the patch reefs at low tide. *Naa kunu* are also considered of lesser importance and valued mainly as a change of diet when the temptation arises.

Both *Natara* and *Tai ava* are groupers placed in the functional group *Te ika hatu*, but they are further divided based on their observable morphology. Although they share the same habitat that is denoted by the functional group, *Natara* are rather bleak coloured spotted groupers with brown, grey and black hues. *Tai ava*, like the *Tai ava kanukanu* (*Plectropomus oligacanthus*) and *Huahua* (*Plectropomus leopardus*), exhibit a more colourful morphology with shades of red, reddish brown, purple, often with blue spots. *Tai ava* are congruent with several species of the genus *Plectropomus*.

Discussion

Takuu nomenclature and hierarchical classification, much like all local knowledge, has changed significantly through time. The introduction of the *Sii* fishing practice from Manus Island during the late-1800s led to previously unnamed fish being targeted. New economic opportunities, such as the sale of valuable lollyfish and white teat sea cucumber, also necessitated distinctions between multiple species. Thus, there is a strong reliance on identification and separation of *Naa lori* of Takuu. Where a local name was not previously established, common English names were adopted to differentiate between various species of sea cucumber.

While the beche-de-mer trade was the most lucrative economic opportunity for decades on Takuu, the islanders faced a major financial burden from the ongoing nationwide ban that was put in place in by the PNG NFA in 2009. Thus, the residents of Takuu are currently dependent almost entirely on remittances. Inadequate and unpredictable shipping services result in islanders obtaining large surpluses of store bought goods, such as rice, flour and tinned fish when a ship does arrive. After a ship comes to the atoll, there is a marked decline in all fishing practices. Several months after the supply ship leaves, however, the islanders return entirely to a subsistence lifestyle for short periods. The island is in a constant state of flux, and many atoll residents have thus decided to resettle in other parts of Papua New Guinea. Poor healthcare services as well as education and employment opportunities also currently drive people away from Takuu. Even in the late-1970s Johannes (1981) noted that increasing connectedness and westernisation of Pacific cultures had accelerated the disappearance of local knowledge during the previous century. While Takuu fishing methods are rapidly disappearing and changing, detailed descriptions of these processes are beyond the scope of this paper. However, I observed that the same effect is taking place on the local taxonomy. The dependence on imported goods leads to less engagement with the island's marine resources. Many of the fish names collected from community elders and fishers could not be identified by most members of the community who were below 30 years of age. The island's youth often cited family names despite the specimen having an established name of its own.

Studies of local knowledge of marine ecosystems necessitate a working lexicon of the marine fauna. Marine folk taxonomy is also especially useful for conservation management planning (Drew 2005). A thorough understanding of local knowledge on Takuu can additionally be used to alleviate some stresses from future rapid environmental change. Furthermore, an analysis of marine organisms provides valuable insight into cultural, social and economic interests of the atoll's population. In sum, the data presented in this paper provides insight into knowledge systems of Takuu as well as establishing a solid foundation for further inquiry.

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Appendix 1

Takuu names of marine vertebrates and invertebrates with the corresponding scientific and English designations. Source: Takuu grammar and dictionary 2011 (names with an asterisk were previously recorded in the Takuu dictionary and verified through this research).

Takuu name	Scientific name	English name
Te ika		**Fish**
Te ika te akau		**lit. Reef fish**
Tikuu*	**Pomacentidae**	**Damselfishes**
Te nnahu	multiple spp.	spp. of damselfish
*Te nnuu**	*Pygoplites diacanthus*	Regal angelfish
Kokoto*	**Pomicentridae**	**Sergeant majors**
*Kokoto**	*Abudefduf* spp.	spp. of sergeant majors
Kokoto pua	*Abdudefduf sordidus*	Blackspot sergeant
Parani*	**Acanthuridae + Siganidae**	**Surgeonfishes + rabbitfishes**
Te umoa	*Acanthurus nigricans*	Whitecheek surgeonfish
Te maa	*Acanthurus olivaceus*	Orangeband surgeonfish
*Te api**	*Acanthurus guttatus*	White-spotted surgeonfish
*Paaua**	*Siganus canaliculatus*	White-spotted rabbitfish
*Pannoo**	*Siganus guttatus* and *Siganus lineatus*	Golden rabbitfish and lined rabbitfish
*Te maarama**	*Siganus virgatus* and *Siganus puellus*	Virgate rabbitfish and masked rabbitfish
*Kukupini**	*Acanthurus lineatus*	Striped surgeonfish
*Te ika uri**	*Acanthurus* spp. and *Siganus* spp.	All black surgeonfish and rabbitfish
Tipitipi*	**Chaetodontidae +** ***Zanclus cornutus***	**Butterflyfishes and Moorish Idol**
Urutuki*	**Cirrhitidae**	**Hawkfishes**
Uhu*	**Scaridae**	**Parrotfishes**
Uhu vela	*Scarus frenatus*	Bridled parrotfish (initial phase)
Te urahi	*Hipposcarus longiceps*	Pacific longnose parrotfish
*Marena (variant maraepuku)**	*Bolbometron muricatum*	Bumphead parrotfish
Paaseri	*Cetoscarus bicolor*	Bicolour parrotfish
Uhu paaheri	*Cetoscarus ocellatus*	Spotted parrotfish
Tama te komokomo*	**Pomacentridae (and** ***Amphirioprion*** **spp.)**	**Anemonefishes**
Malari	**Labridae**	**Wrasses**
Malari hailama	*Halichoeres hortulanus*	Checkerboard wrasse
*Marihana**	*Thalassoma hardwicke*	Sixbar wrasse
*Sipopu purapura**	*Cheilinus fasciatus*	Redbreasted wrasse
Sarakamu	*Halichoeres ornatismus*	Oriental wrasse
Marau*	**Holocentridae**	**Soldierfishes and squirrelfishes**
Marau	*Sargocentron tiere*	Tahitian squirrelfish
Marau kuru	*Myripristis berndti*	Big-scale soldierfish
Marau muu	*Myripristis adusta*	Shadowfin soldierfish
Marau taratasi	*Neoniphon samara*	Spotfin squirrelfish
Marau roa	*Neoniphon aurolineatus*	Gold-lined squirrelfish
Taamarau	*Sargocentron spiniferum*	Sabre squirrelfish
Simu*	**Balistidae**	**Triggerfish**
*Simu rena**	*Balistapus undulates*	Orange-lined triggerfish

*Simu tua**	*Rhinecanthus rectangulus*	Wedgetail triggerfish
*Simu ila**	*Rhinecanthus verrucosus*	Blackpatch triggerfish
*Simu tai**	*Rhinecanthus aculeatus*	Picasso triggerfish
*Simu rautaro**	*Melichthys niger*	Black triggerfish
*Simu matariki**	*Balistoides conspicillium*	Clown triggerfish
*Simu moana**	*Pseudobalistes fuscus*	Blue triggerfish
*Simu sue**	*Cantherhines pardalis*	Honeycomb filefish
*Simu kiore**	*Melichthys vidua*	Pinktail triggerfish
Simu paopao	*Amanses scopas*	Broom filefish
Simu taia mmea	*Pseudobalistes flavimarginatus*	Yellowmargin triggerfish
Simu taia uri	*Balistoides viridescens*	Titan triggerfish
Kanae	**Muglidae**	**Mullets**
*Kanae**	*Mugil cephalus*	Flathead grey mullet
*Kamakamanii**	*Polydaytylus plebeius*	Common threadfin
Tarina	*Liza vaigiensis*	Diamond-scale mullet
*Kiokio**	*Albula vulpes*	Bonefish
Manoo te akau	**Carcharhinidae and Ginglymostomatidae**	**lit. Reef shark**
*Manoo tea**	*Carcharhinus melanopterus*	Blacktip reef shark
Manoo ava	*Triaenodon obesus*	Whitetip reef shark
Moemoeau	*Nebrius ferrugineus*	Tawny nurse shark
Sue	**Tetraodontidae**	**Pufferfish**
Sue kaarevareva	*Arothron mappa*	Map puffer
Sue natara	*Arothron stellatus*	Stellate puffer
***Ika te akau* without family names**		
*Manii**	*Acanthurus triostegus*	Convict surgeonfish
Tauaroro	*Fistularia commersonii*	Cornetfish
*Tautu**	*Diodon hystrix*	Porcupinefish
Akiaki	*Scolopsis margaritifer*	Pearly monacle bream
Moomoa (variant Matuanataa)	*Ostracion cubicus*	Yellow boxfish
*Rikaha**	*Platax teira*	Longfin spadefish
Te matu	*Gerres oyena*	Blacktip silver biddy
Saaripo	*Lutjanus fulvus*	Blacktail snapper
Saiara	*Pterocaesio digramma*	Double-lined fusilier
Matakivi	*Scolopsis bilineatus*	Bridled monacle Bream
Vaelo (variant Te matu vaelo)	*Gerres oblongus*	Oblong silver biddy
*Nakohu**	*Tridacna gigas*	Giant clam
*Te Nai**	*Tridacna squamosa*	Fluted giant clam
*Vaasua**	*Hippopus hippopus*	Bear paw clam
Tuna	*Gymnothorax javanicus*	Giant moray
Te ika te hatu		**lit. Stone fish**
Te ume*	***Naso* spp.**	**Unicornfish**
Te ume atu	*Naso hexacanthus*	Sleek unicornfish
Te ume rei	*Naso lituratus*	Orangespine unicornfish
Te ume ava	*Naso vlamingii*	Bignose unicornfish
*Te keru**	*Naso annulatus*	Whitemargin unicornfish
Te lapiau	*Naso unicornis*	Bluespine unicornfish

Ipiipi	*Naso brachycentron*	Humpback unicornfish
Nutuhelo	*Naso brevirostris*	Spotted unicornfish
Nanue	**Kyphosidae**	**Sea chubs**
Nanue	*Kyphosus cinerascens*	Topsail drummer
Nanue paaua	*Kyphosus vaigiensis* and *Kyphosus bigibbus*	Lowfin drummer and grey drummer
Hiloa	**Lethrinidae**	**Emperors**
Hiloa	*Lethrinus xanthochilus*	Yellowlip emperor
Natura	*Lethrinus olivaceous*	Longface emperor
Karisouna	*Lethrinus harak*	Thumbprint emperor
Saratea	*Lethrinus obsoletus*	Orange-striped emperor
Matakutukutukuto a	*Lethrinus ornatus*	Ornate emperor
Matakutukutukuto a harero	*Lethrinus erythropterus*	Longfin emperor
Te lona	*Lethrinus rubrioperculatus*	Spotcheek emperor
Natara	**Serranidae**	**Groupers**
*Natara mokopiri**	*Anyperodon leucogrammicus*	Slender grouper
Natara heo	*Epinephelus melanostigma*	One-blotch grouper
Kainataa	*Epinephelus polyphekadion*	Camouflage grouper
Natara ppaa	*Aethaloperca rogaa*	Redmouth grouper
Tai ava	**Serranidae**	**Groupers**
Tai ava	*Plectropomus maculatus*	Spotted coral grouper
Tai ava kanukanu	*Plectropomus oligacanthus*	Highfin coral grouper
Tai ava uri	*Plecropomus laevis*	Blacksaddle coral grouper (only dark variation)
Huahua tau matahana	*Plecropomus laevis*	Blacksaddle coral grouper (only pale variation)
Huahua	*Plectropomus leopardus*	Leopard coral grouper
Tono	*Plectropomus areolatus*	Squaretail coral grouper
Ika hatu **without family names**		
*Heata**	*Epinephelus fusgoguttatus*	Brown-marbled grouper
Kurapo	*Gymnocranius satoi*	Blacknape large-eye bream
*Taea**	*Lutjanus gibbus*	Humpback snapper
*Takape**	*Lutjanus kasmira*	Bluestripe snapper
Tausena	*Lutjanus rufolineatus*	Gold-lined snapper
Taaeva	*Lutjanus argentimaculatus*	Mangrove red snapper
Hootua	*Lutjanus monostigma*	Onespot snapper
*Tapurei**	*Lutjanus semicinctus*	Black-banded snapper
Tanahaa	*Plectorhinchus albovittatus*	Giant sweetlips
*Hanamea**	*Lutjanus bohar*	Red snapper
Sanapiki	*Lutjanus rivulatus*	Blubberlip snapper
Kanani	*Macolor macularis*	Midnight snapper
Ssina	*Symphorichthys spilurus*	Sailfin snapper
*Te muu**	*Monotaxis grandoculis*	Humpnose bigeye bream
*Te muu harero**	*Monotaxis heterodon*	Redfin bream
Te peka	*Cephalopholis argus*	Peacock grouper
Tamat marino	*Cephalopholis urodeta*	Flagtail grouper
Kurakura	*Cephalopholis spiloparaea*	Strawberry grouper
Mataere	*Cephalopholis miniata*	Coral grouper
Taupatu	*Cephalopholis sonnerati*	Tomato grouper
Peepee	*Cromileptis altivelis*	Barramundi

Velovelo	*Variola louti* and *Variola albimarginata*	Yellow-edged lyretail and white-edged lyretail
Te ika te moana		**lit. Ocean fish**
Manoo*	**Carchacharhinidae, Sphyridae and *Rhina ancylostoma***	**Sharks and shark ray**
*Manoo hai**	*Rhina ancylostoma*	Shark ray
*Lookea**	*Negaprion acutidens*	Sicklefin lemon shark
Maamaatarina	*Shpyrna mokarran*	Great hammerhead
Paru	**Various species of fish targeted during Kkuu fishing**	
Paru marau	*Pinjalo lewisi*	Slender pinjalo
*Paramea**	*Lutjanus sebae*	Red emperor snapper
Te hai*	**Dasyatidae, Myliobatidae and Mobulida**	**Stingrays**
*Hai haarua**	*Manta birostris*	Manta ray
*Hai manu**	*Aetobatus narinari*	Spotted eagle ray
Saruano	*Urogymnus asperrimus*	Thorny stingray
Tahoraa	**Various (order Cetacea)**	**Whales**
***Ika moana* without family names**		
*Kimaota**	*Coryphaena hippurus*	Dolphinfish
*Lavena**	*Katsuwonus pelamis*	Skipjack tuna
*Te kaso**	*Acanthocybium solandri*	Wahoo
Takua	*Istiophorus platypterus*	Indo-Pacific sailfish
*Te karo**	*Mulloidichthys* sp.	Species of goatfish
Kanapure	*Selar crumenophthalmus*	Bigeye scad
Sarii (variant Te Nehu)	*Atherinomorous lacunosus*	Robust silverside
*Sakuraa**	*Xiphias gladius*	Swordfish
Samono	*Stenella longirostis*	Spinner dolphin
Simu kanae	*Canthidermis maculatus*	Oceanic triggerfish
*Una mea**	*Chelonia mydas*	Green sea turtle
Masana	*Eretmochelys imbricata*	Hawksbill sea turtle
*Te mmusa**	*Epinephelus lanceolatus*	Giant grouper
Te uri	*Caeso cuning* and *Caesio teres*	Yellowtail fusiler and blue and yellow fusiler
*Tama uriuri te manoo**	*Echeneis naucrates*	Sharksucker (dark variation)
*Tama uriuri te una mea**	*Echeneis naucrates*	Sharksucker (pale grey variation)
Te hoo	Various	Collective name for all fry fish
Ika ttea		**Various spp. of jacks and needlefish. Fish caught during '*Sii*' fishing.**
Aku*	**Belonidae**	**Needlefishes**
Matapuku	**Carangidae**	**Trevallies**
Matapuku	*Caranx sexfasciatus*	Bigeye trevally
Urua	*Caranx ignobilis*	Giant trevally
Maapilo	*Carangoides orthogrammus*	Yellow-spotted trevally
Malauseri	*Caranx melampygus*	Bluefin trevally
Tahauri	*Caranx lubricus*	Black jack
Matapai	*Carangoides fulvoguttatus*	Gold-spotted trevally
Araara	*Carangoide ferdau*	Blue trevally
Marakaraka	*Alepes djedaba*	Shrimp scad
Sapela	*Carangoides gymnosthetus*	Bludger trevally
Kosihu (variant kumoso)	*Gnathanodon speciosus*	Golden trevally

Maarahe	*Caranx bucculentus*	Bluespotted trevally
***Ika ttea* without family names**		
*Kamai**	*Elagatis bipinnulatus*	Rainbow runner
*Te atu (hailama)**	*Thunnus albacares*	Yellowfin tuna
Laueva	*Katsuwonus pelamis*	Skipjack tuna
Hoehoe	*Euthynnus xanthochilus*	Yellowlip emperor
Naenae	*Grammatorcynus bilineatus*	Double-lined mackerel
*Te ono**	*Sphyraena jello*	Pickhandle barracuda
Te moratu	*Gymnosarda unicolor*	Dogtooth tuna
Tapaturi	*Sphyraena barracuda*	Great barracuda
Tapatuu	*Sphyraena forsteri*	Bigeye barracuda
Te tenaa	*Rastrelliger kanagurta*	Long-jawed mackerel
Te ature akau	*Selar boops*	Oxeye scad
Uruperuperu	*Decapterus macarellus*	Mackerel scad
Tikava	*Sphyraena obtusata*	Yellowtail barracuda
Kanekanehatu	*Trachinotus blochi*	Snubnose pompano
Tama te puusau	*Alectis ciliaris*	African pompano
Te lai	*Scomberoides lysan*	Double-spotted queenfish
Lailai	*Trachinotus blaillonii*	Small-spotted dart
Maapusa	*Aphareus furca*	Small-toothed dogfish
Ika ttoro*		**lit. Crawling fish**
Te ari*	**Bothidae and Solidae**	**Flounders and soles**
***Ika toro* without family names**		
Panoko	*Paraplotosus albilabris*	Whitelipped eel catfish
*Te nnehu**	*Synanceia verrucosa*	Reef stonefish
Karisittai	*Malacanthus latovittatus*	Blue blanquillo

Mee ttai		**lit. Sea thing**
Lori*	**Holothuroidea**	**Sea cucumbers**
Lori sausau	*Thelenota anax*	Amberfish sea cucumber
Muripata	*Stichopus chloronotus*	Greenfish sea cucumber
Saratea	*Actinopyga miliaris*	Hairy blackfish sea cucumber
Tikava	*Actinopyga palauensis*	Panning's black sea cucumber
Takusana	*Holothuria atra*	Lollyfish sea cucumber
Kavatuitui	*Thelenota ananas*	Pineapple sea cucumber
Kukupo uri	*Holothuria noblis*	Black teatfish sea cucumber
Kukupo	*Holothuria fuscogilva*	White teatfish sea cucumber
***Mee ttai* without family names**		
Hare urahi	*Nautilus pompilius*	Emperor nautilus
*Komokomo**	Order Actiniaria	Various species of sea anemones
Hatuke	*Heterocentrotus trigonarius*	Dark slate-pencil urchin
Te fanka	*Diadema setosum*	Black longspine sea urchin
Te pamu	Sipunculidae	Large species of peanut worm
Te upo	Sipunculidae	Species of peanut worm
Te kina	Sipunculidae	Species of peanut worm
Te ura	*Panulirus versicolor*	Painted spiny lobster

*Siakorukoru**	*Sepia latimanus*	Broadclub cuttlefish
Toka	Order Octopoda	Various species of octopuses
*Karea**	Order Gastropoda	Various species of gastropods
Karea manamana	*Lambis scorpius*	Scorpion spider conch
Taniope	Suborder Balanomorpha	Various species of acorn barnacles
*Aramea**	*Acanthaster planci*	Crown-of-thorn starfish
Te hetuu	Asteroidea	All species of sea stars except crown-of-thorn sea star
*Te ane**	*Millepora* spp.	Various species of fire coral
*Harero**	Order Scleractinia	Various species of boulder corals
*Harero manamana**	Order Scleractinia	Various species of branching corals
Hare tui	Class Polychaeta	Species of polychaete worm (possibly *Diopatra* sp.)
*Kaipea**	Infraorder Brachyura	Various species of crabs
Varo	*Odontodactylus scyllarus*	Peacock mantis
Te kunu	*Tridacna crocea*	Boring giant clam
*Hare atu**	Class Hydrozoa	Various species of stinging hydroids
*Hare tui**	Amphinomidae	Various species of bristle worms
*Hatu mata**	*Ovula ovum*	Common egg cowrie

A field survey of the green snail (*Turbo marmoratus*) in Vanuatu: Density, effects of transplantation, and villagers' motives for participation in transplantation and conservation activities

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Abstract

After summarising previous studies in Vanuatu of the green snail (*Turbo marmoratus*), this article describes a field survey conducted by the authors in Vanuatu in 2017 to estimate the density of green snails on transplantation sites and surrounding areas. As a result, the density of green snails was found to be much higher in sites where transplantation had occurred, thereby highlighting its positive effect. The main reason for the high density of green snails at transplantation sites is thought to be self-seeding, with eggs and larvae having been retained in the spawning ground, and contributing to the increased population. The article then describes the field survey analyses and gives the results of a questionnaire survey that was conducted in order to understand the motives of villagers who participated in green snail transplantation and conservation activities on Lelepa Island, in the village of Mangaliliu in north-western Efate Island, and in Uripiv Island, located in the east of Malakula Island. An awareness survey was also conducted in villages with no experience of green snail transplantation and conservation activities.

Keywords

Green snail, Vanuatu, snail transplantation, conservation, villager participation

Introduction

In the Republic of Vanuatu, a Japan International Cooperation Agency (JICA) technical cooperation project, 'The Project for Promotion of Grace of the Sea in the Coastal Villages (Grace of Sea project) – Phase 1 (2006–2009)' and 'Phase 2 (2011–2014)', was implemented in cooperation with the Vanuatu Fisheries Department (VFD) and local coastal fishers to promote community-based coastal resources management. As one of its activities, the project undertook the enhancement of the green snail (*Turbo marmoratus*) resource, which is in danger of extinction in Vanuatu. This species, which is distributed in the tropical and subtropical zones of the Indo-Pacific region, is one of the largest marine snails, growing to more than 20 cm in shell height. Green snails contain a high quality pearl layer inside the shell, and have been used for mother-of-pearl inlay. It is therefore expensive – especially in China and Japan. Recently, however, the resource has drastically decreased worldwide. In Vanuatu, local resources were also endangered so green snail fishing has been banned nationwide since 2005.

For conservation and propagation of the resource, the project team transplanted adult green snails to a community-based marine protected area ('taboo area'). Research institutions, such as the French Institute for Research and Development (IRD) and the Pacific Community (SPC), as well as VFD, then conducted marine resource surveys around these transplantation areas. According to them and to comments of villagers living around the transplantation areas, the population of green snails seemed to have increased and their population size seemed to be larger where they were transplanted and protected, compared with areas in which no such activities occurred. This is regarded as a positive effect of the 'community-based coastal resources management' activity that was implemented in collaboration with local fishers and staff of VFD.

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However, the contribution of the green snail transplantation to the resource enhancement had not been analysed quantitatively before the survey that described here.

Summary of previous studies

The Project for Promotion of Grace of the Sea in the Coastal Villages (Grace of Sea project) – phases 1 and 2

To conserve green snail populations endangered by overfishing, VFD has banned green snail fishing for 15 years, from 2005–2020. Furthermore, the Grace of the Sea Project Phase 1 provided technical assistance related to aquaculture development for shellfish, including green snails, as an initial activity of the coastal marine resources management by VFD with coastal fishers. It then set up the model site for implementing community-based coastal resources management in Efate Island (Figure 1), where the VFD headquarters are located.

As a result of this activity, techniques of seed production and intermediate breeding were transferred to VFD staff, and, in the model site, activity for the establishment of the community-based coastal resources management approach occurred. As part of the activities that were run by the project, 1200 adult green snails were transferred from Aneityum Island (Figure 1) – which still has a rich resource in a large rearing tank – to Efate Island. Some individuals were then stocked in coastal waters of Mangaliliu and Lelepa islands, which are close to Efate Island, in order to form a breeding population. Green snail transplantation records are shown in Table 1.

To confirm the effect of the formation of the mother population, a field survey was conducted in the coastal waters of Mangaliliu in February 2013. Two young green snails were found after 30 minutes of observation. This is assumed to be a result of reproduction by the transplanted green snails. The underwater surveys of green snail presence were subsequently implemented in several transplantation areas, and young individuals were found each time, except on Moso Island.

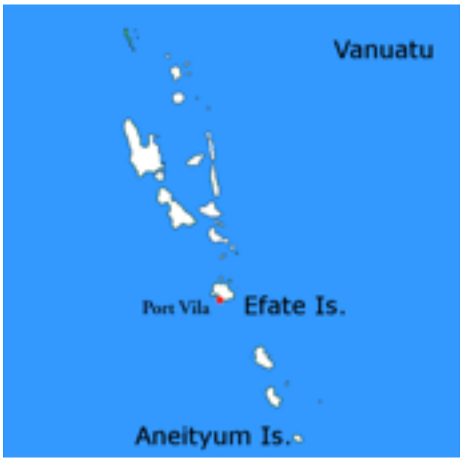


Figure 1. Map of Vanuatu.

In October 2013, during Phase 2, SPC conducted a field survey to confirm the reproductive condition of green snails that were transplanted during Phase 1 in the area of north Efate. Young green snails were found in the transplanted area, which might be the result of the breeding of the mother population that was transplanted during Phase 1.

Survey by SPC and VFD

Green snails have been one of the most heavily exploited marine products of Vanuatu. Under these circumstances, a survey was undertaken from September to October 2013 by SPC and VFD to (1) understand the condition of the resource on Aneityum Island, where green snails are still abundant; (2) estimate the resources' recovery; and (3) evaluate the importance of green snail poaching activities on Efate Island (Pakoa et al. 2014).

Table 1. Records of green snail transplantation.

Transplantation site		Name of location	No. of individuals	Year of transplantation
North Efate	Mangaliliu	Kotoa	205	2007–2008
		Mangaliliu village	262	
	Lelepa Is.	Lakantamas	195	
	Moso Is.	Sunae village	150	
		Total:	812	
East Uripiv			299	2012

Source: Final report of the Grace of Sea Project – Phase 2

The results are described below.

a) *Amount of green snail resource on Aneityum*: At six survey locations around Aneityum Island, 29 and 46 stations were set-up at 3–12 m water depth and 0–3 m water depth, respectively. For the former, two divers moved along the reef at five-minute intervals and recorded the number of green snails and other macro invertebrates that were observed. For the 0–3 m water depth, a belt transect method was used. A total of 667 individual green snails were observed. The survey confirmed that green snails were abundant around Aneityum.

b) *Amount of green snail resources in Efate*: A diving survey was done to estimate the amount of green snail resources at five locations in north-western Efate. A total of 38 individuals were observed, indicating that the number of green snails was extremely low when compared with Aneityum. During the 2003 survey that was conducted in the area by SPC, however, no green snails had been observed. It was suggested, therefore, that the green snail resource was recovering gradually in Efate. It was also suggested that the recovery was due to the reproduction of local stocks, as well as to the group transplanted from Aneityum.

c) *Green snails confiscated by VFD*: Data on poached green snails that were confiscated by VFD has not been recorded by VFD. The staff members of the research department of VFD noted that it was necessary to record such data in future. However, some records of green snails that were confiscated in the Port Vila market can be found in Pakoa et al. (2014) as shown in Figure 2.

Efficiency of taboo areas in Vanuatu (EFITAV) project

In Vanuatu, since the 1990s the traditional no-fishing zone (taboo area) has been revived as one management measure for coastal resources. This is considered effective for invertebrates with low mobility, such as conches or sea cucumbers. This survey was conducted by IRD to confirm the effect of these taboo areas for coastal resources at north-western Efate and, as a control site, at Aneityum where the green snail resource was still rich (Dumas et al. 2012).

The results showed that the density of green snails was very low in Efate Island, and it was suggested that serious disruption of the local population of green snails had occurred (Table 2).

However, the results also showed that the density of green snails inside the taboo area was considerably higher than those outside, and it was suggested that fishery control by the traditional taboo area enabled a slow recovery of green snails. The density of green snails at Mangaliliu was particularly higher than that of other survey areas in Efate. The small-size individuals observed in Mangaliliu suggested that multiple generations of green snails inhabited the area. The Mangaliliu area was a transplantation site of green snails during the Grace of Sea Project – Phase 1 and the report concluded that transplantation had probably been effective in raising the green snail density in the area.

As described above, the survey that was conducted suggested that green snail resources in north-western Efate had recovered. Also, it suggested that this recovery was due to transplantation as well as

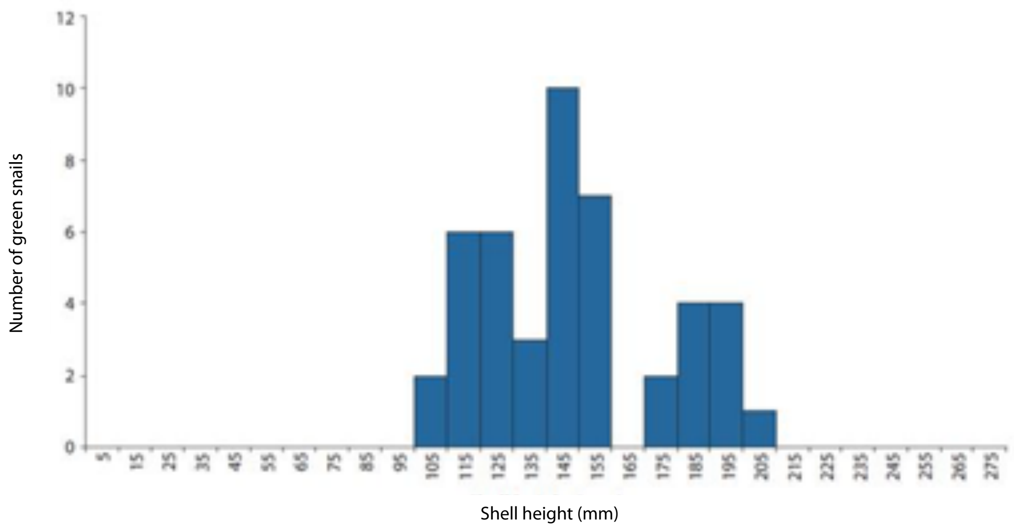


Figure 2. Shell height of green snails (n = 45) confiscated in Port Vila Central Market (Source: Pakoa et al. 2014).

Table 2. Density of green snails at survey sites (Excerpted from Dumas et al. 2014).

Community name	Number of individuals per hectare inside taboo area	Number of individuals per hectare outside taboo area
Efate		
Marou	0.00	0.00
Takara	9.38	2.00
Mangaliliu	21.42	6.00
Aneityum		
Anelcowat	147.10	2.00
Mystery Island	12.80	2.00

conservation activities, such as a fishing ban and the setting-up of a taboo area. However, there had been few detailed statistical surveys and analyses to verify the effect of the transplantation and conservation activities.

Given this situation, the purpose and aims of this survey were adopted, as described below.

Purpose and aims of the survey

This survey aimed to verify the effects and benefits of the transplantation and conservation activities, as well as to analyse the motives of the villagers who participated actively in green snail transplantation and conservation activities.

To achieve these aims, three surveys were conducted as follows:

a) A field survey to estimate habitat density of green snails in the transplantation sites and surrounding areas.

b) A questionnaire survey to understand the motives of villagers participating in green snail transplantation and conservation activities.

c) An awareness survey of the resource management in communities that have no experience of transplanting green snails.

In conducting each survey, the following objectives were applied for collection and analysis of the data.

a) *Field survey for estimation of habitat density of green snails on the transplantation sites and surrounding area*: The Grace of the Sea Phase 3 team decided on the survey sites, including the transplantation site for green snails and the surrounding areas, and implemented the survey to estimate the number of individuals per unit-area, record the size of each individual observed, and then analyse the effect of resource enhancement activities, such as transplantation and protection. It was hoped that the survey would confirm that transplantation and following conservation activities contribute to resource enhancement of green snail. The survey method used was a method mastered by VFD staff, following training done by experts from Japan, France and SPC.

b) *Questionnaire survey for understanding the motive of the villagers participating in transplantation and conservation activities for green snail*: We conducted a questionnaire survey in communities where the transplantation of green snails had been undertaken, and analysed the motives of villagers for their participation in transplantation and conservation activities for green snail.

c) *Awareness survey for green snail resource management in communities having no experience of green snail transplantation activities*: In fishing villages in eastern and southern Efate Island that have not implemented transplantation and conservation activities of green snail, we conducted additional interviews with chiefs and leaders of communities to estimate the status of the green snail population in their area. At the same time, we attempted to understand the ideas of interviewees regarding the transplantation and conservation of green snail. The target fishing village for the survey was determined by discussions with VFD staff.

The survey methods, results and discussions for each survey mentioned above are shown in the following sections.

Field survey to estimate the density of green snails in transplantation sites and surrounding areas

Survey sites

In recent years, green snails have been reported as being present in several locations around Efate Island. This may represent an increase of the green snail resource, as the species was strikingly absent a few years back. It is believed that this increase is associated with the transplantation of green snails in the area. However, to verify the real effect of transplantation and the following conservation activities, it was necessary to precisely estimate the green snail resource status at transplantation sites and their surrounding areas. Accordingly, the restocking areas for green snails and their surrounding areas on the north-western coast of Efate and the outer coast of Uripiv Island and nearby north coast of Uri Island, which is located in the eastern region of Malakula Island, were selected in collaboration with VFD's Research Division, as survey areas of approximately 5 km outer perimeter (Figure 3). In each survey area, two to five sites were established; a total of 26 survey sites were surveyed.

For survey sites, we selected the transplantation sites of green snails and surrounding areas that were known as being green snail habitats by local fishers before the depletion of the resource occurred (Figures 4 and 5).

Figure 3. The survey areas for the estimation of density of green snails in north-western Efate Island and Uripiv and Uri islands.

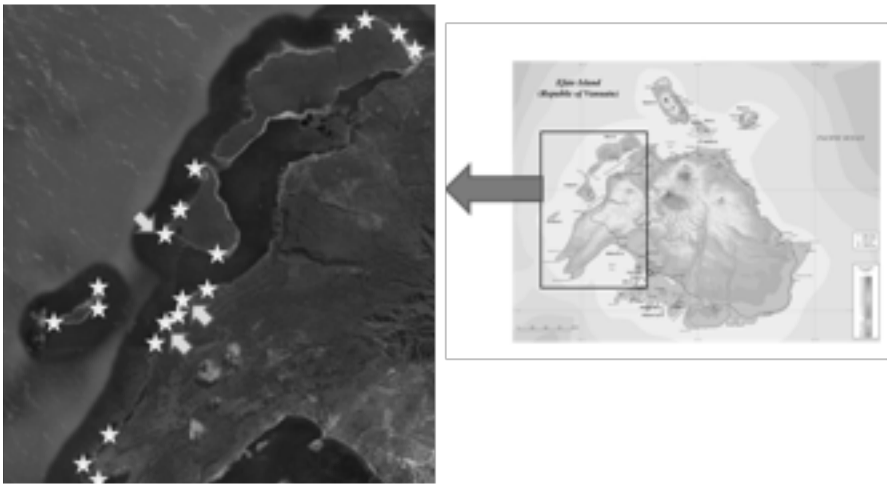


Figure 4. Survey sites in north-western Efate (arrows show transplantation sites).

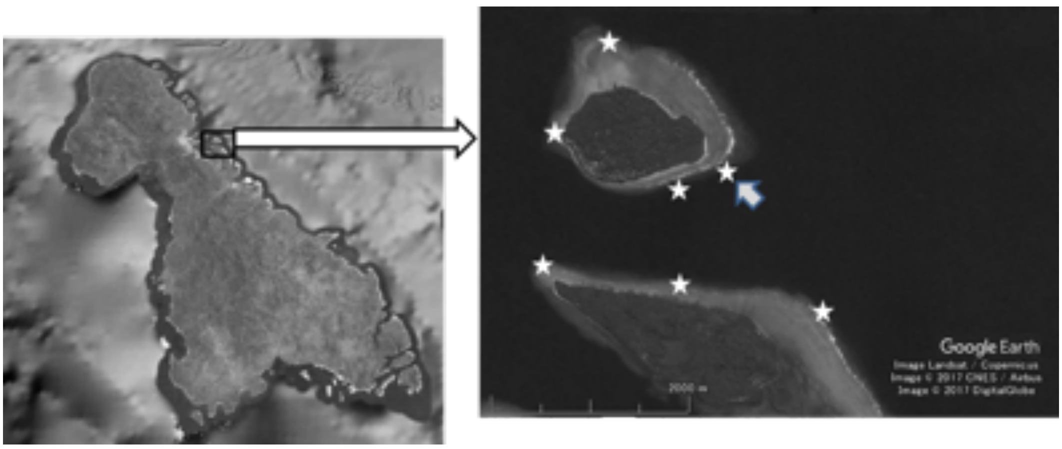


Figure 5. Survey sites of the Uripiv and Uri islands off the north-eastern coast of Malakula Island (arrow shows the transplantation site).

Methods

The survey was conducted using the following procedures:

1. We identified sites that should be good habitats for green snails around transplantation sites, following discussions with VFD staff and local fishers.
2. Based on information provided by VFD staff and local fishers, we surveyed the substrate of the areas by skin-diving, and set the survey sites on bedrocks that were likely habitat of green snails. To facilitate the survey work, each survey site was selected in 0.5–3.0 m water depth.
3. For each survey site, we set up five 50 m long belt transect lines spaced every 50 m along the shoreline (Figure 6).

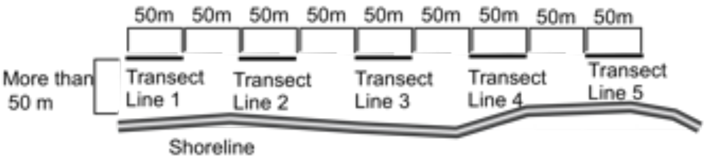


Figure 6. Set of belt transect lines at each survey site.

4. We recorded GPS positions of the start points and azimuth direction of each transect. We also took photos and recorded a video of the bottom conditions.
5. Two free divers made observations of the 2 m wide area along each side of the transect line, counting and recording the number of green snails (Figure 7). Divers checked for green snails beneath rocks and boulders. Simultaneously, they measured with callipers and recorded the shell height of each green snail found (Figure 8).

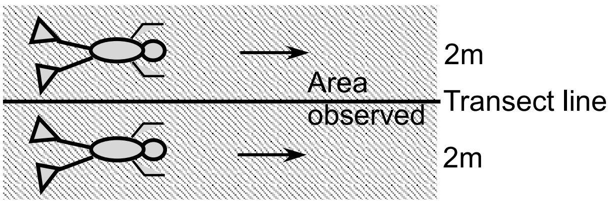


Figure 7. Belt transect.

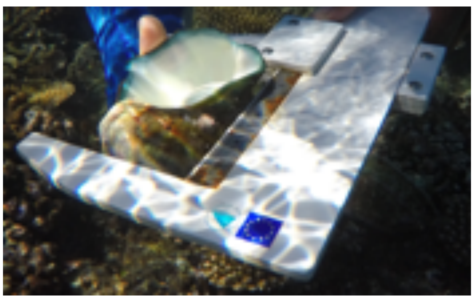
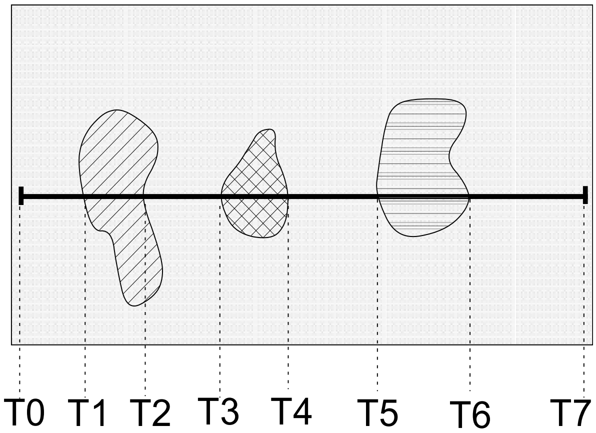


Figure 8. Estimating the size of green snails using callipers.

6. To understand the relationship between green snail distribution and the substrate, we recorded the substrate cover beneath each transect line, as shown in Figure 9. The substrate cover was grouped into categories viz. bedrock, coral, boulder, dead coral, soft coral, gravel, and sand.



Example:

T0–T1: bedrock (0–8 m)

T1~T2: boulders (8–14 m)

T2~T3: bedrock (14–19 m)

T3~T4: gravel (19–23 m)

T4~T5: bedrock (24–29 m)

T5~T6: sand (29–38 m)

T6~T7: bedrock (38–50 m)

Figure 9. Example of a substrate cover record.

7. Numbers of individuals of green snails recorded in the research sites were analysed statistically using the analysis of variance method (ANOVA) to estimate the density differences between a restocking area and surrounding areas.
8. When a significant difference appeared through ANOVA, we analysed it by multiple comparison analysis (Post-hoc test), to identify the survey site where a significant difference occurred.
9. Where possible, the data collected were compared with those from previous research conducted by IRD and SPC.
10. We estimated relations between the substrate cover and the frequency of appearance of green snails.

Results and discussion

We conducted surveys from May to June 2017. Exact dates and times of surveys are shown in Table 3.

Table 3. Dates and times of green snail surveys in May and June 2017.

Date of survey	Time	Location	Depth
12-May-17	12:00–16:30	Lelepa	0.5–5.5 m
15-May-17	12:00–16:30	Mangaliliu	0.5–2.0 m
17-May-17	12:00–15:00	Moso	0.5–3.0 m
25-May-17	11:00–14:00	Hat	0.5–4.0 m
25-May-17	14:30–15:30	Mangaliliu	1.0–4.0 m
2-Jun-17	10:30–14:00	Tukutuku Pt.	0.5–6.0 m
8-Jun-17	8:00–14:00	Uripiv and Uri	0.5–6.0 m
15-Jun-17	11:00–15:00	Uripiv and Uri	0.5–2.5 m
16-Jun-17	8:00–11:00	Uripiv and Uri	0.5–2.0 m

Efate Island survey sites are shown in Figure 10. The Uripiv and Uri islands sites are shown in Figure 11.

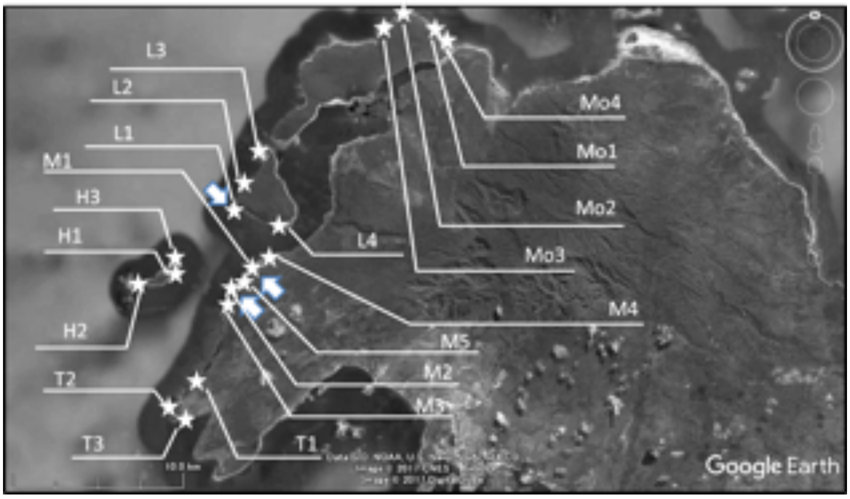


Figure 10. Sites on Efate Island (the arrows show transplantation sites).

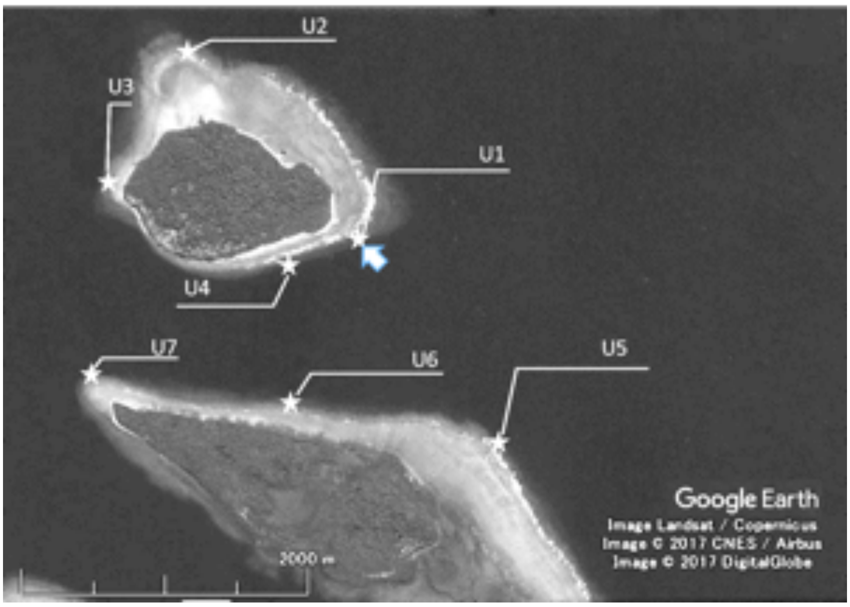


Figure 11. Sites on Uripiv and Uri islands (the arrow shows transplantation site).

Based on the data collected, the mean number of individuals per 100 m^2 on each survey site was estimated. The mean shell height of green snails observed on each survey site was also estimated. We also categorised the substrate cover under the transect line of each survey site.

The summary of the status of each survey site in the north-western part of Efate Island and Uripiv and Uri islands is shown below.

North-western Efate

The mean number of individuals observed per 100 m^2 at each site, the distribution pattern of shell height and the mean shell height of green snails observed in north-western Efate are shown in Figures 12, 13 and 14, respectively.

The substrate cover of each survey site was categorised and then each mean value was estimated. The result is shown in Figure 15.

Summaries of the occurrence status of green snails and the substrate cover of each survey site are given below.

Lelepa Island

On Lelepa Island, four sites were surveyed, each one covering a 1000 m^2 area (50 m x 4 m x 5 transect lines). All of Lelepa Island is designated as a taboo area and all coastal fisheries are restricted. According to the local fishers who participated as data collectors in the survey, the green snail had not been observed in the coastal area until its transplantation was conducted.

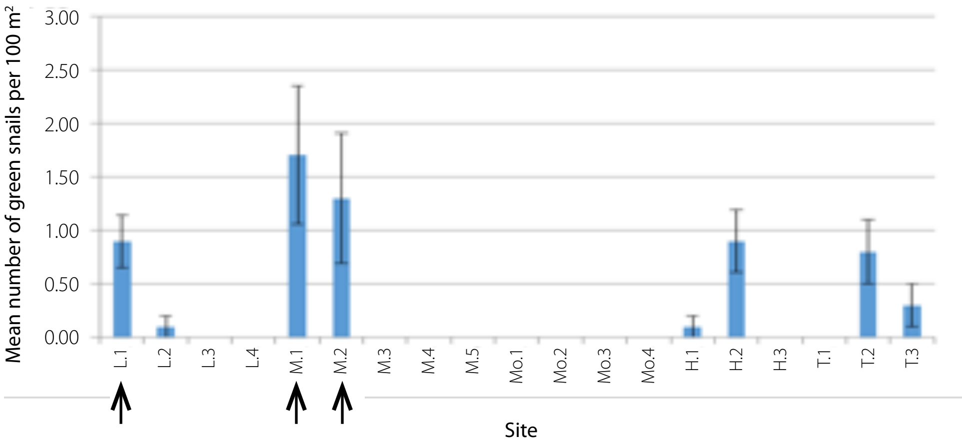


Figure 12. Mean number of green snails per 100 m^2, and standard error, in each survey site of north-western Efate Island (arrows indicate transplantation sites).

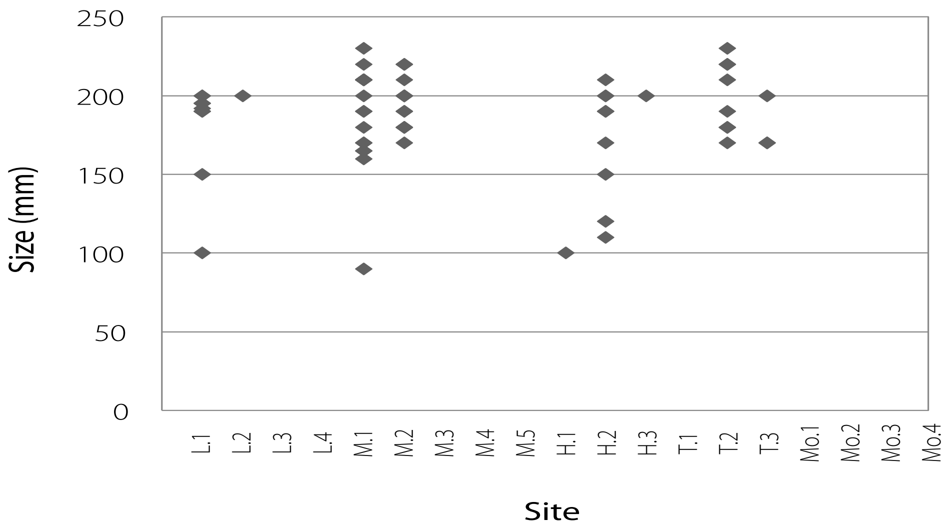


Figure 13. Distribution pattern of shell height of green snails observed in each survey site of north-western Efate Island.

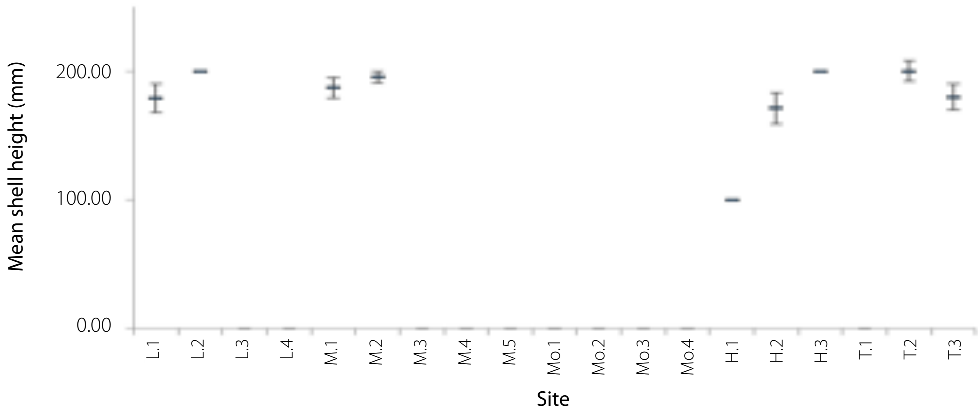


Figure 14. Mean shell height and standard error of green snails observed in each survey site of north-western Efate Island.

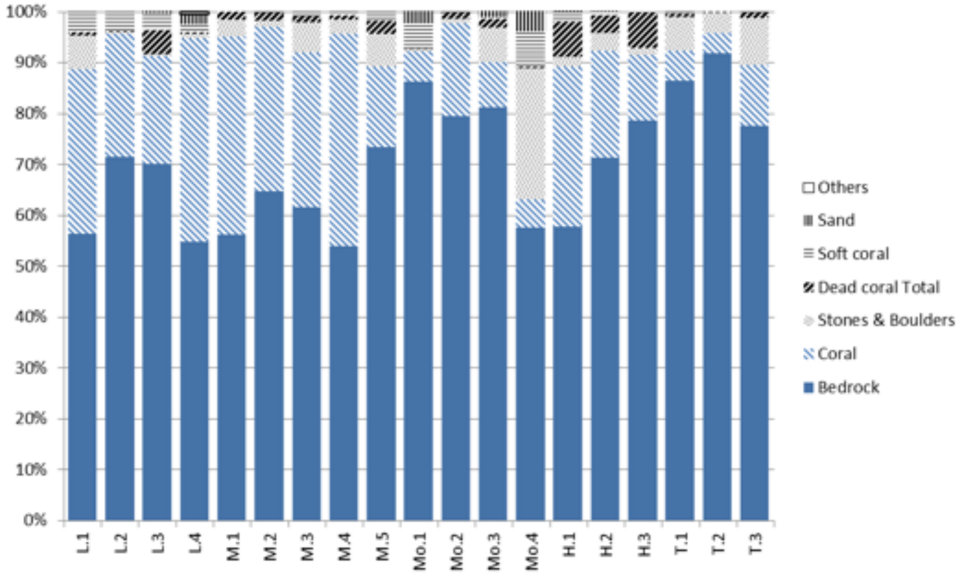


Figure 15. Bottom condition of each survey site of north-western Efate Island.

In L.1 (Figure 10), 195 green snails were transplanted in 2007. A total of nine were observed and the mean number of individuals per 100 m^2 was 0.90 (SE = 0.24). When compared with other survey sites of Lelepa, this site showed a high occurrence ratio of green snails. The range of shell height of green snails observed was 100–200 mm, and the mean shell height was 179.11 mm (SE = 11.11 mm). The survey site substrate was mainly composed of flat bedrock (>50 %) and coral (>30%), and did not include gravel or sand.

In L.2 (Figure 10), approximately 1 km distant from L.1, only one green snail was observed. The mean number of individuals per 100 m^2 was 0.10 (SE = 0.10). The shell height of the green snail observed was 200 mm. The survey site substrate was mainly composed of flat bedrock (>70 %) and coral (<25%).

In L.3, located (Figure 10) approximately 1 km distant from L.2, no green snail was observed. The survey site substrate was mainly composed of flat bedrock (>70 %) and coral (≈25%).

In L.4, located approximately 2.6 km west of L.1 (Figure 10), no green snail was observed. The survey site substrate was mainly composed of flat bedrock (>70 %) and coral (≈20%), and did not include either gravel or sand.

As stated above, the highest occurrence of green snails was found in L.1, the transplantation site. Two or more generations probably existed there owing to the size range. Only one individual was observed in L.2, and no green snail was found in L.3 and L.4. Consequently, it is obvious that the green snail resources had increased around the transplantation site, although the distribution area of green snails was still limited to a very narrow range.

Mangaliliu

In Manzgaliliu, five sites were surveyed, each covering a 1000 m^2 area (50 m x 4 m x 5 transect lines). The whole area of Mangaliliu is a taboo area implying various fishery restrictions. The green snail fishery, as in all other Vanuatu waters, is closed due to a moratorium until 2020 (Fisheries Act). According to local fishers, the green snail had not been observed in the surrounding area before transplantation took place.

In M.1 (Figure 10), 262 green snails were transplanted in 2007. During this survey, 17 individuals were observed, and the mean number of individuals per 100 m^2 was 1.70 (SE = 0.64). It was a relatively high occurrence ratio in comparison to those of other sites. The range of shell height of green snails observed was 90–230 mm, and the mean shell height was 187.06 mm (SE = 8.02 mm). There are hardly any data for the growth curve of the green snail anywhere in the world. According to Kakuma (2017), however, in the Amami Islands, of southern Japan, green snail sizes are as follows:

- 1 year old: around 30 mm;
- 2 years old: around 70 mm;
- 3 years old: around 120 mm;
- 4 years old: around 160 mm; and
- 5 years old: around 200 mm.

Generally, the growth of invertebrates, such as conches, is highly influenced by the local environment. It should therefore be expected that green snail growth would be faster in Vanuatu than in Okinawa and Amami, because water temperature is usually higher in Vanuatu. Nevertheless, the range of green snail shell heights observed in the survey sites suggests that several generations occupy these sites. Three individuals had marks indicating that they had been transplanted. These individuals were approximately 10 years old. The survey site substrate was mainly composed of flat bedrock (>50 %) and coral (≈40%), and did not include gravel or sand.

In M.2 (Figure 10), 205 green snails were transplanted in 2007. In this survey, 13 individuals were observed, and the mean number per 100 m^2 was 1.30 (SE = 0.60). This showed a relatively high occurrence ratio compared with other survey sites, except for M.1, another restocking site. The range of shell height of green snails observed was 180–220 mm, and the mean shell height was 195.38 mm (SE = 4.33 mm). The survey site substrate was mainly composed of flat bedrock (>60 %) and coral (≈30%), and did not include gravel or sand.

In M.3 (Figure 10), located approximately 2 km from M.1 and approximately 800 m south of M.2, no green snail was observed. The survey site substrate was composed mainly of flat bedrock (>60 %) and coral (≈30%); it did not include gravel or sand.

In M.4 (Figure 10), located approximately 1 km northeast of M.1, no green snail was observed. The survey site substrate was mainly composed of flat bedrock (≈50 %) and coral (≈40%); it did not include gravel or sand.

M.1, M.2, M.3 and M.4 substrates showed no major differences.

In M.5 (Figure 10), located between M.1 and M.2, approximately 500 m from both sites, no green snail was observed. The survey site substrate was mainly composed of flat bedrock (≈73 %) and coral (≈15%); it did not include gravel or sand. Topographically, when compared with those of other sites, M.5's bedrock ratio was larger, and that of coral was lower.

As stated above, many green snails were observed in M.1 and M.2, which were transplantation sites and no green snail was found in other sites. In particular, green snails did not occur in M.5, the midway point between the two transplantation sites. Meanwhile, in M.1 and M.2, two or more generations probably co-existed, considering the size differences. It was therefore deduced that green snail resources are limited in distribution to a small range, although they had settled successfully around the transplantation sites.

Moso Island

In Moso Island, four sites were surveyed. In 2007, 150 green snails were transplanted in front of Sunae Village. However, according to the VFD staff who conducted the activity, there was no accurate information about the location of the transplantation. The method of transplantation was to sprinkle the green snails from the boat in waters of about 10 m depth. This was different from the transplantation method used in Lelepa Island and Mangaliliu.

The survey method used in Moso had to be the same than this used in Lelepa and Mangaliliu – a survey method targeting areas of 0.5–3.0 m water depth. Therefore the survey could not be done at the 10-m deep transplantation site. We decided to conduct surveys of the transplantation area at a later date. No taboo area has been declared on Moso Island.

Mo.1 (Figure 10) was the nearest site to the transplantation site, according to VFD staff. However, we could not estimate the distance between the two sites because of the lack of the information about the exact location of the transplantation site. We could not find any green snails there. The survey site substrate was composed mainly of flat bedrock (> 85 %) coral (≈5%) and soft coral (≈5%). The coverage of bedrock was extremely high in this site.

In Mo.2 (Figure 10), approximately 2 km from Mo.1, no green snail was observed. The survey site substrate was mainly composed of flat bedrock (≈80 %) and coral (≈18%). The coverage of bedrock was high in this site, as in Mo.1.

In Mo.3 (Figure 10), approximately 700 m west of Mo.2, no green snail was observed. The survey site substrate was composed mainly of flat bedrock (≈80 %), coral (≈10%) and boulders (≈10%). The coverage of bedrock was also high in this site.

In Mo.4 (Figure 10), approximately 800 m southwest of Mo.1, no green snail was observed. The survey site substrate was mainly composed of flat bedrock (≈60 %), boulders (25%), soft coral (≈7%) and coral (≈6%). The coverage of boulders was relatively high compared with other sites on Moso Island.

At Moso Island survey sites, substrate was dominated generally by bedrock, and few coral colonies were observed. It suggested that the area is always subject to strong wave action, which may influence the green snail distribution.

Hat Island

Although the transplantation of green snails had not been conducted around Hat Island, it was one of the good fishing grounds for green snails before the enforcement of the moratorium on the fishery, and was known as good habitat for green snails. The area is located approximately 5 km from the transplantation sites of Lelepa and Mangaliliu. VFD staff expected Hat Island to be good habitat for young snails produced during spawning events at Lelepa and Mangaliliu transplantation sites, and which could have drifted during their larval stages. All coastal waters around Hat Island were established as a taboo area and green snail fishing was banned.

On Hat Island, three sites were surveyed, each one covering an area of 1000 m^2 (50 m x 4 m x 5 transect lines). In H.1 (Figure 10) located on the northeast coast of the Island, one green snail was found. The mean number of individuals per 100 m^2 was therefore 0.10 (SE = 0.10). The shell height of the green snail observed was 100 mm, and it was considered to be a young individual. The survey site substrate was composed mainly of flat bedrock (≈60 %), coral (≈30%) and dead coral (≈7%).

H.2 (Figure 10) is located on the west coast of Hat Island. According to local fishers, the area was usually difficult to approach because of high waves. In H.2, nine green snails were found and the mean number of individuals per 100 m^2 was 0.90 (SE = 0.29); the same density was found at L.1 site on Lelepa Island. The green snail shell height range was 110–200 mm, and the mean shell height was 171.11 mm (SE = 12.18 mm). The high range of shell heights suggests the presence of multiple generations at the site. The survey site substrate was mainly composed of flat bedrock (>70 %) and coral (≈20%).

H.3 (Figure 10), located in northern point of the Island, is usually difficult to approach because of high waves. In H.3 (Figure 10), one green snail was found. The mean number of individuals per 100 m^2 was therefore 0.10 (SE = 0.10). The shell height of the green snail observed was 200 mm. The survey site substrate was composed mainly of flat bedrock (>80 %), coral (≈10%) and dead coral (≈7%).

On Hat Island, although the transplantation of green snails had not been conducted, a number of green snails were observed, especially in H.2. Besides, the high range of shell heights of green snails observed suggests the existence of multiple generations in the area.

According to VFD staff, no survey targeting green snails had previously been conducted in Hat Island. However, no green snails were observed in 2012, when they conducted other surveys around Hat Island. Therefore, it was deduced that the green snail resource had increased over the last 4–5 years.

Tuku Tuku Point

The transplantation of green snails had not been done around Tuku Tuku Point. Like Hat Island, the area was a green snail fishing ground before the enforcement of the moratorium, and the area was known originally as a good habitat for green snails. Tuku Tuku Point is located 6–8 km from transplantation areas of Mangaliliu and Lelepa. VFD staff estimated the distance suitable for bottom settlement of suspended larvae spawned at transplantation sites of Mangaliliu and Lelepa. Coastal waters around Tuku Tuku point were also a taboo area.

At Tuku Tuku Point, three sites were surveyed, each covering an area of 1000 m^2 (50 m x 4 m x 5 transect lines).

At T.1 (Figure 10), located 2 km north of the tip of Tuku Tuku Point, no green snail was observed. The survey site substrate was mainly composed of flat bedrock (>85 %), boulders (≈7%) and coral (≈6%).

At T.2 (Figure 10), located 1.5 km north of T.1, the sea was rough and strong currents were flowing at the time of the survey. At T.2, eight green snails were observed and the mean number of individuals per 100 m^2 was 0.80 (SE = 0.30). The range of shell height of green snails observed was 170–230 mm, and the mean shell height 200.00 mm (SE = 8.02 mm). The survey site substrate was mainly composed of flat bedrock (>90%), coral (≈ 4%) and boulders (≈ 4%). The bedrock ratio was very high, suggesting the constant presence of strong waves.

At T.3, located on the east coast of Tuku Tuku Point, seas were rough and strong currents were flowing during the time of the survey. At T.3, three green snails were found and the mean number of individuals per 100 m^2 was 0.30 (SE = 0.20). The range of shell height of green snails observed was 170–200 mm, and the mean shell height was 180.00 mm (SE = 10.00 mm). The survey site substrate was mainly composed of flat bedrock (>80%), coral (≈ 10%) and boulders (≈ 10%).

Because of rough seas, the survey could not be carried out at the tip of Tuku Tuku Point. According to VFD staff, the density of green snails at the tip might be higher than at T.2, because it was a good fishing ground for green snails before the enforcement of the moratorium.

Based on those results, comparative densities of each area are shown in Figure 16.

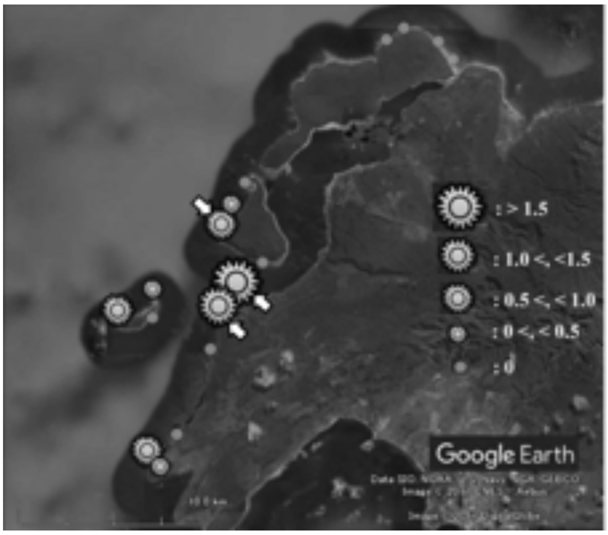


Figure 16. Mean number of individuals per 100 m^2 at each station in north-western Efate (arrows indicate restocking sites).

As described above, the density of green snails in all transplantation sites was quite high. At the time of the present survey, no survey focusing on the effect of transplantation of green snails had been conducted. One of the aims of the present survey was to scientifically evaluate if transplantation of green snails contributed to the resource increase. To do so, an analysis of variance (ANOVA) was used to evaluate the variation of the green snail population at each survey site.

However, when using normal ANOVA, no equality of variance was detected among the data. When no compared group shows an equality of variance, it is advisable to adopt a non-parametric technique that does not require the assumption of the population distribution. Therefore, we used the Kruskal-Wallis test, a non-parametric ANOVA, rather than the normal ANOVA. Each test detected a significant difference ($p < 0.05$). Therefore, we then performed the Tukey HSD test to examine the difference between each survey site. As a result, we detected a significant difference between M.1 and other survey sites without green snails, but we could not detect significant differences between M.1 and other sites with green snails such as M.2, L.1, H.2, H.3, T.2 or T.3. M.2 and L.1 showed significant differences in the number of green snails, but it was difficult to detect any significant difference between other survey sites. However, it should be noted that transplantation of green snails probably contributes to the resource enhancement, as the density of green snails was high in all transplantation sites.

The survey sites of the transplantation at Mangaliliu were almost the same sites used in the study conducted by IRD, mentioned above, although the range of the surveys was different. Therefore, we compared the results of this survey and the IRD study, as shown in Table 4. It revealed that the green snail density in the transplantation sites that we surveyed is extremely high compared with the results of IRD, although a simple comparison should not be made, because of the difference in survey ranges.

In another study, Kakuma (2017) concluded that the density of green snails in transplantation sites arises from the broodstock created by either transplantation or wild stocks. He concluded further that the transplantation sites in Mangaliliu showed relatively high densities compared with surrounding areas because the transplantation of green snails contributed to the increase of the broodstock and resources in the area, although this was difficult to quantitatively verify.

Also, there were places where green snails were present 4–6 km away from the transplantation

Table 4. Comparison of the results by the IRD and this survey.

Green snail density per hectare			
Results from IRD's 2012 study		Results from this survey	
Inside of taboo area	Outside of taboo area	M.1 site (inside taboo area in 2012)	M.2 site (outside of taboo area in 2012)
21.42 ind. ha^{-1}	6.00 ind. ha^{-1}	170.00 ind. ha^{-1}	130.00 ind. ha^{-1}

site, including at Hat Island and Tuku Tuku Point, whereas almost no green snails were found in sites 400–500 m away from transplantation sites. There may be two sources for the many green snails found at Hat Island and Tuku Tuku Point. The first is the reproduction of wild populations that remain there, and the second is the drifting larvae from broodstock of transplantation sites that reach Hat Island and Tuku Tuku Point 1–2 days after being spawned. On the north-western coast of Efate, a southward flowing current is dominant, according to information provided by local fishers and VFD staff. Thereby, larvae produced in Lelepa Island and Mangaliliu possibly drift southward and settle at Hat Island and Tuku Tuku Point.

In future research, it will be important to monitor tidal currents of coastal waters to better understand green snail population dynamics.

Uripiv Island and Uri Island

The mean number of individuals observed per 100 m² at each site, the distribution pattern of shell height and the mean shell height of green snails observed in Uripiv and Uri islands are shown in Figures 17, 18 and 19 respectively. The location of each survey site is shown in Figure 11.

The substrate cover of each survey site was categorised. The result is shown in Figure 20.

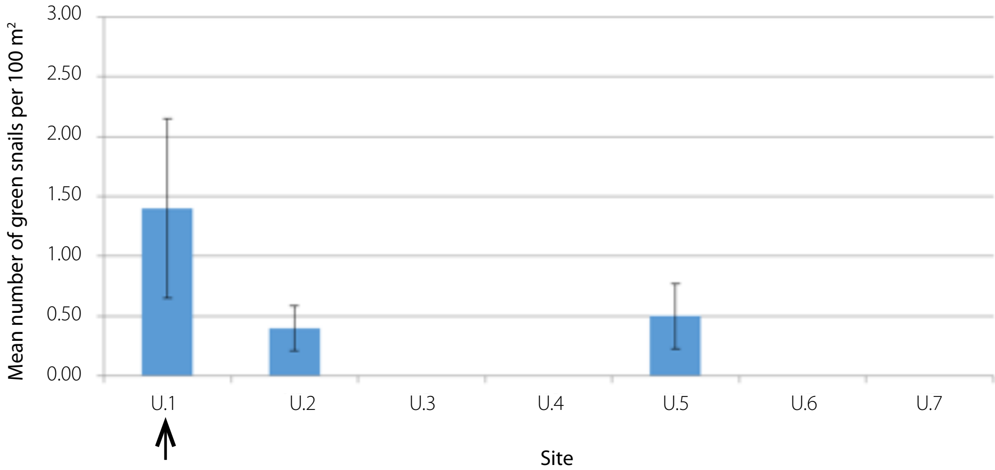


Figure 17. Mean number of green snails per 100 m² (±SE) at each station in Uripiv and Uri islands (arrow shows restocking site)

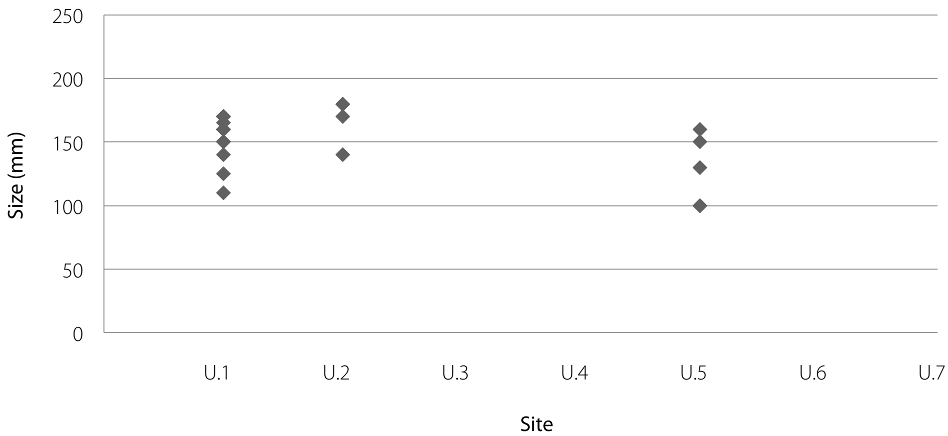


Figure 18. Shell height distribution pattern of green snails found at each survey site in Uripiv and Uri islands.

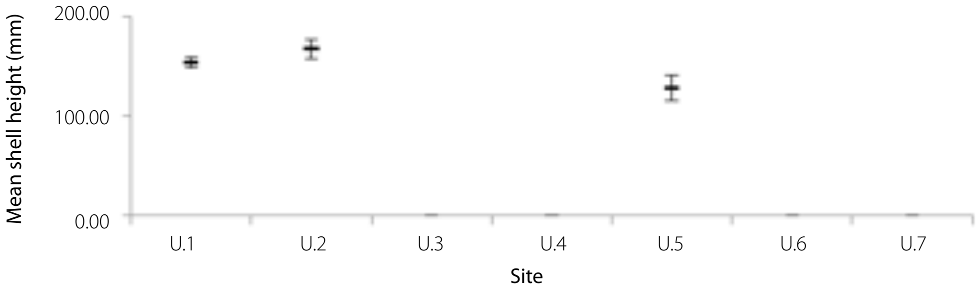


Figure 19. Mean green snail shell height (±SE) recorded at each survey site in Uripiv and Uri islands.

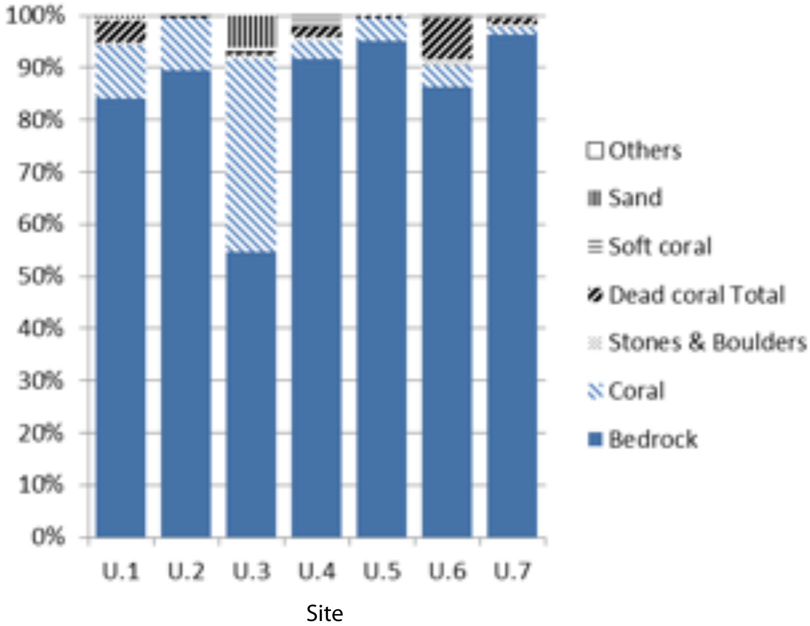


Figure 20. Substrate composition of each survey site in Uripiv and Uri islands.

Brief overviews of the occurrence status of green snails and the substrate cover of each survey site are given in the following section.

Uripiv Island

Uripiv is a small island with a population of 300–400 people located off the northeast of Malakula Island, at a straight line distance of approximately 2.5 km. Four sites, each covering an area of 1000 m^2 (50m x 4m x 5 transect lines), were surveyed on Uripiv Island, of which three (U.1, U.2 and U.3 – Figure 11) were taboo areas where fishing activities had been banned. According to local VFD staff, green snails had not been seen for 20 years in the coastal waters of Uripiv until transplantation was implemented.

In U.1 (Figure 11), located at the east end of Uripiv Island, 299 and 28 green snails were transplanted in 2012 and 2013, respectively. The individuals transplanted had been kept in a water tank at VFD for several years, although the growth rates of these snails were poor. In 2012, the average shell height of individuals transplanted was 56 mm. In 2013, 20 and eight individuals had shell heights of 80 mm and 60 mm, respectively.

In U.1, 14 green snails were found and the mean number of individuals per 100 m^2 was 1.40 (SE = 0.75). The green snail density was relatively high when compared with all survey sites. The range of green snail shell heights observed was 110–170 mm, and the mean shell height was 153.57 mm (SE = 4.84

mm). These sizes were relatively small in comparison to those observed in Efate. The survey site substrate was mainly composed of flat bedrock (≈85%) and coral (≈ 10%). No gravel or sand was observed.

In U.2, located at the northern tip of the island and 1.6 km northeast of U.1 (Figure 11), four green snails were found; the mean number of individuals per 100 m^2 was 0.40 (SE = 0.19). The range of green snail shell heights observed was 140–180 mm, and the mean shell height was 167.50 mm (SE = 9.46 mm). The survey site substrate was mainly composed of flat bedrock (≈90%) and coral (≈ 10%).

In U.3, located on the western side of the island and 1.0 km southwest of U.2 (Figure 11), no green snail was found. The survey site substrate was composed mainly of flat bedrock (≈55%) and coral (≈ 40%). In this site, coral coverage was relatively high in comparison to those of U.1 and U.2.

U.4 is located on the southern side of the island and at a 300 m direct distance from U.1 (Figure 11). This site was selected in the hope that it would host young green snails issued from individuals transplanted in U.1. But, no green snail was found in U.4. The survey site substrate was composed mainly of flat bedrock (≈90%) and coral (≈ 3%).

As stated above, a relatively high number of green snails occurred in U.1, which was a transplantation site. Multiple generations probably existed in the site owing to the high range of sizes. In sites where no transplantation occurred, only four individuals were observed in U.2 on the north side, but none were observed in U.3 and U.4. It was therefore deduced that green snail resources had increased in the transplantation site, although their distribution was limited to a small range.

Uri Island

Uri is a small island located to the south of Uripiv Island. The shortest distance between Uri and Uripiv islands is approximately 1 km. On Uri Island, transplantation of green snails had not been conducted. However, since the island was close to Uripiv Island, three survey sites were set on the northern coast, facing Uripiv Island. According to local VFD staff, green snails had not been observed around the northern coast for 20 years.

U.5 is approximately 1.5 km from U.1 of Uripiv Island, which is located in the outer edge of the reef flat that extended along the east side of the island (Figure 11). In this survey, five green snails were found. The mean number of individuals per 100 m^2 was 0.50 (SE = 0.27). The range of green snail shell heights was 140–180 mm, and the mean shell height was 128.00 mm (SE = 12.41 mm). As at U.1, these sizes were relatively small in comparison to those recorded in Efate. The survey site substrate was mainly composed of flat bedrock (≈95%) and coral (< 5%). No gravel or sand was observed.

U.6 is approximately 1.2 km north-west of U.5 and approximately 1.5 km from U.1 of Uripiv Island (Figure 11). In U.6, no green snail was observed. The survey site substrate was composed mainly flat bedrock (>85%), dead coral (≈ 8%) and coral (≈4%).

U.7 is located on the north-west coast approximately 600 m southwest of U.6 and approximately 2 km from U.1 of Uripiv Island (Figure 11). In U.7, no green snail was observed. The survey site substrate was composed mainly flat bedrock (>95%) and coral (<2%).

As stated above, no green snail was found at U.6 and U.7, but five were found at U.5, which is located on the outer edge of reef flat that extends along the east side of the island. As no green snail had been found in the northern coast of Uri Island for 20 years, it may be considered that the U.5 green snails may be related to those transplanted at U.1.

Based on these results, green snail densities (average number of individuals per 100 m^2) are summarised in Figure 21.

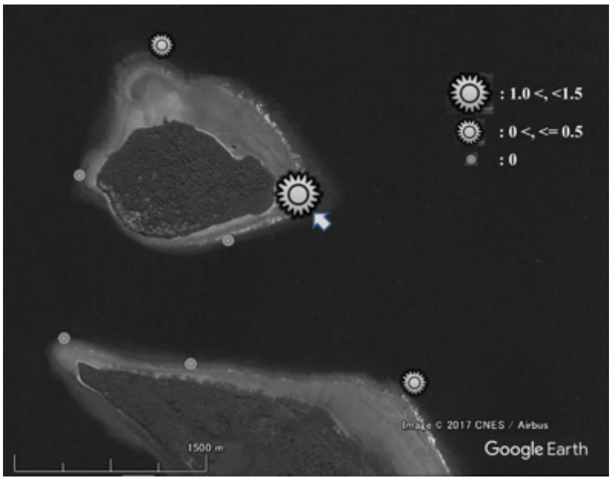


Figure 21. Mean number of green snails per 100 m^2 at each station in Uripiv and Uri islands (arrow indicates restocking site).

As in Efate Island, the highest green snail density in Uripiv Island was found in the transplantation site. We then conducted an analysis of variance (ANOVA) to evaluate if green snail densities in the different sites were significantly statistically different. Equality of variance was not detected among the data. Thereby, we used the Kruskal-Wallis test again. Each test detected a significant difference ($p < 0.05$). Therefore, we used the Tukey HSD test to examine the difference between each survey site. We detected a significant difference between U.1 and survey sites where no green snails were found (U.3, U.4, U.6 and U.7). But we could not detect significant differences between U.1 and other sites where green snails were found (U.2 and U.5). No significant difference was detected when comparing the densities of U.2, U.3, U.4, U.5, U.6 and U.7. Thus it can be concluded that the green snail density of the transplantation site (M.1) was the only one that was significantly higher than those of other survey sites. This suggests that the transplantation of green snails was likely to have contributed to resource enhancement of green snails in Uripiv and Uri islands.

In U.2 and in U.5, approximately 1.6 km north-west and 1.5 km south-east from the transplantation site (U.1) (Figure 11), green snails were found for the first time in 20 years. It is possible that green snail larvae produced in U.1 drifted with the current through the east bank of Uripiv and Uri islands and settled in U.2 and U.5. It would be useful to monitor the currents in the region in order to confirm this hypothesis and better understand green snail population dynamics in the area.

Relationships between the density of green snails and the substrate

The relationship between the number of green snails found and the coverage of bedrock in each site surveyed is given in Figure 22.

The relationship between the number of green snails found and the coverage of coral in each site surveyed is given in Figure 23.

As shown in Figures 22 and 23, no close correlation was found between the number of green snails and the coverage of bedrock. Neither was a close correlation between the number of green snails and the coverage of coral. In the sites where the number of green snails was 0 or 1, it was assumed that larvae could not survive. Therefore, these areas were excluded. The coefficient of correlation became (R) = -0.5791 between the number of green snails and the coverage of bedrock in the

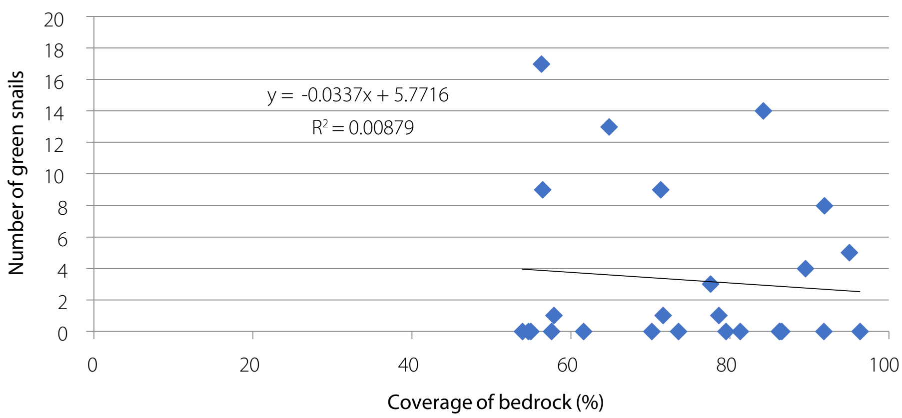


Figure 22. Relationship between the number of green snails and the coverage of bedrock.

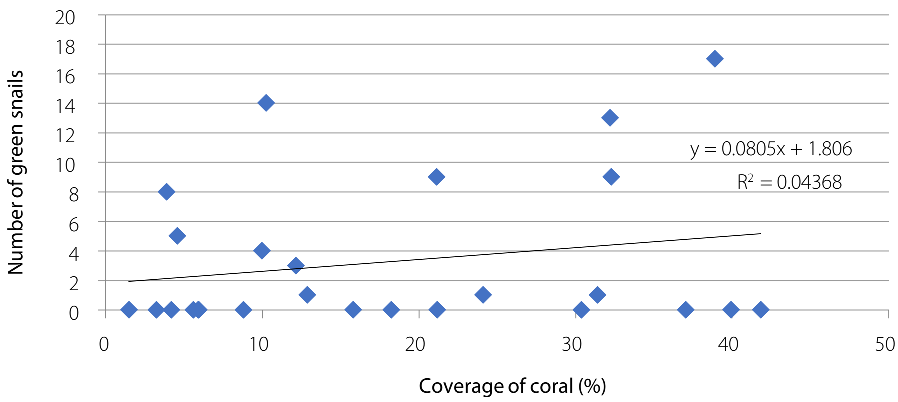


Figure 23. Relationship between the number of green snails and the coverage of coral.

range of 50–100%. Likewise, the coefficient of correlation (R) = 0.6510 between the number of green snails and the coverage of coral was in the range of 0–50%.

The common criterion of the coefficient of correlation is given in Table 5. Therefore, each relationship is thought of as a moderately strong correlation when more than one green snail appeared.

Table 5. Coefficient of correlation and correlation strength.

Coefficient of correlation	Correlation strength
R = 0.7–1	strong correlation
R = 0.4–0.7	moderately strong correlation
R = 0.2–0.4	weak correlation
R = 0–0.2	no correlation

As shown in the Figures 24 and 25, there is a moderately strong negative correlation between the number of green snails and the coverage of bedrock, in the range of 50–100% and, there is a moderately strong positive correlation between the number of green snails and the coverage of coral, in the range of 0–50%, in sites where more than one green snail occurred.

In addition, this survey suggests that the suitable habitat of green snails is very limited, since it did not occur at sites close to the transplantation site. Usually, the green snail inhabits a substrate of bedrock and does not occur on gravel and sandy bottoms.

It is also considered that the area with abundant bedrock with rugosity (irregularities and dimples) is a suitable habitat for green snails. Furthermore, it is expected that locations with abundant microalgae as feed would be a preferred habitat for green snails. Because of time limitations, we were unable to collect data on the rugosity of the bedrock and the availability of microalgae as feed for green snails. It would be necessary to collect topographical details and distribution pattern of microalgae and correlate them with occurrence of the green snail to understand its optimal habitat conditions.

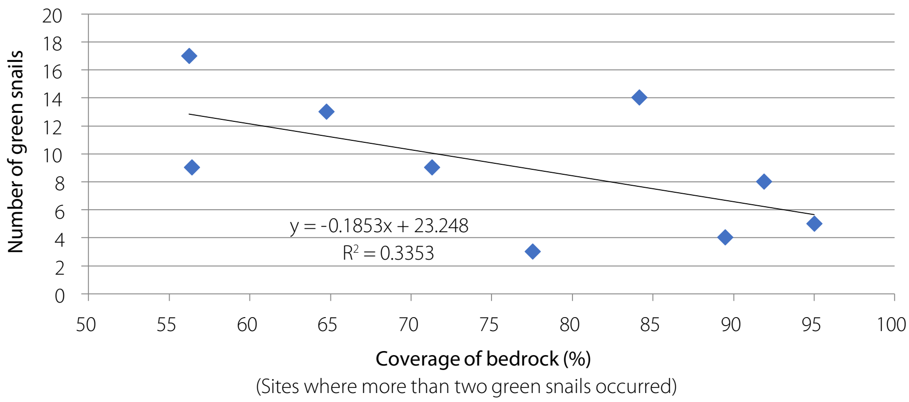


Figure 24. Relationship between the number of green snails and the coverage of bedrock in the range of 50–100%.

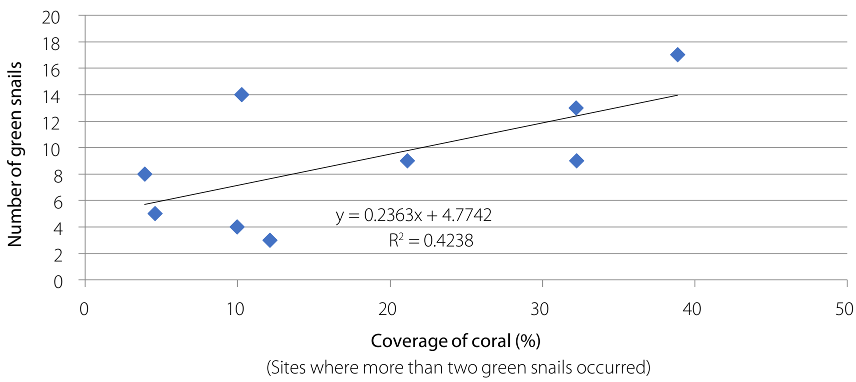


Figure 25. Relationship between the number of green snails and the coverage of coral in the range of 0–50%.

Questionnaire survey for understanding the motives of villagers participating in green snail transplantation and conservation activities

Survey site

The targets were the people in communities who were conducting the transplantation of green snails. These were the inhabitants of villages on Lelepa, Mangaliliu and north-western Efate, and the village of Uripiv Island, located in eastern Malakula Island.

Methods

Information was collected from target villagers using a questionnaire, calibrated by age and gender (Table 6). The questionnaire survey was based on 'Scheffe's pairwise comparisons test', a comparative method used in marketing research, to understand the most important motive for managing and conserving the green snail and as a reference in conducting future similar resource management. On the survey form, we gave examples of motives and received the information regarding the most important motive from each respondent. For example, A) *Because I know (or learned) that it's important and necessary to protect the green snail as a valuable resource*; B) *Because I will be able to make a profit when green snail fishing is re-opened*; C) *Because we decided in a community meeting not to catch green snails*; and D) *Because we have to follow the law and custom that imposed a ban on green snail fishing*.

The data collected in the survey was arranged by age group and gender, and analysed by pairwise comparison to understand the most important factor in the community.

We then compared the results of the questionnaire administered in each community using pairwise comparisons and analysed the results by ANOVA and multiple comparison tests, to estimate the most important motive among these of A–D, for the villagers of each community implementing transplantation of green snail.

Table 6. Questionnaire administered for understanding the villagers' motives for participating in green snail transplantation and conservation activities.

Information on respondent	
Village/community (if we have the information)	
Name of enumerator (if we have the information)	
Date of interview (if we have the information)	
Name of interviewee (if we have the information)	
1. Age	
2. Gender (m = male, f = female)	
3. Usual number of hours of fishing per day	
4. The group activity you participate periodically in the village	
General knowledge on green snails	
5. What do you know about green snail?	
5.1 The resources have been endangered since the 1990's owing to overfishing. (y = Yes, n = No)	
5.2 Green snail fishing has been banned since 2005 by national law. (y = Yes, n = No)	
5.3 Green snails are rare and an expensive worldwide. (y = Yes, n = No)	
5.4 Green snails were exported previously from Vanuatu as a raw material for ornamentations. (y = Yes, n = No)	
5.5 Green snails seem to be increasing recently. (y = Yes, n = No)	
5.6 Other.	
6. Were you taught about green snails by your family, community elders or school teachers? (y = Yes, n = No)	
7. If you selected 'Yes' on question 6, what kind of topic and from whom did you receive it?	
8. How large does a green snail become, and in how many years?	
Attitude to conservation activity for green snails	
9. Did you catch green snails until the fishing ban of 2005? (y = Yes, n = No)	
10. If you selected 'Yes' on question 9, how many did you find in your area around 2005? a = 0. b = Less than 5 within a day's dive. c = Less than 10 within a day's dive. d = 10 or more within a day's dive.	

Table 6 (continued).

11. Did you participate in the restocking activities for green snails organised by JICA? (y=Yes, n=No)	
12a. If you selected 'Yes' on question 11, what was the reason for your participation? a = Because I thought it was a meaningful activity. b = Because I was ordered to by a village chief or leader. c = Because I was invited by friends or acquaintances. d = Other. If 'Other', write the answer here:	
12b. If you selected 'No' on question 11, what was the reason for your non-participation? a = Because I didn't know about the activity. b = Because I was too busy with other things. c = I was not interested in the activity. d = Other. If 'Other', write the answer here:	
13. Do you think the restocking of green snails is a good activity in order to protect and increase the green snail population? (y=Yes, n=No)	
14. Do you think surveillance is needed to protect green snail resources from now on? (y=Yes, n=No)	
15a. If you selected 'Yes' on question 14, how do you think you should carry on the surveillance or monitoring activities?	
15b. If you selected 'No' on question 14, why do you think you do not have to do surveillance or monitoring activities?	
Motive for conservation activities of green snails	
16. What is the most important reason for protection of green snail populations? Respondents replies must be graded from highly positive (+4) through neutral (0) to highly negative (-4).	

	+4	+3	+2	+1	0	-1	-2	-3	-4	
A) Because I know (or learned) that it's important and necessary to protect green snail as valuable resource.										B) Because I will be able to make a profit when green snail fishing is opened after its resource increases in the future.
A) Because I know (or learned) that it's important and necessary to protect green snails as valuable resource.										C) Because we decided in a community meeting not to catch green snails. (Social linkage – perspective of Socio-culture)
A) Because I know (or learned) that it's important and necessary to protect green snail as a valuable resource.										D) Because we have to obey the law and custom commandment that banned green snail fishing.
B) Because I will be able to make a profit when green snail fishing is opened after its resource increases in the future.										C) Because we decided in a community meeting not to catch green snails.
B) Because I will be able to make a profit when green snail fishing is opened after its resource increases in the future.										D) Because we have to obey the law and custom commandment that banned green snail fishing.
C) Because we decided in a community meeting not to catch green snails.										D) Because we have to obey the law and custom commandment that banned green snail fishing.

Results and discussion

The number of respondents to the questionnaire in each community, with the information of age and gender, is given in Table 7, daily fishing hours of those who responded is in Table 8, and the number of respondents by group activity is in Table 9.

Based on these data, the general knowledge and attitude toward conservation activity for green snails were reviewed, and the motive for transplantation and conservation activities for green snails was described by the communities in Lelepa, Mangaliliu and Uripiv Islands.

Table 7. Number of respondents to the questionnaires in each community by age and gender.

		≤ 20	≥21 and ≤40	≥41 and ≤60	≥61	Total
Lelepa	Female	2	18	12	2	34
	Male	6	18	17	6	47
	Sub-total	8	36	29	8	81
Mangaliliu	Female	3	11	5	2	21
	Male	4	17	5	1	27
	Sub-total	7	28	10	3	48
Uripiv	Female	2	18	5	0	25
	Male	4	21	10	2	37
	Sub-total	6	39	15	2	62
					Total:	191

Table 8. The daily fishing hours of respondents.

		No fishing activity	1–3 hours	3–6 hours	More than 6 hours	Total
Lelepa	Female	3	13	8	10	34
	Male	1	1	13	30	47
	Sub-total	4	14	21	40	81
Mangaliliu	Female	3	1	9	8	21
	Male	0	6	18	3	27
	Sub-total	3	7	27	11	48
Uripiv	Female	5	19	1	0	25
	Male	10	26	1	0	37
	Sub-total	15	45	2	0	62

Table 9. Number of respondents by community group activity (multiple answers allowed).

		Religious group	Female group	Livelihood improvement group	Sport team	Junior chamber	Others	Total
Lelepa	Female	23	6	8	3	2	0	42
	Male	12	0	10	12	5	6	45
	Sub-total	35	6	18	15	7	6	87
Mangaliliu	Female	17	10	2	0	2	0	31
	Male	13	0	3	9	3	1	29
	Sub-total	30	10	5	9	5	1	60
Uripiv	Female	14	0	4	4	0	2	24
	Male	23	0	4	8	0	3	38
	Sub-total	37	0	8	12	0	5	62

Lelepa Island

Many respondents on Lelepa Island knew that the green snail was very valuable although its population had decreased owing to overfishing. It was commonly perceived that the resource had been abundant until the early-1990s, but then suddenly decreased and were hardly found when the total ban on green snail fishing was enforced, in 2005. The information about the resource recovery of recent years had not been shared widely enough. Furthermore, many respondents, both men and women, recognised the green snail was globally expensive, and therefore rare. However, many respondents did not know that Vanuatu had exported many green snails as raw materials for making accessories.

In addition, many male respondents replied that they had been taught about green snails by teachers and their family members. In particular, all the male respondents aged 20 years or younger admitted to getting the information either at school or at home. This might indicate that in recent years, education regarding the coastal resources has advanced. In contrast, many female respondents replied that they had not been taught about it. Thus a contrast occurred by gender.

The commonest information learned from family members was that the shell of green snails was very expensive; therefore, consuming its meat first then selling the shell was recommended. Regarding the population of green snails before a fishing ban was imposed, many responded that they found less than five individual green snails per day when diving. This suggested that the size of populations was formerly very small.

Many respondents felt that the transplantation activity of green snails was useful for its resource enhancement and conservation. Respondents who participated in the transplantation activities of green snails conducted by the Grace of Sea Project felt the activity was meaningful in that it would lead to an increase of green snail resources. Thus, it is inferred that the understanding of the transplantation activity was advanced among those villagers. Furthermore, many respondents felt that villagers must press ahead with monitoring and surveillance activities for the conservation of green snail resources. Such awareness building might be attributed to the activities undertaken through the Grace of the Sea Project.

Mangaliliu

In Mangaliliu, many respondents lacked a basic knowledge of the green snail and did not know that it was very valuable, that it had decreased because of overfishing and that it had been subject to a fishing ban since 2005. Also, there were few respondents who had conducted green snail fishing before the ban. This might indicate that green snail fishing was not carried out actively in Mangaliliu, or it may suggest that most of respondents do not know of the days when the green snail was abundant, since most were aged in their 20s to 40s. Few recognised that the population of green snails seemed to have increased.

However, many responded that they had been taught about the green snails by their school teachers and family members. Owing to several workshops organised by the Grace of the Sea project, some responded that they learned that the green snail resource would contribute to improvement in their lives if it were to increase in the future. This could be one result of the awareness activity for resource management of the green snail. Regarding the population of green snails before its fishing was banned, a few responded that they found less than five individuals in one day of diving. This suggested that the population size was very small.

Like the respondents on Lelepa Island, those who had participated in the transplantation activities of green snails conducted by the Grace of the Sea project felt that the activity was meaningful, since it would lead to an increase in green snail resources. Many responded that surveillance activity was required for effective conservation of the green snail, and that they would consider cooperating with future activities.

Uripiv Island

On Uripiv Island, it was widely known that the green snail was very valuable, but that it had decreased due to overfishing, that it had been subject to a fishing ban since 2005 and that it was globally rare and so expensive. However, information about the resource recovery and the history of the green snail fishing had not been well shared.

Many respondents had learned that green snail meat was edible and that the shell was expensive from their teachers, chief and family members. However, a few responded that they had conducted regular green snail fishing before the fishing ban. This might suggest that the green snail had not been abundant on Uripiv for a long time.

For those respondents who had participated in the green snail transplanting activity conducted by the Grace of the Sea project, the major motive for participation was that they were members of the community. Besides, most of respondents considered that the transplantation activity of green snails was useful for resource enhancement and conservation of the resource. This attitude could demonstrate that the understanding of the transplantation was advanced among the villagers. In contrast, a few responded that surveillance activity to protect green snail resources was unnecessary, since the fishing ban was already legally established and no villagers would break the law by poaching. It might be that because Uripiv is a very small island, there is a high trust among community members because strangers do not often visit.

The ranking order of the four motives for participating in the transplantation and conservation activities exemplified above were analysed statistically using Scheffe's pairwise comparisons test. Results for each community are given in Tables 10 to 12.

Table 10. Order of the motive of villagers in Lelepa Island for transplantation and conservation of green snails.

Lelepa Island			Number of samples	Order of the strength of the motive (the higher the number, the stronger the motive)			
				1st	2nd	3rd	4th
		In total:	81	B: 1.373	D:0.015	A: -0.012	C: -1.377
Breakdown	Gender	Female	34	B: 1.331	D:0.110	A: -0.294	C: -1.147
		Male	47	B: 1.404	A: 0.191	D:0.053	C: -1.543
	Age group	x <= 20	7	B: 1.857	A: 0.679	D:-0.286	C: -2.250
		20< x <= 40	37	B: 1.372	D:-0.074	A: -0.135	C: -1.311
		40< x <= 60	29	B: 1.302	D:0.000	A: -0.207	C: -1.095
		60< x	8	B: 1.219	D:0.063	A: 0.656	C: -1.938

A) Because I know (or learned) that it is important and necessary to protect the green snail as valuable resources.
B) Because I will be able to make a profit when green snail fishing is opened after its resource increases in the future.
C) Because we decided in a community meeting not to catch green snails.
D) Because we have to follow the law and custom commands that banned of green snail fishing.

Table 11. Order of the motive of villagers in Mangaliliu for transplantation and conservation of green snail.

Mangaliliu			Number of samples	Order of the strength of the motive (the higher the number, the stronger the motive)			
				1st	2nd	3rd	4th
		In total:	49	D: 0.959	B: 0.643	A: 0.296	C: -1.898
Breakdown	Gender	Female	21	D: 1.345	B: 1.012	A: 0.393	C: -2.750
		Male	28	D: 0.670	B: 0.366	A: 0.223	C: -1.259
	Age group	x <= 20	7	D=1.821	A: 0.000	B: -0.250	C: -1.571
		20< x <= 40	29	D: 1.198	B: 0.966	A: 0.517	C: -2.681
		40< x <= 60	9	B: 0.472	A: 0.111	C: -0.278	D: -0.306
		60< x	3	A: 0.500	B: 0.000	C: -0.250 D: -0.250	

A) Because I know (or learned) that it is important and necessary to protect the green snail as valuable resources.
B) Because I will be able to make a profit when green snail fishing is opened after its resource increased in the future.
C) Because we decided in a community meeting not to catch green snails.
D) Because we have to obey the law and custom ordered ban on green snail fishing.

Table 12. Order of the motive of villagers in Uripiv Island for transplantation and conservation of green snail.

Uripiv Island			Number of samples	Order of the strength of the motive (higher number shows stronger motive)			
				1st	2nd	3rd	4th
		In total:	62	A: 2.601	B: -0.262	D: -1.085	C: -1.254
Breakdown	Gender	Female	25	A: 2.560	B: -0.290	D: -1.070	C: -1.200
		Male	27	A: 2.628	B: -0.243	D: -1.095	C: -1.291
	Age group	x <= 20	5	A: 2.900	B: -0.400	D: -1.200	C: -1.300
		20< x <= 40	40	A: 2.594	B: -0.250	D: -1.094	C: -1.250
		40< x <= 60	15	A: 2.483	B: -0.283	D: -1.000	C: -1.200
		60< x	2	A: 2.875	B: 0.000	D: -1.250	C: -1.625

A) Because I know (or learned) that it is important and necessary to protect the green snail as valuable resources.
B) Because I will be able to make a profit when green snail fishing is opened after its resource increases in the future.
C) Because we decided in a community meeting not to catch green snails.
D) Because we have to obey the law and follow the custom ordered ban on green snail fishing.

All responses to the questionnaire were examined using the Games-Howell multiple comparison test in order to see if the order of the strength of the motive in each community was statistically significant.

No significant differences among motives A, B and D occurred in Lelepa Island. However, they showed significant differences with motive C. This might suggest that motive C was not regarded as important for green snail transplantation and conservation. It probably suggests that in some communities there were not enough green snails to justify making a rule for them. However, a rule might be necessary in these communities to enable them to either understand the idea of the activity, to help them envision the future economic benefit of regulation, or to enforce the law and regulations concerning their ownership.

In Mangaliliu, no significant difference was found in any combination of the four motives. Although motive D came first in the counting of the questionnaire, the four motives could not to be ranked statistically.

In Uripiv Island, motive A (1st) showed a significant difference to motive B (2nd), motive D (3rd), and motive C (4th). In addition, motive B (2nd) showed a significant difference with motive D (3rd) and motive C (4th). Therefore, motive A ('Because I know [or learned] that it is important and necessary to protect the green snail as a valuable resource') was the strongest in the Uripiv community, compared with the other two communities.

Based on those results, it is important to understand the tendency of a motive and its strength in the community, in order to promote transplantation and conservation activities for green snails.

Awareness survey for resource management in a community that has no experience of the transplantation of green snails

Survey site

In the fishing villages in eastern and southern Efate Island, where transplantation and conservation activities had not yet been undertaken, an awareness survey was implemented for the chiefs and leaders of the eight communities in order to understand how people recognise the present status of green snails and the effect of transplantation and conservation activities for green snails.

Method

1. The chief, leader and other collaborators were interviewed in each target community regarding resource management activities.
2. Inquiries were made in the same manner and in accordance with the contents of the questionnaire described in Table 6.
3. Results obtained were analysed regarding respondents' recognition of the present status of green snail resources and, the most important motive for the resource enhancement and conservation activities.

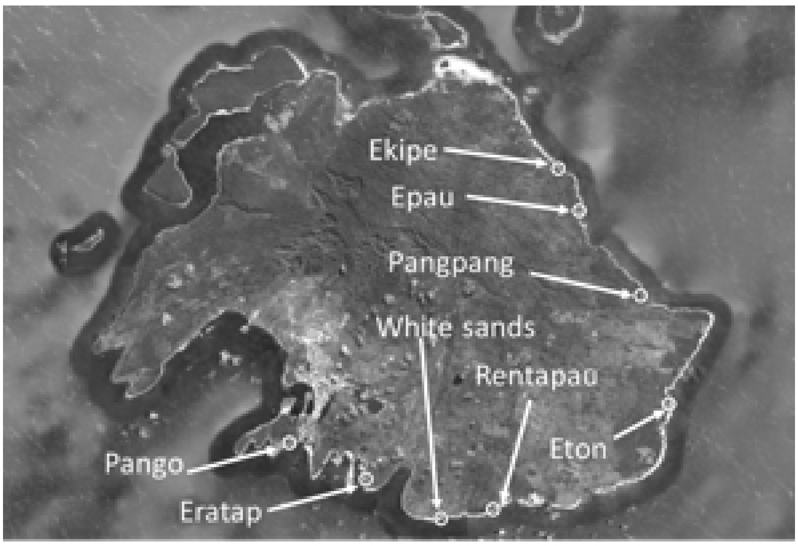


Figure 26. Sites for the awareness survey in the eastern and southern Efate.

Results and discussion

The number of respondents to the awareness survey in each community is shown in Table 13.

General knowledge of green snails

Eighty per cent or more of respondents understood that the green snail was already endangered by overfishing in Vanuatu in the 1990s and 2000s, therefore green snail fishing had been banned nationwide in 2005, that the meat was edible and that the shell was expensive. However, almost 40% of them were unaware that the green snail had been an important export product for Vanuatu. In addition, around 70% of respondents were aware of the recovery of green snail, and all respondents had been taught about green snails by their parents, relatives and teachers. This suggests that the information about green snails had been introduced successfully to community leaders and others interested in the green snail fishery. The main content of the information they were taught is that the green snail was formerly abundant, although it had become scarce in recent years, and therefore its fishing had been banned. Also, some respondents who mistakenly collected green snails had either their father explain that it was prohibited to catch it, or VFD staff had warned them and confiscated their catch, perhaps indicating that young people, in particular, were unaware that the green snail population had decreased. It is important to familiarise the younger generation about the biological and economic characteristics of green snails, so as to continue its management.

Population and resource management of green snails

Regarding the population of green snails before the fishing ban was implemented, more than 70% of respondents answered that they found less than five to 10 individual green snails in one day of diving – the area that one fisher could cover in one day would be more than one hectare, at least. Therefore, the population of green snails was probably very small in the area before enforcement of the fishing ban. In addition, most respondents replied that the green snail resource had increased. This may suggest that recognition of the increase of green snail resources is common knowledge in the survey area in eastern and southern Efate Island.

All respondents replied that the transplantation activities of green snails were effective for resource enhancement and conservation. Furthermore, more than 90% regarded surveillance as necessary for resource management. Almost all respondents recognised the need for both transplantation and the surveillance activities for the management of the green snail resource.

Table 13. Number of respondents to the awareness survey in each community by age and gender.

		≤ 20	≥21 and ≤40	≥41 and ≤60	≥61	Total
Ekipe	Female	0	1	1	0	2
	Male	0	2	0	0	2
	Sub-total	0	3	1	0	4
Epau	Female	0	0	0	0	0
	Male	0	4	1	0	5
	Sub-total	0	4	1	0	5
Pangpang	Female	0	0	1	0	1
	Male	0	2	2	0	4
	Sub-total	0	2	3	0	5
Eton	Female	0	0	0	0	0
	Male	0	2	3	0	5
	Sub-total	0	2	3	0	5
Rentapau	Female	0	1	0	0	1
	Male	0	0	2	0	2
	Sub-total	0	1	2	0	3
White sands	Female	0	0	0	0	0
	Male	0	0	1	0	1
	Sub-total	0	0	1	0	1
Eratap	Female	0	0	0	0	0
	Male	0	2	2	1	5
	Sub-total	0	2	2	1	5
Pango	Female	0	0	0	0	0
	Male	2	2	2	3	9
	Sub-total	2	2	2	3	9
					Total:	37

On the other hand, only two respondents out of 37 mentioned issues with green snail transplantation and surveillance activities. One was a villager who declared that he did not care about resource management. In the case that green snail management transplantation and surveillance activities take place, such an attitude could jeopardise the operations' success. The other said that transplantation might not be always effective because resource enhancement of green snails depends on its habitat preference and the availability of food. In the future, guidelines regarding green snail transplantation and surveillance must address these issues.

Conclusion drawn from the survey

- As a result of survey, the density of the green snails was found to be much higher in the sites where transplantation had been conducted through 'the Grace of the Sea' project phases 1 and 2. The fishers in both sites related that no green snail had been found prior to the transplantation activities. At both areas of Efate and Uripiv islands, in geographically remote locations, similar results and densities had been obtained. This strongly supports the positive effect of green snail transplantation.

- The main probable reason accounting for the high density of green snails in the transplantation sites is self-seeding by eggs and suspended larvae that had remained on the spawning ground. Meanwhile, the fact that the green snail was found at locations several kilometres from the transplant location could be due to: (1) self-seeding from the few broodstock that are naturally remaining at the site; (2) settlement of drifting larvae produced in neighbouring areas; or (3) settlement of drifting larvae produced in transplantation sites. All these reasons would contribute to the increase of the population to varying degrees. Even so, the artificially transplanted broodstock might contribute significantly to the promotion of the resource increase, since the natural population size had been small. The dense population of broodstock, resulting from transplantation, also might have boosted the reproduction rate of green snail.

- Transplantation of green snails had been conducted in Moso Island, in northern Efate Island, in 2007. However, the green snail was not found there during this survey. It was reported that the depth of the transplantation site was more than 10 m, but the precise location of the transplantation site on Moso Island has not been recorded by VFD. The location of the survey site that we set up may have been several hundred metres away from the transplantation site. Furthermore, the water depths of other survey sites were no more than 6 m and we used the same depth for standardising the environmental condition among the survey sites. Also, when transplanting green snails, participants usually place individual snails carefully on the sea bottom. But in Moso Island, green snails were just sprinkled from a boat, so individuals probably remained widely scattered. The relatively deep water could have also affected green snail survival. All these reasons may explain why we have not been able to find green snails at Moso Island.

- Most transplantation sites were placed in either a taboo area or a marine protected area (MPA). It is very effective to set up transplantation sites in such areas to facilitate surveillance. Green snail density increased mainly around transplantation sites, but its distribution range remained limited. Furthermore, while the green snail population tended to increase, it is still very small, and the green snail remains endangered in Vanuatu. It is therefore necessary to continue the transplantation and conservation activities with a focus on taboo areas and MPAs. In addition, periodic monitoring of the density of green snails is indispensable for evaluating population trends.

- Where green snail transplantation took place, it was well received by the inhabitants. However, some people felt uncomfortable with the long limitation of fishery activities imposed by large-scale resource management. They were asking for a better balance between opening the fishery for economic activities and closing it for resource management. In recent years, chiefs and leaders of communities that were not involved in transplantation activities perceived, nevertheless, transplantation and conservation activities positively. They understood the significance of green snail resource management activities. Their positive reaction might indicate an interest in participating in such activities. However, before starting any resource management activity it is necessary to carefully consider the balance between fishery-related economic activities and resource management.

- In one area where transplantation of green snails was undertaken, motives for the implementation of green snail resource management activities, as reported by members of the community, were mainly: A) *Because I know (or learned) that it is important and necessary to protect green snails as a valuable resources*., B) *Because I will be able to make a profit when green snail fishing is opened after its resource has increased in the future*, D) *Because we have to follow the law and custom-ordered ban on green snail fishing*. However, it was suggested that motive C) *Because we decided in a community meeting not to catch green snail* was generally not a strong motive among inhabitants. When considering implementing pilot activities in target communities, management and support activities must be selected in accordance with how communities rate the different motives for resource management and support activities, using statistical analysis.

- In the future, it will be important to increase resource enhancement activities such as green snail transplantation. It will be necessary to explain to target community members that the transplantation technique is actually applicable to low-mobility animals such as green snails, big-eyes, button shells, sea cucumbers and giant clams. It is also necessary to demonstrate the effectiveness of resource enhancement by techniques such as transplantation, and not merely to recommend conservation of species. It is vital to utilise these examples to ensure the transition from simple resource management, which passively waits for spontaneous growth under restriction of fishing activities, to an enhancement type of resource management, which provides better conditions for accelerating resource propagation.

- In 'The Grace of the Sea' project – Phase 3, as one of the resource management tools in the pilot project we will consider resource enhancement by transplantation for other low-mobility animals other than the green snail. For example, on the east coast of Tanna Island, women of the Waisisi community harvest the big-eye snail (*Turbo setosus*), a low-mobility animal from coastal waters. This could be one of candidate species for resource enhancement by the community. In addition, the transplantation of low-mobility animals might be considered on the west coast of Tanna Island, where fish populations have decreased remarkably in coastal waters. It may also be possible to conduct these activities elsewhere in Oceania as an example of community-based coastal resource management.

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Note about contents

It was decided not to include the set of annexes in this version of the article that accompanied the original submission. Those readers who wish to examine the annexes are requested to contact Dr A. Terashima, the corresponding author, for a copy of them, using the email address provided on the front page. The annexes that are omitted are as follows:

Annex 1. *GPS position and location map of each transect line (Longitude and Latitude);*

Annex 2. *Green snails seen at each transect line;*

Annex 3. *Ratio (%) of substrate cover of each survey site;*

Annex 4. *Results of statistical analysis for comparison of the number of green snails seen in northeast Efate;*

Annex 5. *Results of statistical analysis for comparison of the number green snail seen in Uripiv and Uri islands;*

Annex 7. *Aggregate results of respondents to closed-ended questions for understanding the motive of villagers participating in transplantation and conservation activities for green snails;*

Annex 8. *Figures and tables from the results of closed-ended questions for understanding the motive of villagers participating in transplantation and conservation activities for green snails;*

Annex 9. *Results of a pairwise comparisons test for the most important motive to manage and conserve the green snail resources in the local community; and*

Annex 10. *Aggregate results of awareness survey for resource management in communities having no experience of the transplantation activity of green snail.*