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Field inventory and population assessment of sea cucumbers from Vanuatu

Frédéric Ducarme,^{1*} Pascal Dumas² and Rocky Kaku³

Abstract

This contribution describes the results of a sea cucumber (Holothuroidea) survey that was conducted in Vanuatu (South Pacific) from 2019 to 2020. A field species inventory was undertaken around Efate Island during this period, of which outcomes are then compared with the results from the 2019–2020 sea cucumber monitoring surveys, implemented by the Vanuatu Fisheries Department under the current Vanuatu National Sea Cucumber Fishery Management Plan. The main result of this survey is the correct health of sea cucumber populations, both abundant and diverse, including threatened species. These results bring the total number of sea cucumbers in Vanuatu to 36, including 20 species of commercial interest and 5 species of conservation interest observed throughout the course of the study.

Keywords: Holothuroidea, Vanuatu, Melanesia, South Pacific, fisheries management, Echinodermata, marine biodiversity

Introduction

Vanuatu is an island country in the southwest Pacific Ocean, and part of the region known as Melanesia. It is located between New Caledonia to the southwest, Fiji to the east, and Solomon Islands to the north. It is one of the youngest countries in the world, gaining independence in 1980, but also among the poorest in terms of market economy, and among the least known to science. Coastal fisheries, including for marine invertebrates, is widespread but mostly targeted at local consumption, hence making an important contribution to food security (Raubani 2007). Small-scale, commercial fishing targets a small variety of higher-value species, including trochus topshell (*Rochia nilotica*), lobsters (*Panulirus* spp.) and coconut crab (*Birgus latro*). While not consumed locally, sea cucumbers are also a major source of income for coastal communities. Vanuatu is known for having its official language, Bislama, based on a European word designating sea cucumbers (beche-de-mer), suggesting an ancient tradition of fishing and trade (Pakoa et al. 2014). Documented at least since the 19th century, this activity has progressively evolved from unregulated, artisanal harvesting, eventually tempered with several temporal or local bans and regulations (Kinch et al. 2008), to community-based fisheries management (Léopold et al. 2013b) and, more recently, towards a national fishery regulated under a fully integrated management strategy (Kaku et al. 2020).

The marine fauna of Vanuatu remains poorly known, the main recent scientific expedition being the MNHN (Muséum national d'Histoire naturelle) expedition to Espiritu Santo Island in 2006 (Bouchet et al. 2008), which did not include a dedicated study of echinoderms (Bouchet et al. 2011). However, the isolation and geological particularities of the country may entail a diverse and original

fauna, potentially divergent from better-known neighbouring countries such as New Caledonia (Cherbonnier 1980; Conand 1989; Améziane 2007). This ecological originality especially comes from the lack of “classical” coral lagoons around most of the islands, due to the rapid uplift of the New Hebrides tectonic plate (Taylor et al. 2005).

The present study describes the result of a pilot sea cucumber survey that was conducted on the shores, reefs and shallow (< 40 m) bottoms of Efate Island (including its surrounding islets) during one year, from August 2019 to August 2020. The results are discussed in light of the countrywide sea cucumber population monitoring carried out over the same period by the Vanuatu Fisheries Department.

Methodology

A survey of the distribution and diversity of holothurians was carried out at more than 20 sites around Efate Island and its islets (Fig. 1). These sites included mangrove forests (Erakor Channel and “lagoons”), sand beds (Erakor Channel, Havannah Harbour, Port Villa seafront), muddy bottoms (Havannah Harbour, Mele Bay, Port Villa seafront), seagrass beds (Erakor Channel and “lagoons”) and coral reefs (most other sites).

Sites were investigated using scuba or snorkel, depending on depth, down to 40 m. Most sites were surveyed several times during the year, at different hours of the day and night and across different seasons, in order to avoid sampling bias. More than 50 surveys were conducted, including more than 10-night surveys and more than 20 dives deeper than 20 m, all longer than one hour. All surveys were carried out by examining the benthos using the “roving diver technique” (RDT) as described in Schmitt and Sullivan (1996) and Bourjon et al. (2018), searching under crevices and rocks,

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Figure 1. Location of main sampling stations (red stars) around Efate Island. Source: Wiki Commons

and identifying and photographing all sea cucumbers encountered. No specimens were sampled for this pilot study.

During this period (2019–2020), management surveys were implemented under the Vanuatu National Sea Cucumber Fishery Management Plan across six provinces of Vanuatu, recording specific abundances of commercial species. Target islands included Efate, Gaua, Santo, Maewo, Malekula, Maskelynes, Epi, Emau, Erromango and Tanna, along with associated islets (Fig. 2). All surveys were carried out by the Vanuatu Fisheries Department using a transect method, where all specimens observed within a geolocalised area, 100 m x 2 m corridor, were identified to species level and measured (body length and width). The number of transects ranged from 46 to 292 per site, depending on the depth and habitat of the sample station. Data were collected by walking, snorkelling or scuba diving. All surveys were limited to daytime.

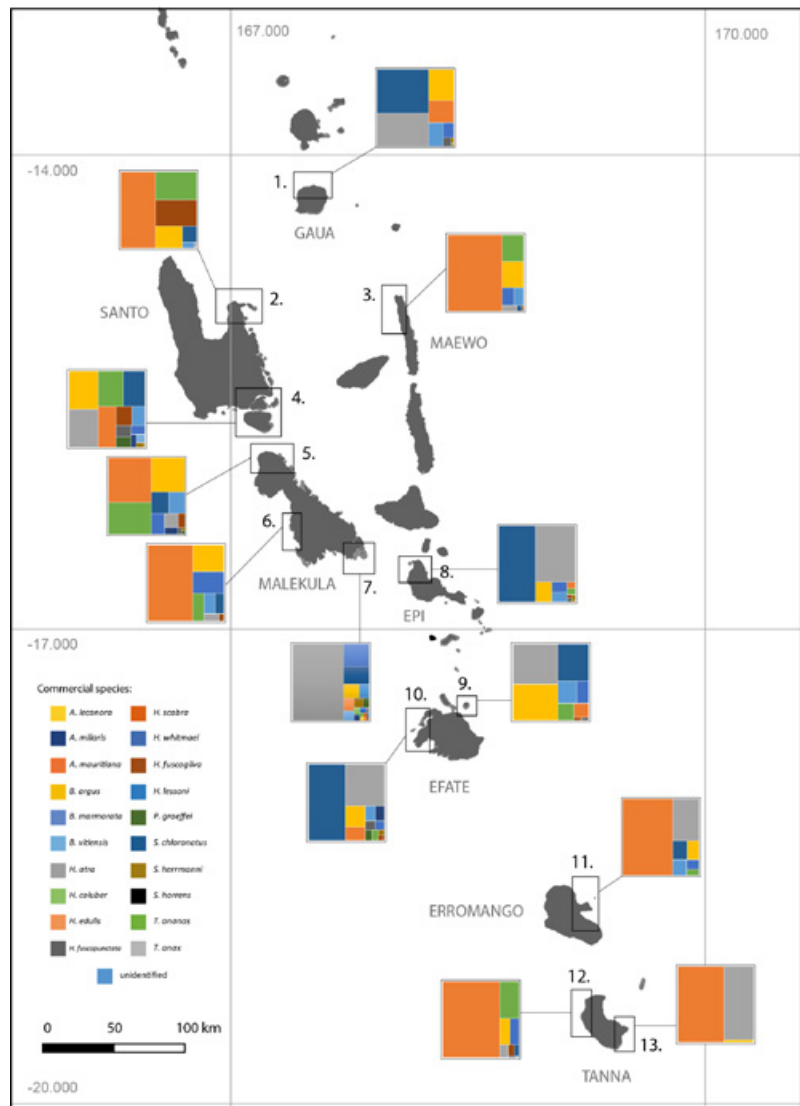


Figure 2. Species distribution patterns across the Vanuatu archipelago. Relative abundances of commercial holothurian species observed across 13 survey sites during the 2019–2020 surveys.

Results

Holothurian diversity

In total, 36 species of sea cucumbers were encountered during the scientific survey (Table 1), including 3 Apodida, 8 Synallactida (all belonging to the family Stichopodidae), and

24 Holothuriida (all belonging to the family Holothuriidae). It is worth noting that the species previously identified as *Actinopyga mauritiana* (an Indian Ocean endemic) appears to be its Pacific sister-species *Actinopyga varians*. Five species could not be identified beyond the genus level from the *in situ* observations, and are left as “sp.” or “cf.”.

Table 1. List of holothurians recorded during the Efate scientific surveys. Species are listed with relative abundances per benthos type (from 0 to 3 stars) along with commercial value and comments.

| Order | Family | Species | Mangrove/ seagrass | Mud | Sand | Coral | Comments | Commercial value | | |
|--------------|---------------|---------------------------------------|-----------------------|--------------------------------|------|-------|---------------|---------------------|-----|---|
| Holothuriida | Holothuriidae | <i>Actinopyga lecanora</i> | | | | * | Nocturnal | ** | | |
| | | <i>Actinopyga miliaris</i> | | | | * | IUCN VU | ** | | |
| | | <i>Actinopyga varians</i> | | | | | * | | ** | |
| | | <i>Bohadschia argus</i> | | * | *** | *** | | Most abundant | ** | |
| | | <i>Bohadschia koellikeri</i> | | | | * | | | | |
| | | <i>Bohadschia marmorata</i> | *** | * | | | | | * | |
| | | <i>Bohadschia vitiensis</i> | * | | ** | | | | * | |
| | | <i>Holothuria atra</i> | * | | * | | * | | * | |
| | | <i>Holothuria cinerascens</i> | | | | | * | | * | |
| | | <i>Holothuria coluber</i> | * | | * | | * | | * | |
| | | <i>Holothuria difficilis</i> | | | | | ** | | | |
| | | <i>Holothuria edulis</i> | | | | | * | | * | |
| | | <i>Holothuria fuscopunctata</i> | | | | * | | | ** | |
| | | <i>Holothuria hilla</i> | | | | | * | | * | |
| | | <i>Holothuria impatiens</i> | | | | | * | | * | |
| | | <i>Holothuria leucospilota</i> | | | | | *** | | * | |
| | | <i>Holothuria lineata</i> | | | | | * | | | |
| | | <i>Holothuria pardalis</i> | | | | | * | | * | |
| | | <i>Holothuria scabra</i> | ** | * | | | | IUCN EN | *** | |
| | | <i>Holothuria whitmaei</i> | | | | | * | IUCN EN | *** | |
| | | <i>Holothuria cf. verrucosa</i> | | | | | * | | | |
| | | <i>Holothuria sp.</i> | | | | | * | | | |
| | | | | <i>Labidodemas rugosum</i> | | | * | | | |
| | | | | <i>Pearsonothuria graeffei</i> | | | | ** | | * |
| Synallactida | Stichopodidae | <i>Stichopus chloronotus</i> | | | | ** | | *** | | |
| | | <i>Stichopus herrmanni</i> | | ** | * | | IUCN VU | *** | | |
| | | <i>Stichopus horrens</i> | | | | * | Nocturnal | ** | | |
| | | <i>Stichopus cf. monotuberculatus</i> | | | | * | Nocturnal | ** | | |
| | | <i>Stichopus pseudohorrens</i> | | | * | | Deeper (>30m) | * | | |
| | | <i>Stichopus vastus</i> | * | * | | | | * | | |
| | | <i>Thelenota ananas</i> | | | * | * | IUCN EN | *** | | |
| | | <i>Thelenotaanax</i> | | | * | * | | * | | |
| Apodida | Chiridotidae | <i>Chiridota sp.</i> | | | | * | | | | |
| | Synaptidae | <i>Opheodesoma sp. 1</i> | * | | | | | | | |
| | | <i>Opheodesoma sp. 2</i> | | | * | | | | | |
| | | <i>Synapta maculata</i> | * | | | | | | | |

In contrast, lower diversity was consistently recorded during the management surveys, with an average of 10 species observed per site out of 20 sites (ranging from 3 to 19

species per site, eventually including non-identified specimens) (Table 2).

Table 2. Occurrence of commercial holothurians across the Vanuatu archipelago. Reports of presence (+) or absence (-) of sea cucumber species recorded during the 2019–2020 management sea cucumber surveys.

| Species | Gaua | Northeast Santo | West Maevo | South Santo | North Malekula | West Malekula | Maskelynes | West Epi | Emao | West Efate | East Erromango | West Tanna | South Tanna |
|---------------------------------|------|-----------------|------------|-------------|----------------|---------------|------------|----------|------|------------|----------------|------------|-------------|
| <i>Actinopyga lecanora</i> | - | - | - | - | - | - | + | - | - | - | - | - | - |
| <i>Actinopyga miliaris</i> | - | - | - | - | - | - | + | - | + | + | - | + | - |
| <i>Actinopyga varians</i> | + | + | + | + | + | + | + | + | + | + | + | + | + |
| <i>Bohadschia argus</i> | + | + | + | + | + | + | + | + | + | + | + | + | - |
| <i>Bohadschia marmorata</i> | - | - | - | - | - | - | + | - | - | - | - | - | - |
| <i>Bohadschia vitiensis</i> | + | - | - | + | + | - | + | + | - | + | - | - | - |
| <i>Holothuria atra</i> | + | + | + | + | + | + | + | + | + | + | + | + | + |
| <i>Holothuria coluber</i> | - | - | - | - | - | - | + | - | - | - | - | - | - |
| <i>Holothuria edulis</i> | - | - | - | + | - | - | + | - | - | + | - | - | - |
| <i>Holothuria fuscopunctata</i> | + | - | - | + | + | - | + | + | - | + | - | + | - |
| <i>Holothuria scabra</i> | - | - | - | - | - | - | + | - | - | - | - | - | - |
| <i>Holothuria whitmaei</i> | + | - | + | + | + | + | + | + | + | + | + | + | + |
| <i>Holothuria fuscogilva</i> | - | + | - | + | + | + | + | - | - | - | - | + | - |
| <i>Holothuria lessoni</i> | - | - | - | - | - | - | + | - | - | - | - | - | - |
| <i>Pearsonothuria graeffei</i> | - | - | - | + | - | - | + | + | + | + | - | - | - |
| <i>Stichopus chloronotus</i> | + | + | + | + | + | + | + | + | + | + | + | - | - |
| <i>Stichopus herrmanni</i> | + | - | + | + | + | - | + | + | - | + | - | - | - |
| <i>Stichopus horrens</i> | - | - | - | - | - | - | + | - | - | - | - | - | - |
| <i>Thelenota ananas</i> | + | + | + | + | + | + | + | + | + | + | + | + | - |
| <i>Thelenota anax</i> | - | - | - | + | + | - | - | - | - | + | - | - | - |
| Non-identified species | + | + | + | + | + | + | + | + | + | + | + | - | - |
| Total nb. of species | 10 | 7 | 8 | 14 | 12 | 8 | 20 | 11 | 9 | 14 | 7 | 8 | 3 |

Species in bold are high-value commercial species, and most are on the IUCN Red List.

Holothurian abundance

Five species accounted for 90% of abundances: *Holothuria atra*, *Actinopyga varians*, *Stichopus chloronotus*, *Bohadschia argus* and *Thelenota ananas*. Relative abundances highlighted contrasted patterns of species assemblages among islands, with some similarities, particularly across central sites 7–10 (south Malekula, north Epi, north and west Efate) and southern sites 11, 12 and 13 (Erromango and Tanna). Monitoring surveys highlighted the presence of potentially dense but highly localised populations of both high- and medium-value commercial species, including *S. chloronotus* (19.8% of total abundance), *A. varians* (22.4%), *B. argus* (8.4%) and *T. ananas* (4.4%). Overall, high- and medium-value species, respectively, accounted for 28.6% and 31.5% of total abundance.

Discussion

A first inventory of sea cucumbers from Vanuatu

The results show a diverse and seemingly healthy population of sea cucumbers, including some rare or endangered species. The taxonomic composition is typical of western Pacific Island countries (Clark and Rowe 1971; Kinch et al. 2008), and most species are also encountered in New Caledonia (Améziane 2007), apart from *Actinopyga varians* (identified as *A. mauritiana* in the source), *Bohadschia koellikeri*, *Holothuria lineata*, *H. whitmaei* (still merged in *A. nobilis* in the source), *Labidodemas rugosum*, *Stichopus herrmanni* (identified as *S. variegatus* in the source), *S. cf. monotuberculatus*, and *S. vastus*. *Holothuria lessoni*, recorded only

outside of Efate, is also absent from Améziane's study (2007), but this species was described after this paper went out, and is often confused with *H. scabra*. This accounts for 38 shallow sea cucumber species recorded in Vanuatu, compared to 67 in New Caledonia (Conand 1989; Améziane 2007). Five species are reported on the International Union for Conservation of Nature "Red List" (Conand et al. 2014), including three species considered as endangered and two as vulnerable.

This result is consistent with other reports from neighbouring countries such as Fiji (with 27 known species according to Pakoa et al. 2013), even if most of the literature concentrates only on commercial species (such as Kinch et al. 2008).

Sea cucumber resources

Vanuatu has been a member of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) since 1989, applying international regulations on the trade of wild animals. The commercial fishery of sea cucumbers had been poorly regulated since independence (1980) and relied mostly on community-based fisheries management (Léopold et al. 2013b) until a global moratorium was put in place from 2008 to 2013. A major shift occurred in 2014, when scientific collaboration between Vanuatu and regional stakeholders led by IRD (French National Research Institute for Sustainable Development) led to a more comprehensive management framework (Léopold et al. 2013a and b). Based on an adaptive quota-based, co-management system, this approach was progressively updated and finally enforced under the 2019–2024 Vanuatu National Sea Cucumber Fishery Management Plan, with a first opening season starting in 2019 under strict control of the Vanuatu Fisheries Department (Kaku et al. 2020).

Among all the species recorded during this study, 7 are of high commercial value (Purcell et al. 2012; Di Simone et al. 2022), 7 are of medium value and 14 are of low value, although commercial values vary considerably with time

and location (Conand 2018). The 10 remaining species are not subject to trade (too small, too rare, too difficult to reach or part of non-edible groups such as Apodida). At the country scale, abundance surprisingly did not correlate with commercial value: 60% of individuals recorded during the national management surveys belonged to species with high or medium market value. While the most expensive species such as "teatfishes" (*Holothuria whitmaei* and *H. fuscogilva*) and "sandfish" *H. scabra* remain rare (< 1.5% of total abundances), these still exhibited some localised dense populations (perhaps thanks to closure policies), and populations of other valuable species (e.g. *Stichopus chloronotus*, *Thelenotia ananas*, *Bohadschia argus*, *Holothuria atra*, *Actinopyga varians*, 5–35% of total abundances) were eventually found with significant abundances in a number of sites across the archipelago.

These results are truly an encouraging sign in terms of biodiversity and harvest potential, especially in the current context of generalized overfishing of sea cucumbers. This suggests that the current commercial fishing pressure in Vanuatu may be (relatively) low compared to other countries such as the Maldives (Ducarme 2016) or, to a lesser extent, Fiji (Pakoa et al. 2013), and/or that the current updated management framework is working, despite sporadic reports of illegal poaching in Vanuatu (Fig. 3). This contrasts with reports from Kinch et al. (2008), who state that holothurian populations in Vanuatu back then as "depleted around the most populated areas" and then "barely recovered" five years later (Léopold et al. 2013a), suggesting positive effects from latter conservation policies. Whether or not this is sufficient to avoid the classical boom-and-bust cycle and ensure a sustainable exploitation of the resource on the longer term remains uncertain. This is particularly true given 1) the small-scale fragmentation of species distribution, which makes them particularly vulnerable to overharvest; and 2) the adverse effects of an ever-increasing demand for sea cucumber products from the Asian market, including rising fishing pressure and poaching in rural areas.



Figure 3. Seizure at the Port Vila airport of sea cucumbers illegally harvested during the fisheries moratorium, and bound for Asia. © IRD – P. Dumas

Sea cucumber aquaculture in Vanuatu

A small artisanal aquaculture of *Holothuria scabra* exists in Vanuatu (along with at least one hatchery), but little official information is available regarding it so far. Hatchlings are also imported from Australia by some Australian-based private companies (Kinch et al. 2008).

The government has made it a priority for the fisheries department to develop sea cucumber aquaculture in the future, in order to make it a valuable export product to Asia, which could provide to be an interesting economical sector for Vanuatu (Hamel et al. 2022).

Conclusion

Marine resources in Vanuatu appear to be in a reasonably good state at least with regards to sea cucumbers and despite growing demand and pressure. Although it is difficult to tell whether: 1) this is an effect good local enforcement and compliance of regulations; 2) to the still low and artisanal fishing pressure; or 3) other unsuspected drivers. The current state of this fishery seems currently sustainable under proper management rules, and compatible with the preservation of a healthy reef environment, which is paramount for such an isolated and vulnerable nation.

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References

- Améziane N. 2007. Echinodermata of New Caledonia. p. 337–347. In: Payri C., (ed), Richer De Forges B. (ed) and Colin F. (Préf.). Compendium of marine species from New Caledonia, second edition. Noumea, New Caledonia: IRD. Documents Scientifiques et Techniques: II ; 7. https://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers15-05/010059821.pdf
- Bouchet P., Le Guyader H. and Pascal O. 2008. Des voyages de Cook à l'expédition Santo 2006 : un renouveau des explorations naturalistes des îles du Pacifique. *Journal de la Société de Océanistes* 167–186. <https://doi.org/10.4000/jso.4622>
- Bouchet P., Le Guyader H. and Pascal O. 2011. The natural history of Santo. *Museum national d'Histoire naturelle, Paris; IRD, Marseille; Pro-Natura international, Paris.* 572 p. (Patrimoines naturels; 70). https://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers20-06/010051939.pdf
- Bourjon P., Ducarme F., Quod J. and Sweet M. 2018. Involving recreational snorkelers in inventory improvement or creation : A case study in the Indian Ocean. *Cahiers de Biologie Marine* 59:451–460. <https://doi.org/10.21411/CBM.A.B05FC714>
- Cherbonnier G. 1980. Holothuries de Nouvelle-Calédonie. *Bulletin du Muséum national d'histoire naturelle. Paris Quatrième Série* 2:659–700. <https://www.biodiversitylibrary.org/page/58313401>
- Clark A.M. and Rowe F.W.E. 1971. *Monograph of shallow-water Indo-West Pacific echinoderms.* British Museum (Natural History). London: Trustees of the British Museum.
- Conand C. 1989. Les holothuries aspidochirotes du lagon de Nouvelle-Calédonie : biologie, écologie et exploitation. *Etudes et Thèses, ORSTOM, Paris.* 393 p.
- Conand C. 2018. Tropical sea cucumber fisheries: Changes during the last decade. *Marine Pollution Bulletin* 133:590–594. <https://doi.org/10.1016/j.marpolbul.2018.05.014>
- Conand C., Polidoro B., Mercier A., Gamboa R., Hamel J.-F. and Purcell S.W. 2014. The IUCN Red List assessment of aspidochirotid sea cucumbers and its implications. *SPC Beche de mer Information Bulletin* 34:3–7. <https://purl.org/spc/digilib/doc/mhke9>
- Di Simone M., Horellou A., Ducarme F. and Conand C. 2022. Identification guide – Commercial sea cucumbers. CITES guide, Patrinat. <https://cites.org/sites/default/files/virtual-college/files/Guide-identification-concombres-de-mer-2022-EN.pdf>
- Ducarme F. 2016. Field observations of sea cucumbers in Ari Atoll, and comparison with two nearby atolls in Maldives. *SPC Beche de mer Information Bulletin* 36:9–14.
- Hamel J.-F., Eeckhaut I., Conand C., Sun J., Caulier G., Mercier A. 2022. Global knowledge on the commercial sea cucumber *Holothuria scabra*. p. 1–286. In: A. Mercier and J.-F. Hamel (eds). *Advances in Marine Biology* vol. 91, Academic Press. doi:10.1016/bs.amb.2022.04.001
- Kaku R., Arudere A. and Raubani J. 2020. Vanuatu sea cucumber fishery opens under a strengthened quota management system. *SPC Fisheries Newsletter* 161: 25–30. Noumea, New Caledonia: Pacific Community. <https://purl.org/spc/digilib/doc/qs28i>
- Kinch J., Purcell S., Uthicke S. and Friedman K. 2008. Population status, fisheries and trade of sea cucumbers in the western central Pacific. p. 7–55. In: Toral-Granda V., Lovatelli A. and Vasconcellos M. (eds). *Sea cucumbers. A global review of fisheries and trade.* FAO Fisheries and Aquaculture Technical Paper no. 516. Rome: FAO.

- Léopold M., Cornuet N., Andréfouët S., Moenteapo Z., Duvauchelle C., Raubani J., Ham J. and Dumas P. 2013a. Comanaging small-scale sea cucumber fisheries in New Caledonia and Vanuatu using stock biomass estimates to set spatial catch quotas. *Environmental Conservation* 40:367–379. <https://doi.org/10.1017/S037689291300009X>
- Léopold M., Beckensteiner J., Kaltavara J., Raubani J. and Caillon S. 2013b. Community-based management of near-shore fisheries in Vanuatu: What works? *Marine Policy* 42:167–176. doi: 10.1016/j.marpol.2013.02.013
- Pakoa K., Saladrau W., Watisoni L., Valotu D., Tuinasavusu I., Sharp M. and Bertram I. 2013. The status of sea cucumber resources and fisheries management in Fiji. Noumea, New Caledonia: Secretariat of the Pacific Community. <https://purl.org/spc/digilib/doc/gmdey>
- Pakoa K., Raubani J., Siaoisi F., Amos G. and Ham J. 2014. The status of sea cucumber fisheries and resources in Vanuatu. Noumea, New Caledonia: Secretariat of the Pacific Community. <https://purl.org/spc/digilib/doc/q4cs6>
- Purcell S.W., Samyn Y. and Conand C. 2012. Commercially important sea cucumbers of the world. *FAO Species Catalogue for Fishery Purposes*, no. 6. Rome: FAO.
- Raubani J. 2009. The Status of Coral Reefs in Vanuatu 2007. p. 167–208. In: Whippy-Morris C. (ed). *South-west Pacific status of coral reefs report – 2007*. Noumea, New Caledonia: CRISP, Secretariat of the Pacific Regional Environment Programme,
- Schmitt E.F. and Sullivan K.M. 1996. Analysis of a volunteer method for collecting fish presence and abundance data in the Florida Keys. *Bulletin of Marine Science* 59:404–416.
- Taylor F.W., Mann P., Bevis M.G., Edwards R.L., Cheng H., Cutler K.B., Gray S.C., Burr G.S., Beck J.W., Phillips D.A., Cabioch G. and Recy J. 2005. Rapid forearc uplift and subsidence caused by impinging bathymetric features: Examples from the New Hebrides and Solomon arcs. *Tectonics* 24(6). <https://doi.org/10.1029/2004TC001650>