The status of sea cucumber fisheries and resources in Vanuatu

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by

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Summary

Fishing for sea cucumber is an old fishery in Vanuatu but for many years the fishery and resources have not been monitored effectively. Continuous fishing and limited management controls have resulted in the over-exploitation. Assessments conducted by SPC in 2003 revealed that sea cucumber resources were depleted and it was recommended that the fishery be rested to allow recovery. In 2008, the fishery was closed for a five-year period, 2008–2013. In 2011, assessments were undertaken at Maskelyne Islands and Paunangisu as follow-up surveys to assess the state of the recovery since the closure. Sea cucumber export information and local buying prices were analysed to provide production trends. The results of these analyses are presented in this report.

The export of sea cucumbers from Vanuatu boomed in the early 1990s but then declined steadily. An increase in buying prices was experienced up to 2006, indicating the rising demand as the supply decreased. However, the variation in local buying prices in different localities and for different stages of production (live, gutted, first boil, second boil, dry, etc.) remains an issue. Setting minimum prices according to different product stages is a practical solution.

The densities of most species assessed in the Maskelyne Islands and Paunangisu are lower than healthy densities but better than they were in 2003, which indicates that stocks are recovering. Of importance is the re-appearance of a golden sandfish (*Holothuria lessoni*) in the Maskelyne Islands and a recovering sandfish stock at Paunangisu. Alarmingly, the sandfish stock of Uliveo Island has not recovered since the last fishing. The resource should be allowed to fully recover before fishing is recommended.

The mean recorded sizes of sea cucumbers species are lower than the sizes found elsewhere in the Pacific region. This indicates that many specimens are young and have yet to reach their full breeding capacity. Generally, these young stocks would lack the body mass and weight required to produce high-grade products if harvested. The seized consignment at Port Vila Airport in August 2013 is evidence of this; the consignment was comprised of sea cucumbers that were below the current minimum size limit.

The five-year moratorium on the fishery is insufficient to allow sea cucumber stocks to fully recover. The ban must be extended for another five or more years to enable further recovery. Monitoring assessments are needed after the ban to determine if the species has recovered well enough for fishing purposes.

While traditional *tabu* areas can be a useful management tool for protecting localised breeding stocks, it is not a long-term solution, as periodical fishing is allowed. The overharvesting of sandfish at *ringi-teh-suh* community-managed area is an example of the exposure of community-managed stocks to exploitation pressure in the absence of national management measures. The national sea cucumber management plan provides overall control of the fishery and in a way can protect community-managed stocks from pressure.

1. Introduction

1.1 Background

Sea cucumber resources are a source of income for coastal communities in Vanuatu. The Ni-Vanuatu people do not consume sea cucumbers, so the fishery is entirely a commercial activity. Since the beginning of the 20th century, the dried form of sea cucumbers was one of the principle exports for the former New Hebrides Condominium Government. A by-product of this early trading period is the Pidgin English language spoken today in Vanuatu – *Bislama* – which derives from the word *beche-de-mer*, or sea cucumber, and developed from early communication between fishers and traders. The trade was at low levels from the 1930s to the 1970s for various reasons: World War II affected most trading activities with the outside world; there was over-harvesting of the resource in some traditional production areas; and other commodities in the Pacific, such as copra, gained in importance (Ward 1972). The revival of the trade began in the 1980s, facilitated by the removal of trade barriers to China. Sea cucumber fisheries boomed in this period across the Asia-Pacific region (Kinch et al. 2008) but the peak export production of 66 tonnes in the early1990s was followed by a steady decline until, by mid-2000, the fishery was no longer profitable. A total ban on the fishery and export for five years was enforced in January 2008.

Three years into the closure period, resource assessments were conducted at the Maskelyne Islands in Malekula and at Paunangisu on Efate to monitor resources and effectiveness of the current ban. In a preliminary survey report delivered in March 2012, the Vanuatu Fisheries Department was advised to extend the ban for another five years to allow full recovery of stocks, which were only beginning to recover. The finalisation of this report was delayed to await results from other areas but for various reasons no further assessments were conducted with the same assessment methods used in the two sites.

This report presents an analysis of the current state of the sea cucumber fishery and resources in Vanuatu based on the results of resources surveys and export information provided by the Vanuatu Fisheries Department. The report also presents several recommendations on measures needed in the Vanuatu national sea cucumber fishery management plan to ensure sustainability of sea cucumber fisheries.

1.2 Sea cucumber resources

Of the 1,200 species of Holothuroidea that have been described, 23 commercially important species are present in Vanuatu (Table 1) and nineteen of these are commonly exploited in the sea cucumber fishery. Sea cucumbers feed by ingesting sand and detritus matter and digesting the bacteria and fungi attached to the sediment. By doing so they help turn over bottom sediment and recycle nutrients locked in organic matter on the reef floor, making it available to other organisms, thus contributing to ensuring a healthy ecosystem.

Some sea cucumbers breed by both vegetative regeneration by splitting (Conand 2004) and sexual reproduction by spawning and egg fertilisation. Most sea cucumbers have separate sexes and reach sexual maturity at around three to four years of age. Some species like the sandfish (*Holothuria scabra*), are relatively fast-growing and reach reproductive size within around two years at 160 mm (Conand and Sloan 1989) but take another two years to reach an acceptable market size. Other species, such as black teatfish (*Holothuria whitmaei*) and white teatfish (*Holothuria fuscogilva*) grow more slowly, with a lifespan of up to 12 years (Conand 2004). Breeding for most species usually occurs in the summer months. Successful reproduction involves fertilisation of millions of eggs, and this requires a good aggregation of adult sea cucumbers in close proximity to each other. Fertilised eggs hatch (planktonic larval stages) and drift with ocean currents from two to several weeks before settling on the sea floor as juvenile sea cucumbers. Adults appear not to move very far from the areas in which they settled as juveniles.

The presence, diversity and abundance of species vary geographically across the Pacific (Wright and Hill 1993) with diversity decreasing towards the eastern Pacific (Pinca et al. 2010). Species distribution and

abundance vary by habitat types across the reef: seagrass beds, reef flats, back reefs, lagoons, reef crests, exposed reef fronts, reef slopes and deep channels.

Past resource assessment surveys at Uri-Uripiv, Maskelyne, Moso and Paunangisu in 2003 (Friedman et al. 2008a) and at Epi (Pakoa et al. 2008) provide information on diversity and abundance. This, in addition to results from the current surveys, was used to update Vanuatu's sea cucumber species diversity to 24 species, including tiger tail (*Holothuria hilla*), which is used in the live aquarium trade (Table 1). The results of the 2003 surveys indicate that resources have been overfished and a recommendation was made to the Vanuatu Fisheries Department to close the fishery (Friedman et al. 2006), which led to a five-year ban on harvesting, processing and exports, beginning in 2008.

Table 1. Commercial sea cucumber species at sites assessed in Vanuatu.

Abbreviation	Common name	*Bislama* name	Scientific name
AF	Amberfish	Ambafis	*Thelenota anax*
BCF	Brown curryfish	Braon karifis	*Stichopus vastus*
BSF	Brown sandfish	Braon sanfis	*Bohadschia vitiensis*
BTF	Black teatfish	Blak titfis	*Holothuria whitmaei*
CF	Curryfish	Karifis	*Stichopus herrmanni*
CHF	Chalkfish	Jokfis	*Bohadschia marmorata*
DF	Dragonfish	Dragonfis	*Stichopus horrens*
DWBF	Deepwater blackfish	Dipwota blakfis	*Actinopyga palauensis*
ETF	Elephant trunkfish	Elefenfis	*Holothuria fuscopunctata*
FF	Flowerfish	Flaoafis	*Pearsonothuria graeffei*
GF	Greenfish	Krinfis	*Stichopus chloronotus*
GSF	Golden sandfish	Kolten sanfis	*Holothuria lessoni*
HBF	Hairy blackfish	Blakfis	*Actinopyga miliaris*
LF	Lollyfish	Lolifis	*Holothuria atra*
PF	Pinkfish	Pinkfis	*Holothuria edulis*
PRF	Prickly redfish	Paenapolfis	*Thelenota ananas*
RSF	Red snakefish	Red snekfis	*Holothuria flavomaculata*
SF	Sandfish	Sanfis	*Holothuria scabra*
SNF	Snakefish	Snekfis	*Holothuria coluber*
SRF	Surf redfish	Sefredfis	*Actinopyga mauritiana*
STF	Stonefish	Stonfis	*Actinopyga lecanora*
TF	Tigerfish	Taikafis	*Bohadschia argus*
TTF	Tiger tail	Taikatelfis	*Holothuria hilla*
WTF	White teatfish	Waet titfis	*Holothuria fuscogilva*

Past assessment surveys in Vanuatu adopted a variety of sampling strategies. Surveys in 1990 used 40 m x 5 m transects at 35 sites from Banks in the north to Aneityum in the south (Chambers 1990). Chambers (1990) recorded 18 commercial species of sea cucumbers, with Uliveo Island and Cooks Reef having more diverse species. These surveys recorded high densities of greenfish and lollyfish at Gaua lagoon and estimated densities of 5 per 100 square metres for both species together, or around 500 individuals per hectare.

At Efate, Chambers (1990) noted high densities of sandfish (43 ind. 100 m^{-2} or 4,300 ind. ha^{-1}), hairy blackfish (785 ind. 100 m^{-2} or 78,500 ind. ha^{-1}), lollyfish (214 ind. 100 m^{-2} or 21,400 ind. ha^{-1}) and pinkfish (21 ind. 100 m^{-2} or 2,100 ind. ha^{-1}) in the lagoons of Port Vila and Ekasuvat on Efate (Bell and Amos 1994). These stocks on Efate were concentrated in small areas and would not support continuous fishing (Chambers 1990).

Other assessments by the Vanuatu Fisheries Department used 60 m x 5 m wide transects to assess resources at Emae (Marae, Sulua, Vaitini, Siwo, Worarana, Tongamea and Makatea) (Gibbs et al. 1998). Another assessment (Lamont et al. 1999) used 50–60 m by 5 m transects to assess resources in the Banks and Torres Islands. In another (Saunders et al. 2000) used 15 minutes timed searches by snorkelling or wading to record sea cucumbers at Avokh, Sakao, Peskarus, Lamap, Litzlitz, Crab Bay, Uri, Vao, Labubu, Pinalum and Tedka Island. Sea cucumber density analysis from these assessments is presented in Appendix 1. A summary of these different assessment protocols is shown in Table 2.

Table 2. Summary of survey methodologies used in Vanuatu to assess sea cucumbers.

Year	Method	Transect size (m)	Coverage (m^2)[#]	Sites	References
1990	Transect	40 x 5	200	23 sites from Banks to Aneityum	Chambers 1990 (AIMS)
1998	Transect & timed snorkel	60 x 5	300	Emae, Mataso, Makira	Gibbs et al. 1998
1999	Transect & timed snorkel	50–60 x 5	250–300	Banks and Torres Islands	Lamont et al. 1999
2000	45 minutes timed snorkel/ walk at 15 m/5 min x 3	45 x number of surveyors	Vary by sites	13 sites at Malekula	Saunders et al. 1999
2003	Transect & manta tow	40 x 1 x 6 300 x 2 x 6	240 3,600	Paunangisu, Moso, Uri-Uripiv, Maskelyne	Friedman et al. 2008a (SPC)
2008	Transect	40 x 1 x 6	240	Epi-Lamen Bay to Valestia	Pakoa et al. 2008 (SPC)
2011	Transect & manta tow	40 x 1 x 6 300 x 2 x 6	240 3,600	Maskelyne, Paunangisu	This report (SPC)
2011	Transect	50 x 4	200	Maskelyne, Lamap, Farun	Ham et al. 2012 (IRD)

[#] transect size or estimated area for timed swims.

1.3 Sea cucumber fisheries

Sea cucumber is a food delicacy in Asian markets and is used in Chinese medicines. The increasing demand is attributed to the increasing demand in China and growing new markets in the Middle East, Europe and the United States of America. This, coupled with the reduction in supplies from traditional sources due to overharvesting, has resulted in substantial increases in market prices. Prices for low-value species have increased two- or three-fold and prices for high-value species have increased four- or five-fold over the last seven years (Carleton et al. 2013). In addition, species that were not traded during the 1980s are now being collected, processed and traded. High prices have provided a lucrative sea cucumber trade in the Pacific. And with declining supplies, traders are moving throughout the Pacific Islands to secure supplies in remote islands that were not of interest in the past due to the high cost of transporting the product to Asia. Fishing for sea cucumber is conducted by local fishers using various methods: reef gleaning, shallow dives, spears and sea cucumber bombs (Fig. 1). The use of scuba for harvesting sea cucumbers is banned in the Vanuatu sea cucumber fishery but there have been reports of aquarium fish divers collecting sea cucumbers during fish collection dives.

The catch is sold as a finished, dried product to exporters' agents in rural areas. Some traders in Port Vila and Santo would prefer to purchase the raw or partly processed product and reprocess it into a final dried product. Sea cucumber export companies are normally owned mainly by Asian nationals who are in joint venture arrangements with local interests. These exporters have an influence on fishing activities and

processing of sea cucumbers by supplying fishing gear, fuel, boats, salt and processing equipment and by buying the end product in return.

There are different prices for different species, according to the size (large, medium and small) and what production stage the sea cucumbers are at (alive, gutted, first boil, second boil, dry, etc.). They are classified in four grades: A, B, C and D, with A grade being the highest quality and D grade discarded as waste. Buying prices are agreed on by fishers and buyers.

Figure 1. Common sea cucumber fishing methods: gleaning in the shallow areas; snorkelling with the aid of canoes or boats; and using fishing equipment such as torches, long spears and scuba. (Illustration by Youngmi Choi, SPC)

Sea cucumber fishing was suspended briefly in 1988 due to product quality issues (Dalzell 1990). After training conducted by SPC on processing methods, the fishery resumed in 1990. Exports picked up again and in 1992 and 1994 annual production was 66 tonnes (Fig. 2). Exports fell to an average of 20 tonnes over the period 2002–2007, although increased production was noted in 2006 and 2007. Falling production prompted the government to close the fishery in January 2008. It should be noted here the discrepancies in the export data held by the Customs and Inland Revenue Department and the Fisheries Department. The Customs data set captures actual exports, while Fisheries export data are often less accurate as they are based on export permit applications from exporters a week prior to actual exporting. The export figures presented (Fig. 2) are the highest reported figure from the two data sets.

Sea cucumber catch composition information is not available for most years, only for 1990 and 1993 in the Vanuatu fisheries profiles (Bell and Amos 1994) and for 2004–2005, provided by the Vanuatu Fisheries Department. In 1990 and 1993, five species — black teatfish, hairy blackfish, sandfish, tigerfish and surf redfish — were important in the catch, comprising 64% of production (Fig. 3). Twenty per cent of production was reported only as "beche-de-mer"; these could have been a number of species, aggregated. High-value species were more important in the fishery in the 1990s.

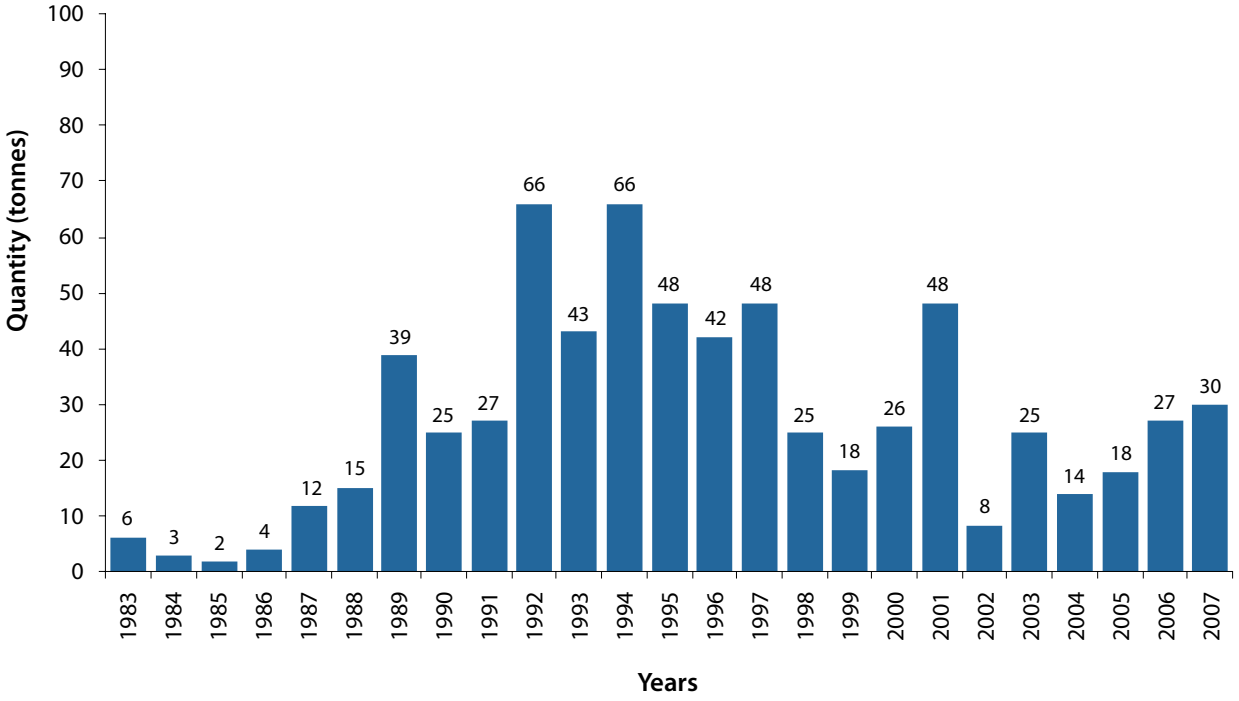

Figure 2. Historical sea cucumber exports from Vanuatu (based on the highest figure from Customs Department and Fisheries Department data sets).

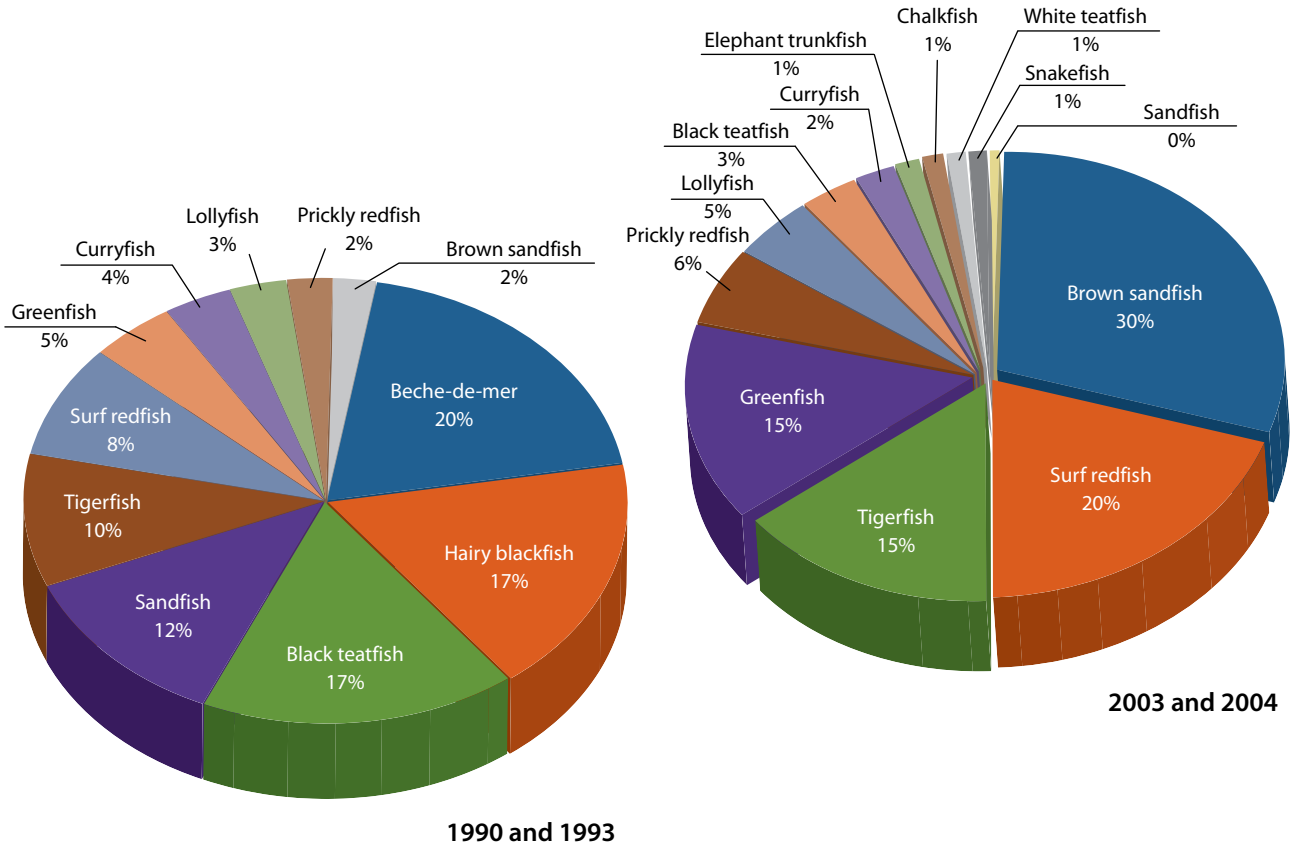

Figure 3. Catch composition for 1990 and 1993 exports (Bell and Amos 1994) (left) and 2003–2004 (Vanuatu Fisheries Department) (right).

1.4 Management measures

The primary management control was the licensing of export operators under the Fisheries Regulations of 1988, prohibiting exports without a valid license. Three years later, the Ministerial Order of 1991 imposed an annual sea cucumber export of 35 tonnes, although the quota was not effectively enforced for various reasons. As a condition of the licensing, export permits are used to authorise export consignments.

Several management measures were recommended by Chambers (1990), such as developing a harvest strategy by site, based on resource assessments, and the production of harvest quota, minimum size regulations, and enforcement of closed seasons, but most of these measures were not implemented. The minimum sea cucumber size limit was only regulated in 2009 under the Fisheries Regulations Order No. 28 of 2009. Monitoring and compliance has been minimal as there were limited regulatory measures to enforce. Vanuatu's case is the same as other sea cucumber fisheries in the Pacific region that are currently faced with the challenge of managing their sea cucumber fisheries as a result of past ineffective management (FAO 2012).

Community-based management through customary marine tenure systems is still practised in Vanuatu. Co-management of coastal fisheries has been encouraged by the Vanuatu Fisheries Department since the 1990s to empower communities to manage their resources and preserve this traditional practice. It appears, however, that while the local systems can offer protection of localised stocks, commercial pressure to harvest resources is beyond the control of resource owners, which is a challenge for community management efforts. Many communities were not able to control their fishers from harvesting and selling sea cucumbers.

Sea cucumber mariculture and ranching has been tried at Uliveo Island, Maskelyne, but failed to deliver positive results. The deal by the company responsible for the trial to harvest wild sea cucumber stocks in the area left negative impressions with the concerned community. The effectiveness of aquaculture and ranching needs to be properly demonstrated before they are introduced to communities.

A draft Vanuatu national sea cucumber fishery management plan provides a governance structure and measures for a sustainable sea cucumber fishery. These measures include the roles of national and provincial councils and communities, the types of licenses, quotas, monitoring measures, and opportunities to raise the economic value of the fishery. The plan is, however, yet to be finalised and implemented.

1.5 Objectives of this report

This report presents information about the state of the sea cucumber fishery in Vanuatu, focusing on the resources, fishing activities, production, management measures and ways forward. Information on the current state of the resources will be used with other resources assessments undertaken by the Vanuatu Fisheries Department to decide on the current moratoria. A preliminary report has been delivered to the Vanuatu Fisheries Department so that they can make a decision about the current ban. Many of the measures proposed in this report have been incorporated in the draft sea cucumber management plan. This report is therefore a reference document, collating currently available information about sea cucumber resources and the fishery in Vanuatu as the basis for future reporting of this fishery.

The information presented here and the results of the monitoring assessment can be used for management needs. Importantly, the recommendations can be considered by responsible authorities for improved management of sea cucumber fisheries.

2. Monitoring sites and methodology

2.1 Sea cucumber monitoring sites

Initially, the strategy was to set up permanent sea cucumber monitoring sites in selected locations distributed across Vanuatu (Fig. 4) based on Chambers (1990). Locations of particular interest for sea cucumbers are Vanua Lava (Pakea and Ravenga), Santo (East Santo and Malokilikili), Malekula (Litz-litz and Maskelyne Islands), Emae, Efate (Paunangisu and Moso) and Aneityum (Port Patrick and Anelgouhat) (Fig. 4). At the very least, two sites per area would provide sufficient information on the resource condition. Using the regional standardised invertebrate assessment protocols in all these sites would allow for comparability of resource statuses with available information. However, this plan was derailed for another assessment protocol introduced by *L'Institut de recherche pour le développement* (Institute of Research for Development) Bishlamar Project. The assessment results presented here are for the two sites assessed using the regionally standardised invertebrate resources assessment methodologies promoted by SPC (SPC in press).

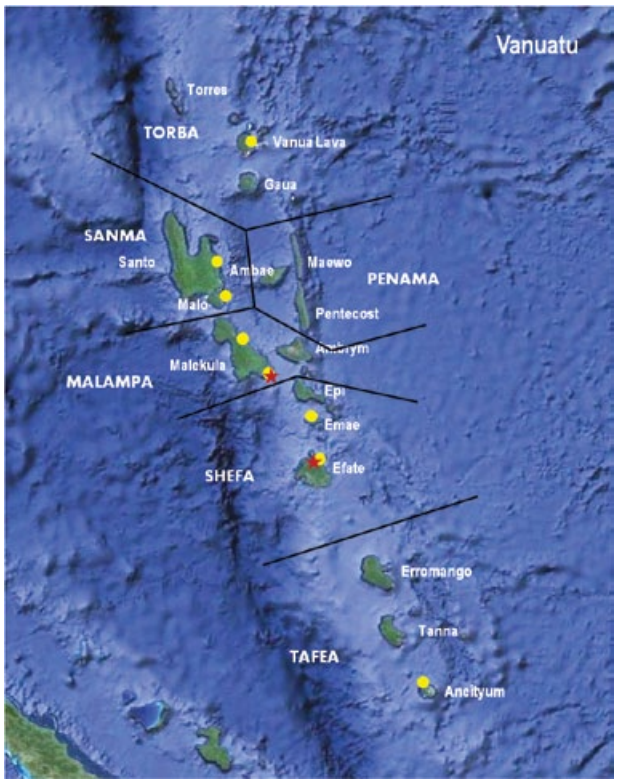

Figure 4. Selected locations for sea cucumber monitoring (yellow circles) and sites surveyed during this assessment (red stars) (other sites assessed by VFD are not included).

Maskelyne Islands: Maskelyne comprises seven islands located at the south-eastern end of Malekula Island (Red star on Malekula, Fig. 4). Olive is the largest and most populated island with a population of around 217 people, and 51 people live on Avokh and Awei Islands (Vanuatu National Statistics Office 2009). The marine ecosystem of Maskelyne is complex; mangroves, lagoons and deep channel systems separate the islands — rich ecosystems supporting marine life. A more detailed description of the reef habitat of the Maskelyne Islands is found in Friedman et al. (2008a). Maskelyne communities have been managing their marine resources through the customary practice of *tabu*. Several areas are set aside as periodical closures (*tabu*); they are open only occasionally for fishing. A permanent marine protected area (MPA) — *ringi te suh* — was established in 1992 at Pellonk to conserve giant clams and sandfish. Avokh's restricted area on the other hand is a disputed area which has been placed under a "restricted access" court order issued by

the Malekula Island Court in 1988 and has been under this restricted access since then. Maskelyne is one of the main suppliers of reef fish to Port Vila markets and was a major supplier of beche-de-mer. Aside from fisheries; agriculture is the primary source of income for the people of Maskelyne through the sale of crops (e.g. copra, kava and root crops) and livestock, which are exported to Port Vila markets.

Paunangisu and Emua: Paunangisu and Emua villages are located on the northern coast of Efate (red star on Efate, Fig. 4). The reef system at Paunangisu is relatively large and complex, containing mangrove, seagrass beds, lagoons and shallow reefs that support sea cucumber diversity. A more detailed description of reef habitat of Paunangisu is found in Friedman et al. (2008a). Emua and Paunangisu are close to Port Vila markets, and buyers of sea cucumbers readily go to the villages to buy them. Fishers can also take their raw sea cucumber catch to be sold to processors in Port Vila. Traditional management at Paunangisu is not as active as in the Maskelyne Islands; the village is split into two major groups that are in conflict over the community leadership role. Such a situation is not conducive to effective community management of reef resources. Collection and sale of sea cucumbers around Efate were common activities prior to the ban in 2008.

2.2 Survey methodology

2.2.1 Fishery data collection

Historical sea cucumber export information was gathered from literature: Chambers (1990); Bell and Amos (1994); Fisheries annual reports Pakoa et al. (2008); and Kinch et al. (2008). Information on local purchase prices came from agent price lists provided to rural fisheries officers and from surveys undertaken by the Vanuatu Fisheries Department in 2004–2005 (Tony Taleo, Fisheries Officer). Recent export data were provided by the Vanuatu Fisheries Department. Information on catch composition was collected in September 2013 from the seized beche-de-mer consignment held at Vanuatu Fisheries Department. Analysis of fishery status are based on the procedure for assessing sea cucumber fishery indicators provided in the Sea cucumber Fisheries Managers Tool Box (Friedman et al. 2008b).

2.2.2 Underwater resource surveys

The survey was based on maximum coverage of shallow reef habitat (0–10 metres) within the time allocated and resources available for the assessment at Maskelyne. The survey was a follow-up of the 2003 assessment report (Friedman et al. 2008a). The broad scale surveys used manta tow and the fine scale surveys used shallow water reef transects on the range of habitats in a site.

Manta tow: Manta tow surveys were conducted over the back reef, shallow lagoon and lagoon slopes where coral and hard bottom substrates predominate (Fig. 5). These areas are representative of habitats suitable for tigerfish, black teatfish, prickly redfish and brown sandfish. Manta surveys are conducted at depths of 1 m to 10 m, depending on visibility, but mostly around 1.5–4 m over coral and sand substrates. Manta tow surveys could not be conducted in areas that were too shallow for an outboard powered boat (< 1 m), in murky waters where visibility was poor, adjacent to wave-impacted reefs (reef top), or over dangerous swells. A manta tow transect covers a swath 300 m long and 2 m wide, an area of 600 m^2 per transect. Six transects constitute a station (3,600 m^2). The detail of the method is provided in Friedman et al. (2008a), Pinca et al. (2010), English et al. (1997), and in the invertebrate resources survey manual (SPC in press).

Reef benthos and soft benthos transects: Reef benthos and soft benthos transects follow the same methodology but are differentiated by their respective habitat types (Fig. 5). Both methods are conducted in shallow waters (0–3 m) by snorkelling or wading at low tide over reef crest, back reef, reef flat and seagrass beds. Six 40 m by 1 m transects are examined per station by two observers snorkelling on either side of the transect line and recording benthic invertebrates within each transect. Reef benthos transects were conducted over hard bottom habitat where lollyfish, greenfish and surf redfish aggregate. Soft benthos transects were conducted over soft bottom seagrass and seaweed beds for hairy blackfish, chalkfish, dragonfish, golden sandfish, brown sandfish, red snakefish and sandfish.

Figure 5. Illustrations of the two assessment methods used for sea cucumber surveys during this assessment in Vanuatu: A) reef benthos transects and B) manta tow surveys.

The underwater resource assessment data gathered were entered into the Reef Fisheries Integrated Database (RFID) in Noumea as part of the attachment training attended by two officers from Vanuatu. The database allows extraction of summaries on species presence, densities, size frequency, mean sizes, etc. for reporting purposes.

2.2.3 Community views

Community views and inputs were gathered by talking to fishers during the fieldwork in June 2011 but many of the comments were expressed during a consultation held after the field assessment work at Peskarus village. Community leaders and fisheries officers shared their views and ideas on how to improve management at the community level. Views and experiences were provided also by the rural fisheries officer for Malampa (Kevin Morris). Fisheries officers in Port Vila shared their opinions and experiences of the increasing number of requests for sea cucumber export licenses. Sea cucumber was a popular topic of discussion in the local media in the lead up to the national general election in November 2012. There was increasing pressure to open the fishery and public opinion was expressed in the local media (The Vanuatu Independent 2012; Vanuatu Daily Post 2012). These are useful public perceptions of the sea cucumber fishery.

3. Results

3.1 Fishery and trade trends

Annual sea cucumber exports have declined since the peak exports in 1992 and 1994 (Fig. 2). In the years 2002 to 2007, annual exports averaged 20 tonnes. Investments in fisheries activities within the archipelagic waters and the six miles of territorial seas are protected for the nationals of Vanuatu under the Maritime Zones Act No. 23 of 1981 (CAP 138).

In the case of a joint venture arrangement between a Vanuatu citizen and a foreign partner, the foreign partner has the advantage in the management of company finances. The local partner is paid a share without knowing the correct value of an export. Exporting of sea cucumber out of Vanuatu is known to be an activity influenced largely by people of Asian ethnicity, either local or foreign. As is the case in many Pacific Island sea cucumber fisheries, sea cucumber products have been underestimated and true export market prices have been a closely guarded secret of the export and import companies. Sea cucumber prices have increased between two and five fold for species of low, medium and high value in the last seven years (Carleton et al. 2013).

Sea cucumber purchase prices were available for some exporters for 1990 (Bell and Amos 1994), and from Fisheries Department records for 2003 and 2006 prices. These prices were compared to assess price changes over time. Where several prices are provided for a species, the highest price is used in this comparison. As shown in Figure 6, sea cucumber prices rose for most products between 1990 and 2006. Four species; black teatfish, greenfish, sandfish, and white teatfish were highly priced products, with sandfish being the highest priced product.

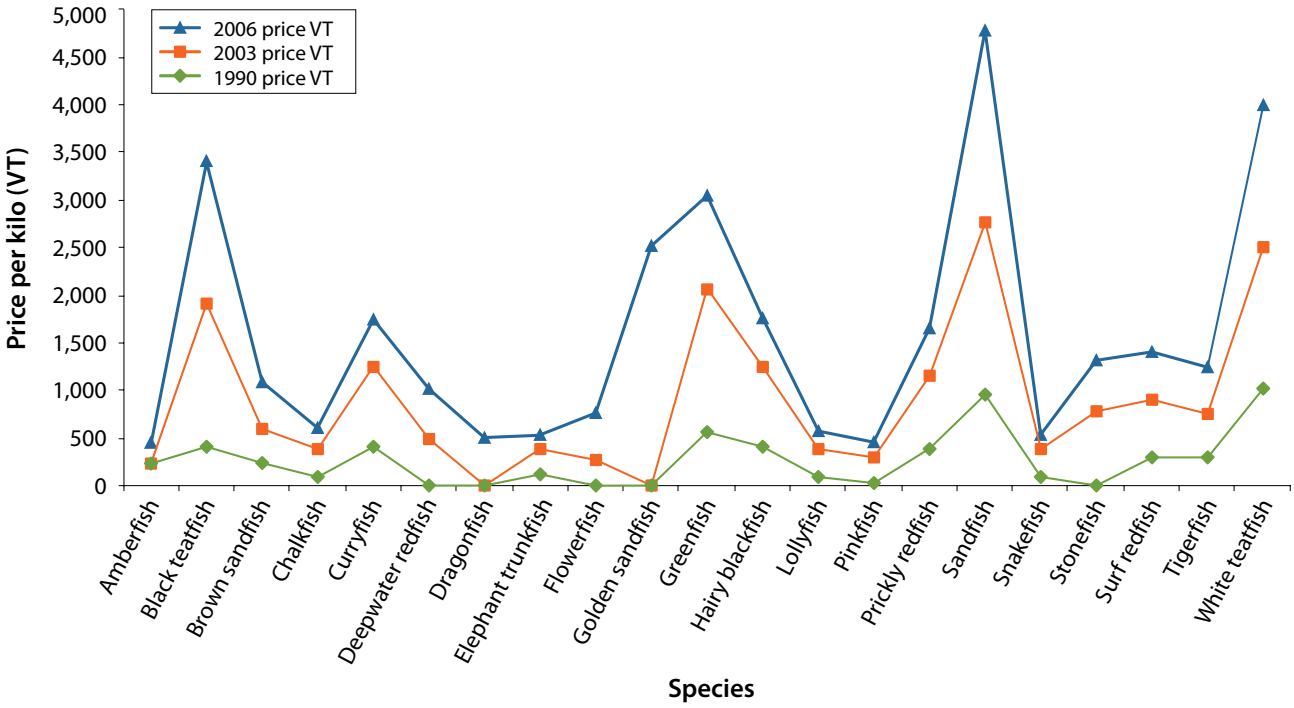

Figure 6. Changes in local sea cucumber buying prices in Vanuatu between 1990 and 2006.

Further comparison is made with purchase price estimates for the Melanesian region in 2012 (Carleton et al. 2013), the wholesale prices in Guangzhou, China (Purcell et al. 2012) and the 2006 prices offered in Vanuatu (Malekula) (Fig. 7). Although prices may have changed in 2007 prior to the ban, 2006 prices were lower than the recent 2012 estimates. Local purchase prices for sea cucumber products offered in Malekula in 2006 are lower than the estimated realistic purchase prices for the Melanesian countries in 2012 (Fig. 7 and Appendix 2).

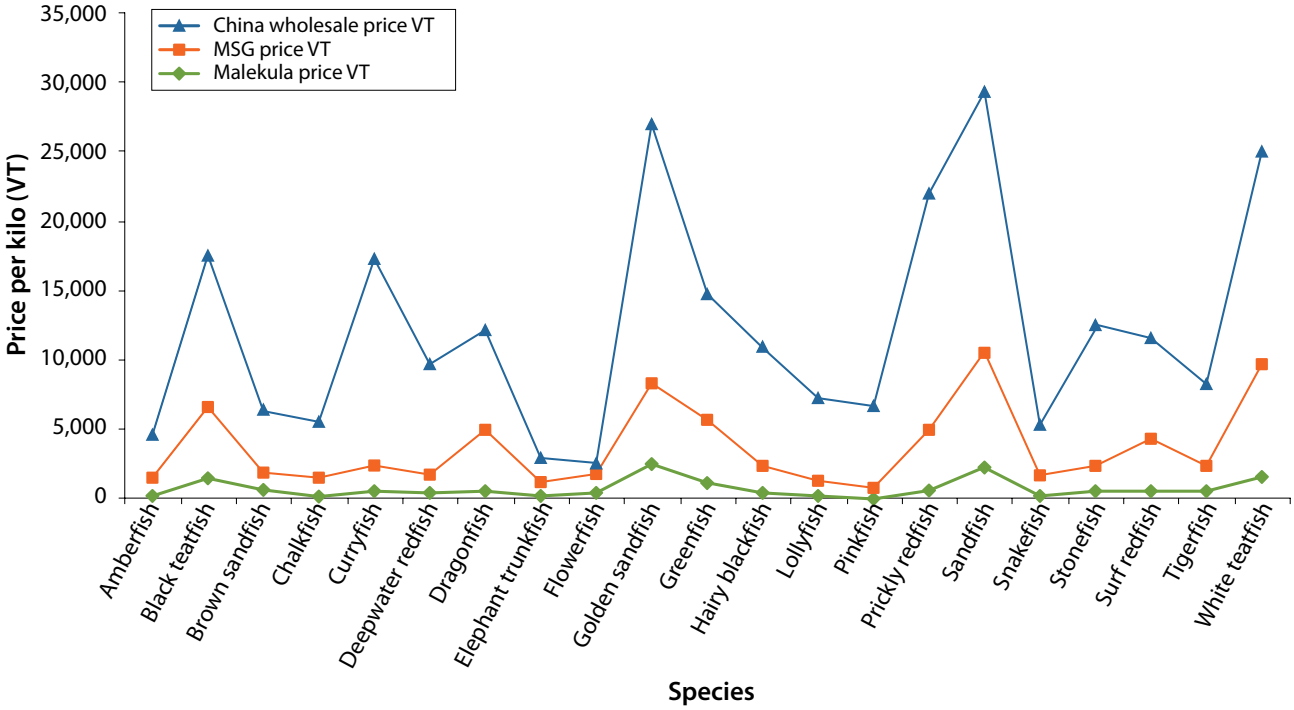

Figure 7. Beche-de-mer price comparison for Malekula in 2006, purchase price estimates for Melanesian countries[1], and wholesale prices at Guangzhou, China[2].

Monitoring of the fishery has been a challenge in the past. Illegal harvest and product smuggling is known to be occurring in the Pacific region but is not being adequately reported. In 2008, a consignment of partly processed sea cucumber was confiscated from a processor (Fig. 8). In September 2013 a consignment of sea cucumber was seized at the international aiport in Port Vila. The dried sea cucumbers were neatly packed in sealed plastic bags (Fig. 8) and were about to be transported out of the country in suitcases belonging to an Asian national.

Figure 8. Illegally harvested sea cucumbers confiscated at the Port Vila airport in September 2013 (left) and partly processed sea cucumbers confiscated in March 2008 (right).

[1] The average prices estimated by Carleton et al. (2013) are the purchase prices for high grade, good quality sea cucumber in Melanesia and Tonga.

[2] The upper price paid for sea cucumber products at Guangzhou wholesale market, China, as reported by Purcell et al. 2012.

There was a total of 900 pieces, comprising chalkfish, tigerfish, curryfish, prickly redfish and sandfish, weighing 23 kilograms altogether. Chalkfish was the main product (89%) (Fig. 9). It was packed in 1 kg and half a kg packs, comprising on average 22 pieces per 1 kg pack and 29 pieces per half kg packs, indicating that the product was packed separately by grade. All the illegally harvested products were below the minimum sea cucumber size (Fig. 9). This indicates that sea cucumber is valuable and some people are willing to take the risk of smuggling the product out of the country. The lifting of the ban could lead to more smuggling activities if monitoring, control, surveillance and prosecution are are not effective.

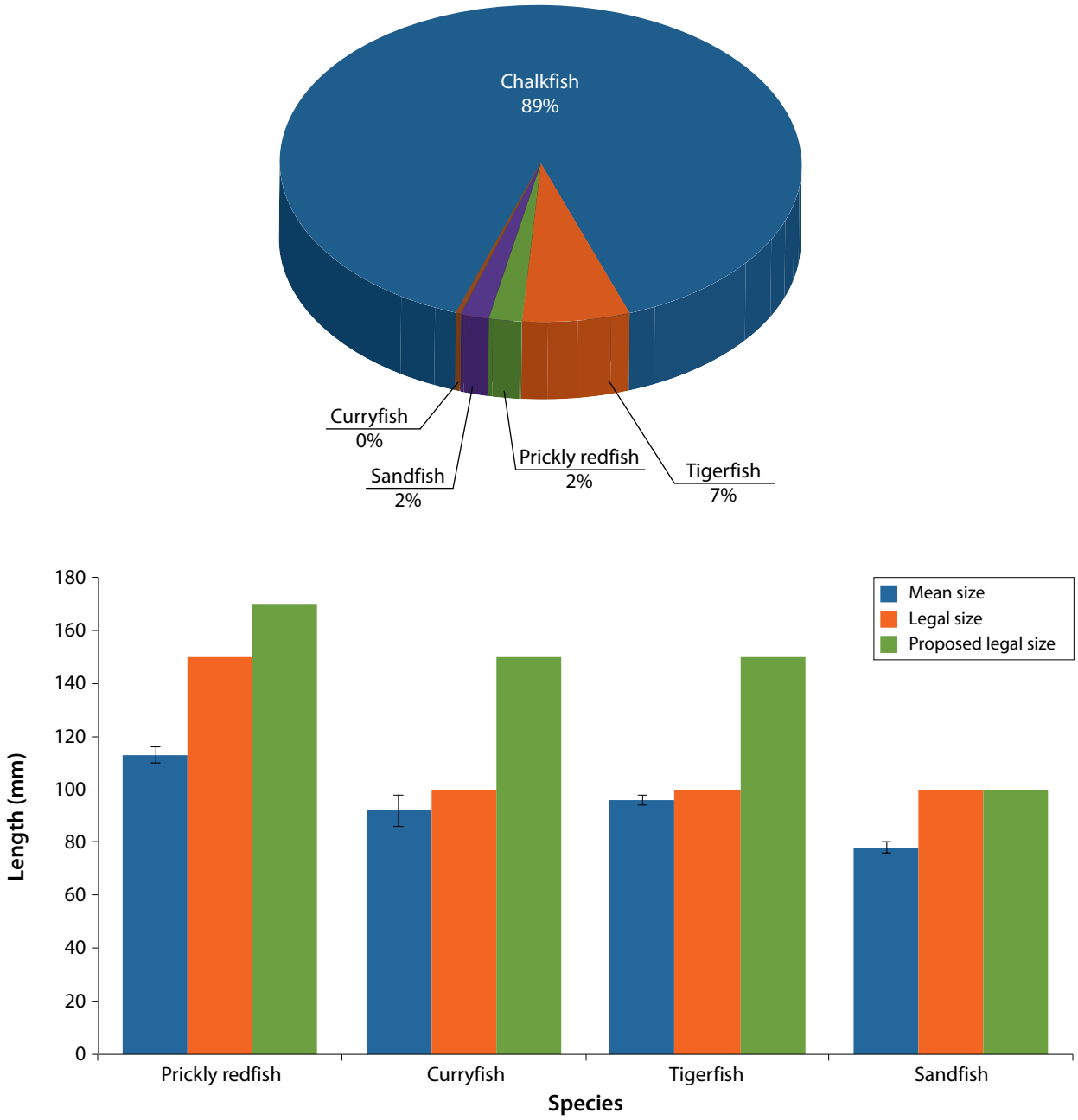

Figure 9. Catch composition (top) and mean sizes (bottom) of the sea cucumber seized in August 2013.

3.2 Underwater resource surveys

3.2.1 Survey coverage

In total, 89 stations (534 transects) were completed in Maskelyne in June 2011, covering 73,572 m² (7.4 ha), and 29 stations (2.2 ha) of reef and lagoon areas were covered at Paunangisu (Table 3). The distribution of stations at the two sites is shown in Figures 10 and 11.

Table 3. Survey coverage by this assessment at Maskelyne and Paunangisu (2011).

Site	Survey type	No. of stations	Area per station (m²)	Total area (m²)	Total area (ha)
Maskelyne	Manta	14	3,600	50,400	5.0
	Soft benthos transect	49	240	11,760	1.2
	Reef benthos transect	13	240	3,120	0.3
	Reef front search	8	822	6,576	0.7
	Deepwater scuba search	1	756	756	0.1
	Shallow water scuba transect	4	240	960	0.1
Paunangisu	Manta	4	3,600	14,400	1.4
	Soft benthos transect	18	240	4,320	0.4
	Reef benthos transect	1	240	240	0.0
	Reef front search	2	822	1,644	0.2
	Reef front search walk	1	846	846	0.1
	Shallow water scuba transect	3	240	720	0.1

Figure 10. Sampling stations at Maskelyne Islands, Malekula.
Yellow dots are station positions for reef transects and manta tow positions for each replicate tow; the dashed red area as a restricted area (Source: GoogleEarth.com).

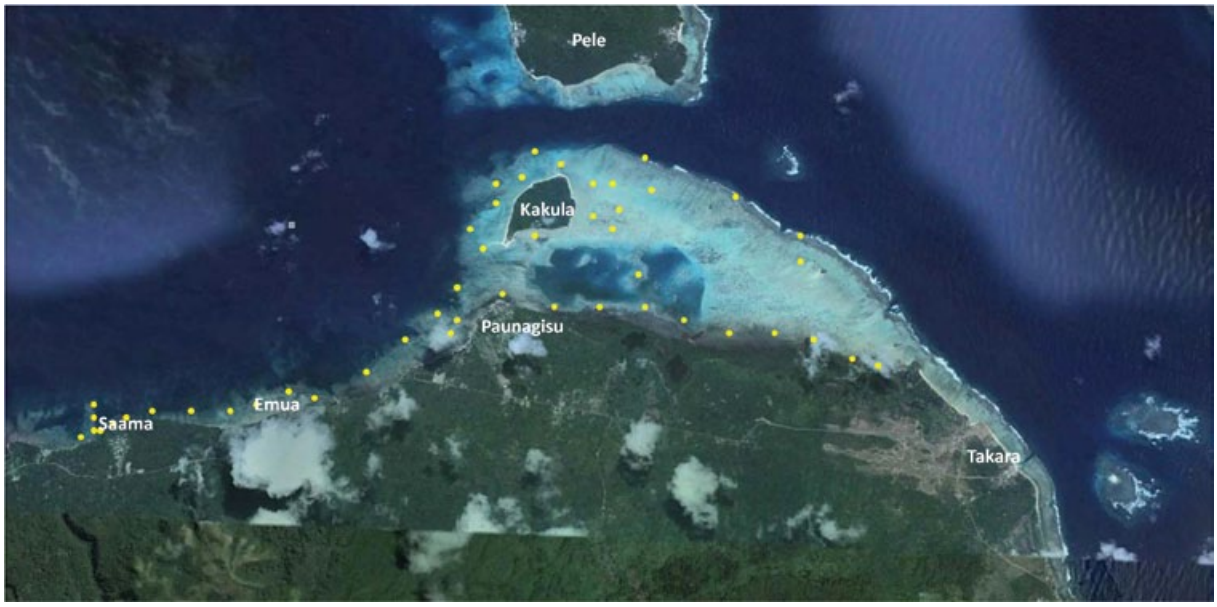

Figure 11. Sampling stations at Paunangisu, North Efate. Yellow dots are station positions for reef transects and manta tow positions for each replicate tow (Source: GoogleEarth.com).

3.2.2 Species presence

Resources assessments undertaken at Maskelyne, Uripiv, Moso and Paunangisu in 2003 (Friedman et al 2008a) and at Epi (Pakoa et al. 2008), as well as this survey, have improved our knowledge about the number of species present at these sites (Fig. 12). The number of species varies with the habitat; Maskelyne holds the full range of sea cucumber species diversity in Vanuatu — 24 species. Another assessment by Vanuatu Fisheries Department and the L'Institut de reserche pour la développement (IRD) in 2011 recorded 14 species at Uri-Uripiv, which corresponds to the same number of species recorded previously (Friedman et al. 2008a). A smaller number of species was recorded at Maskelyne (14 species) and ten species at Paunangisu (Fig. 12), despite the high sampling coverage in the two areas (Ham et al. 2012). Accurate monitoring of species present is important in determining prescribed species lists for a fishing season and species that are in need of special attention.

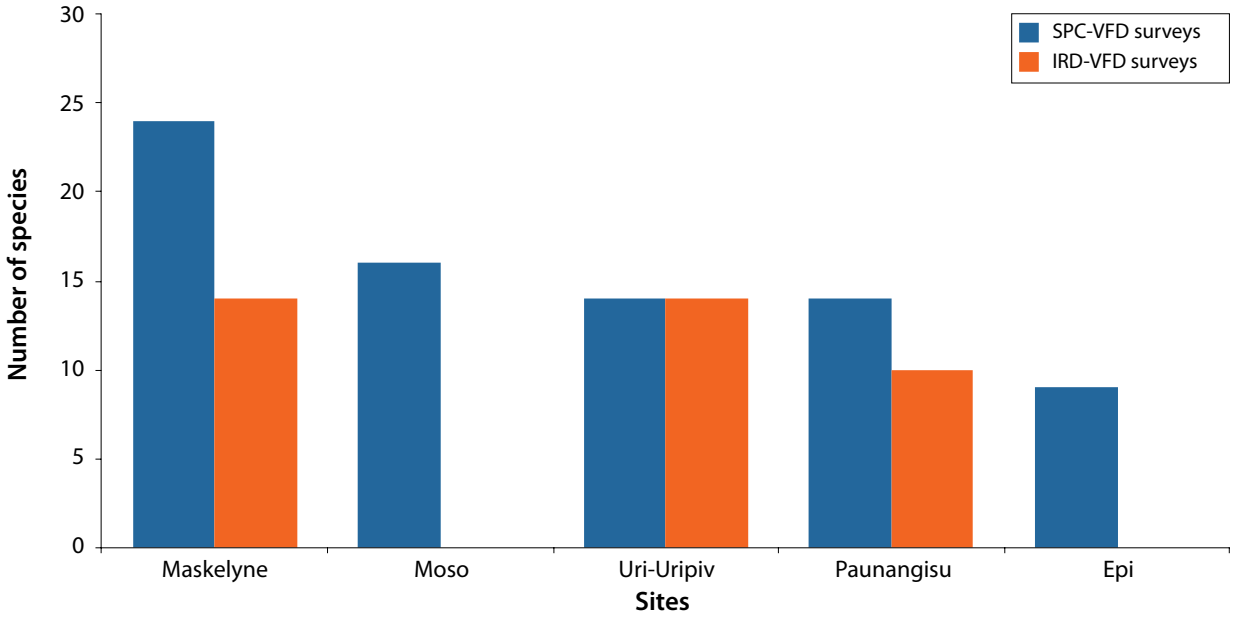

Figure 12. Commercial sea cucumbers recorded by sites assessed since 2003.

Interestingly, this survey was able to confirm the presence of two rare sea cucumber species. Golden sandfish (*Holothuria lessoni*, formerly identified as *Holothuria var versicolor*) were first sighted at Paunangisu in 2003 (Kim Friedman, personal observation, 2003) but were not recorded by earlier surveys. This assessment recorded golden sandfish at Avokh Island (in an area that was placed under restricted access by the court due to an ownership dispute). Active recruitment of golden sandfish was noted by records at Sucere point, Uliveo, and at Vulai Island. Golden sandfish share similar habitats to those occupied by sandfish (*H. scabra*); both species are highly priced in the sea cucumber trade and are of interest for breeding and ranching research. Both species are now listed under the IUCN Red List as endangered species.

The red snakefish (*Holothuria flavomaculata*), one of the commercial species in the snakefish group, was first recorded in 2003 (Friedman et al. 2008a). Red snakefish is present in the northern Pacific in Palau (Friedman et al. 2008a), Yap (Kronen et al. 2009) and Pohnpei, but its Pacific distribution to the east is unknown (Alexander Kerr, personal communication, 2011). Photographic records from recent surveys (Fig. 13) at Maskelyne confirm the presence of *H. flavomaculata*, thus expanding the known species' natural distribution range as far south as Vanuatu.

Figure 13. Golden sandfish (*Holothuria lessoni*) specimen at 400 mm undisturbed size (top left) and its colour morphs (top right) recorded at Maskelyne; Redsnakefish (*Holothuria flavomaculata*) recently confirmed sighting at Maskelyne (bottom).

At Paunangisu there was no record of sandfish (*H. scabra*) in the 2003 SPC surveys (Friedman et al. 2008a). However, in 2011, 53 specimens were recorded to confirm its presence and recovery as a result of the moratorium. Specimens recorded in assessments conducted in 2011 and 2012 are summarised in Table 4 and indicate similarities and differences in the number or records for some species. In both assessments chalkfish and lollyfish were the most common species recorded at Maskelyne. Past assessments by Vanuatu Fisheries documented sandfish at Vaitini, Emae, Uri and Tedka Islands at Port Stanly, and Crab Bay, Northeast Malekula (Gibbs et al. 1998; Saunders et al. 2000). Density analyses for these assessments are provided in Appendix 3. A dedicated sandfish assessment is recommended for these areas to gather more information about these stocks.

Table 4. Count of individual species observed for assessments in 2011 and 2012.

Common name	Maskelyne 2011 SPC-VFD (6.53 ha)	Maskelyne 2011 IRD-VFD (5.72 ha)	Paunangisu 2012 SPC-VFD (2.20 ha)	Paunangisu 2012 IRD-VFD (3.42 ha)
Chalkfish	1,662	1,460	2	1
Lollyfish	1,546	3,974	249	136
Curryfish	441	119	28	7
Sandfish	369	42	53	
Greenfish	185	260	69	184
Pinkfish	181	154	4	2
Tigerfish	180	139	2	22
Snakefish	172		40	
Brown sandfish	130	110	23	9
Dragonfish	80		1,595	
Hairy blackfish	65	57		
Black teatfish	43	42	1	5
Red snakefish	41			
Prickly redfish	40	18	9	15
Flowerfish	30		9	
Golden sandfish	28			
White teatfish	23	23		1
Surf redfish	6	8		
Elephant trunkfish	6			
Amberfish	4		10	
Brown curryfish	4			
Deepwater blackfish	3			
Stonefish	1	1		

3.2.3 Threatened and endangered species (IUCN Red List)

The International Union of Conservation of Nature (IUCN) has placed 16 species of sea cucumbers under the IUCN Red List of Threatened Species (IUCN 2013). Nine of these species are present in the Pacific Island region, and four of them — sandfish (*Holothuria scabra*), golden sandfish (*Holothuria lessoni*), black teatfish (*Holothuria whitmaei*) and prickly redfish (*Thelenota ananas*) — are listed as endangered with extinction or

species that are facing a very high risk of extinction. The other five species — deepwater redfish (*Actinopyga echinites*), surf redfish (*Actinopyga mauritiana*), hairy blackfish (*Actinopyga miliaris*), white teatfish (*Holothuria fuscogilva*) and curryfish (*Stichopus hermanni*) — are considered vulnerable to extinction, or species that are likely to become endangered if no management measures are taken in the short to medium term (Fig. 14). All nine species are shallow- to mid-water species; golden sandfish, sandfish, hairy blackfish and deepwater redfish are restricted to very shallow mangrove-influenced and seagrass habitats. Use of these threatened species for aquaculture development must take into consideration this listing and ensure the use of wild stocks for breeding purposes. Any introduction or translocation should be accompanied by proper risk assessment analysis.

Figure 14. IUCN Red Listed sea cucumber species present in Vanuatu; golden sandfish (GSF), sandfish (SF), black teatfish (BTF), prickly redfish (PRF) are endangered with extinction, and curryfish (CF), white teatfish (WTF), deepwater redfish (DWRF), surf redfish (SRF) and hairy blackfish (HBF) are vulnerable to extinction.

3.3 Species densities

Overall density (density for all stations) and present density (densities for stations where the species was recorded) are presented for manta tow (Fig. 15) and merged reef benthos / soft benthos transects (RBt-SBt) (Fig. 16). Curryfish is best assessed by manta tow and the similarities in overall and present densities explain its broad distribution in Maskelyne lagoons. Highly aggregated chalkfish, sandfish, golden sandfish, hairy blackfish and tiger tail are best assessed using reef transect surveys (RBt-SBt). Density analysis for these species is assessed by merging both survey types. High present densities for chalkfish, dragonfish and tiger tail explain their patchy aggregation in preferred habitat (Fig. 16).

Comparatively densities for most species improved at Maskelyne in 2011 (Fig. 17 and Appendix 3), which is the direct result of the current ban. Exceptions are sandfish, tigerfish and snakefish, which show decreases in densities in 2011. Sandfish density dropped from 734 ind. ha^{-1} to 369 ± 180 ind. ha^{-1} between 2003 and 2011 due to fishing pressure, which happened just before the ban was put in place. Sandfish have not recovered since the last harvest in Maskelyne.

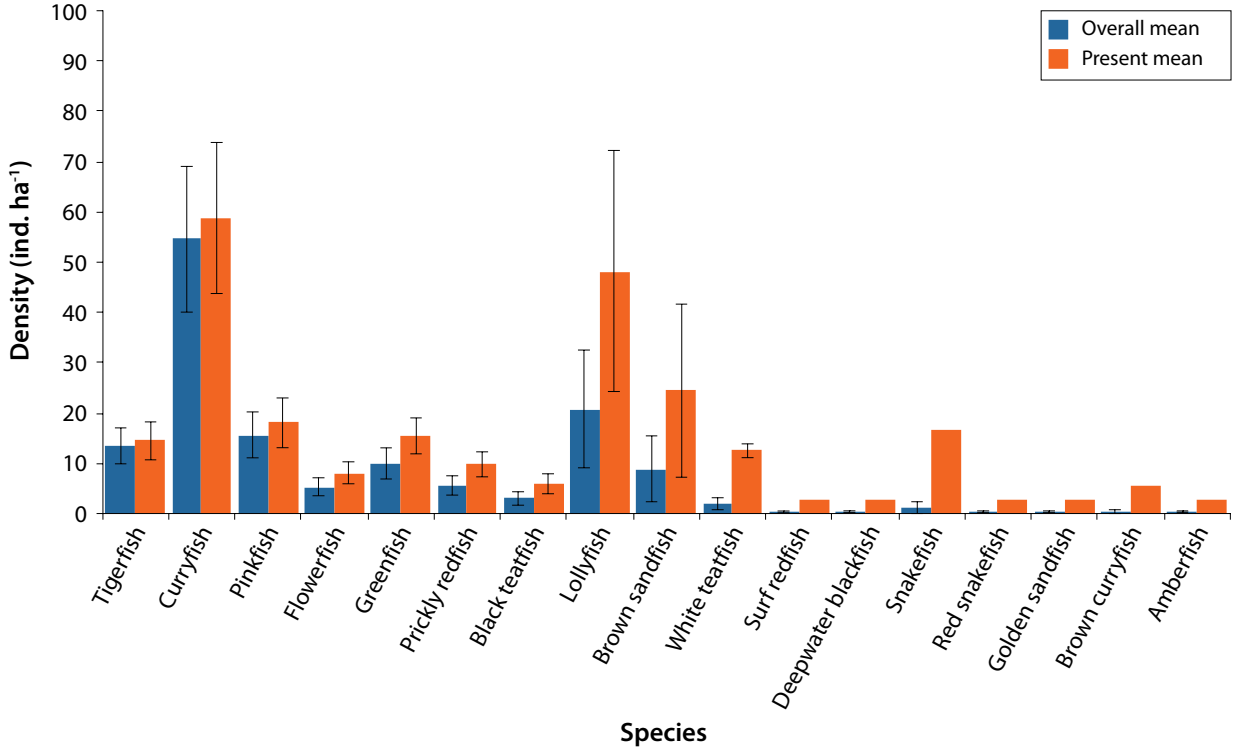

Figure 15. Overall and present mean densities for manta tow assessment at Maskelyne.

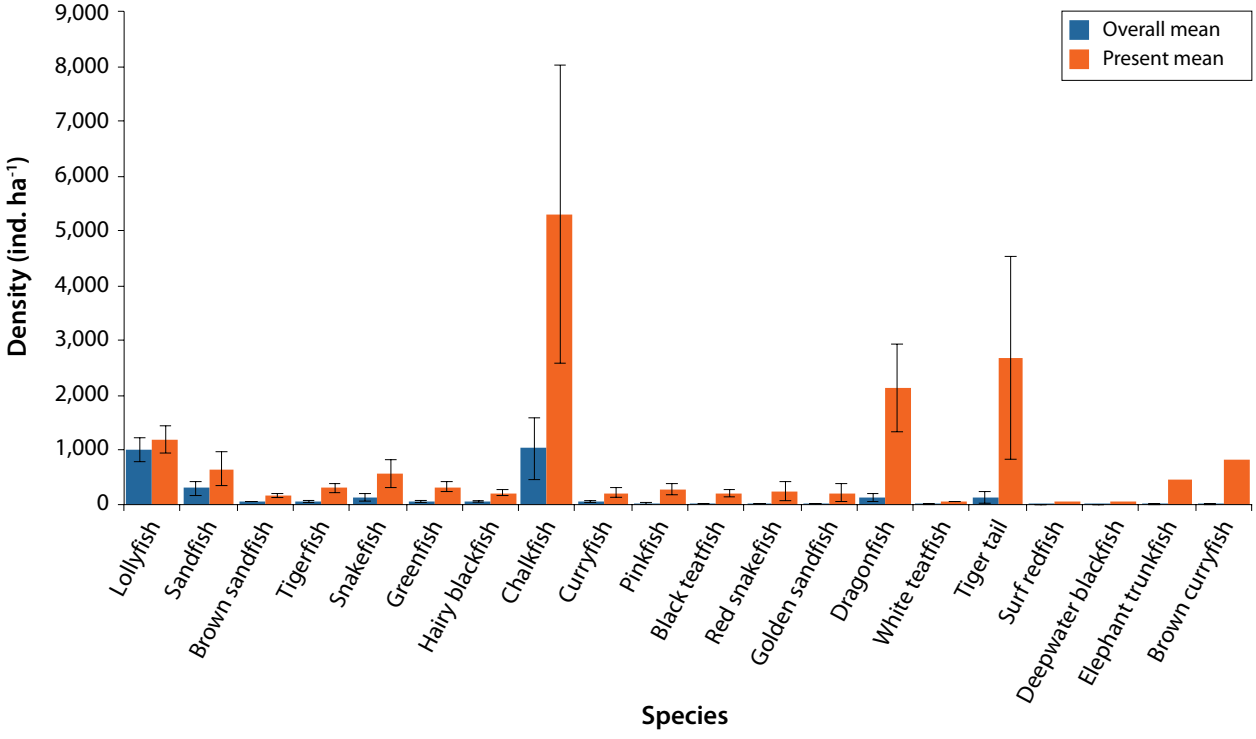

Figure 16. Overall and present mean densities for reef transect surveys (RBt-SBt) at Maskelyne.

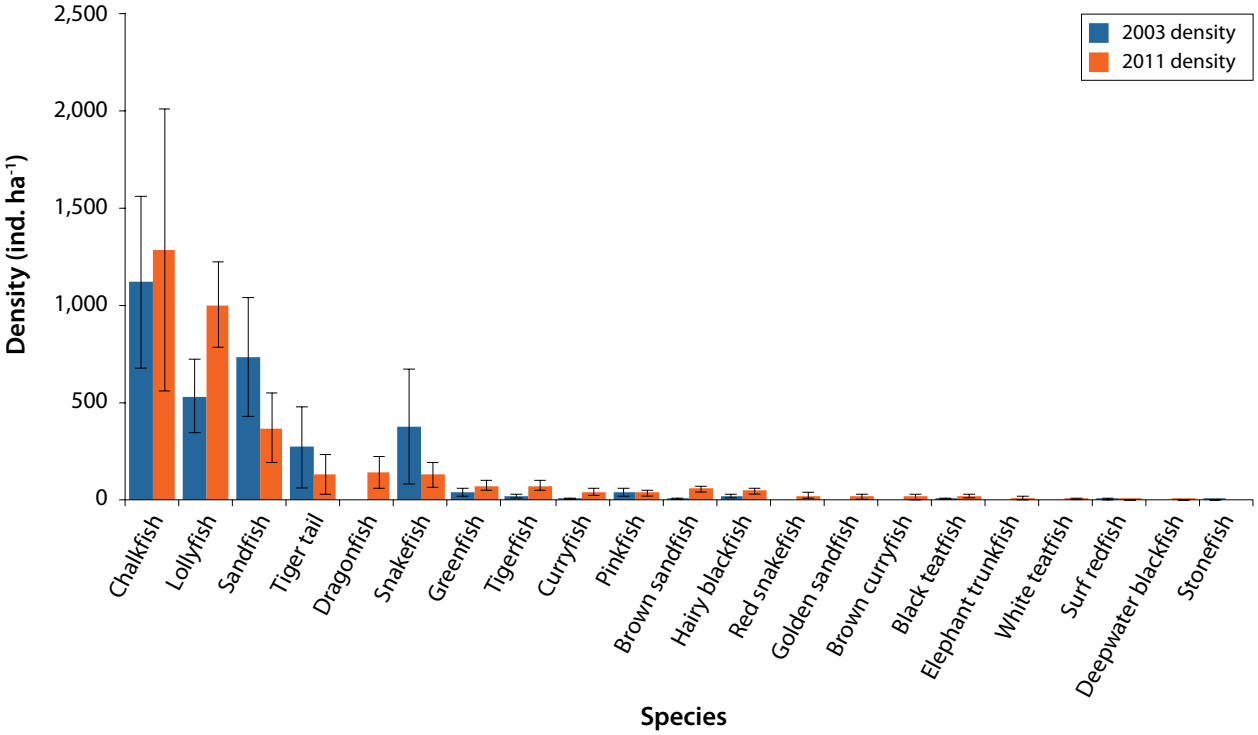

Figure 17. Mean density of sea cucumbers at Maskelyne for 2003 (left bar) and this survey (right bar).

An outcome of the SPC Heads of Fisheries meeting held in Noumea in March 2013 was the need to produce reference densities for sea cucumber species in the Pacific Islands for management use. The meeting also supported SPC's effort to encourage all countries to use a set of similar resources assessment methods in order to encourage better understanding regionally. References densities were produced for broad scale assessment (manta tow) and fine scale assessment (RBt-SBt) based on the assessment protocols promoted by SPC (SPC in press). These densities were derived from an analysis of 91 sites and more than 2,000 stations in 17 countries across the Pacific (Table 5) and can be used as a rule of thumb to compare species densities. The set reference densities are important in multispecies sea cucumber fisheries, where different habitats reflect differences in the density of species.

Sea cucumber resources in Maskelyne and Paunangisu remain depleted with low densities (Table 5). The five-year closure has not offered enough time for stocks to recover, particularly for the longer-lived species such as black teatfish, which take over ten years to recover (Uthicke and Benzie 2000). Determining site-specific reference densities for Maskelyne and Paunangisu is preferred but is possible for most species only after at least ten years of resting or until the stocks have fully recovered.

Table 5. Overall sea cucumber densities by assessment types in Vanuatu compared with reference densities.

Species	Maskelyne densities		Paunangisu densities		Reference densities	
	Manta	RBt-SBt	Manta	RBt-SBt	Manta	RBt-SBt
Lollyfish	21	1,001	119	300	2,400	5,600
Greenfish	10	170	15	77	1,000	3,500
Chalkfish		1,281		4	na	1,400
Snakefish	1	275			350	1,100
Sandfish		370		11	na	700
Pinkfish	15	36			250	260
Surf redfish		1			20	200
Hairy blackfish		49			na	150
Tigerfish	13	256		4	50	120
Brown sandfish	9	56		50	160	100
Curryfish	55	42	19	2	130	100
Flowerfish	5	<1	3		50	100
Black teatfish	3	48			10	50
Prickly redfish	6		5		10	30
White teatfish	2	3			10	20
Elephant trunkfish	7				10	10
Stonefish					na	10
Amberfish	<1		7		20	na
Brown curryfish	13	<1			na	na
Dragonfish		173		3,497	na	na
Deepwater blackfish	<1	1			na	na
Golden sandfish		21			na	na
Red snakefish		24			na	na

na = insufficient data to determine reference densities.

3.4 Size distribution and mean sizes

3.4.1 Mean sea cucumber sizes

Accurate measures of length in sea cucumbers can be a challenge because they lack hard structures and their bodies are largely made up of water. In this assessment, size measures were taken with minimal disturbance of the animal. This is done by measuring the animal while it is on the substrate or measuring the animal quickly soon after it is picked up. The sizes of some species — dragonfish (*Stichopus horrens*), greenfish (*S. chloronotus*), surf redfish (*Actinopyga mauritiana*) and lollyfish (*Holothuria atra*) — can also vary by geographical location in the Pacific. Here we compare sizes of sea cucumber assessed in Vanuatu with common sizes of these species assessed across the Pacific (Purcell et al. 2008). The majority of species (93%) sampled at Maskelyne Islands and 83% of species sampled at Paunangisu were smaller than their common sizes found across the Pacific (Fig. 18 and Fig. 19), indicating young stocks. This result is consistent with the mean size of the consignment seized at Port Vila airport (Fig. 8). The stocks of many species are comprised of young sea cucumbers which are of lower quality in the sea cucumber trade.

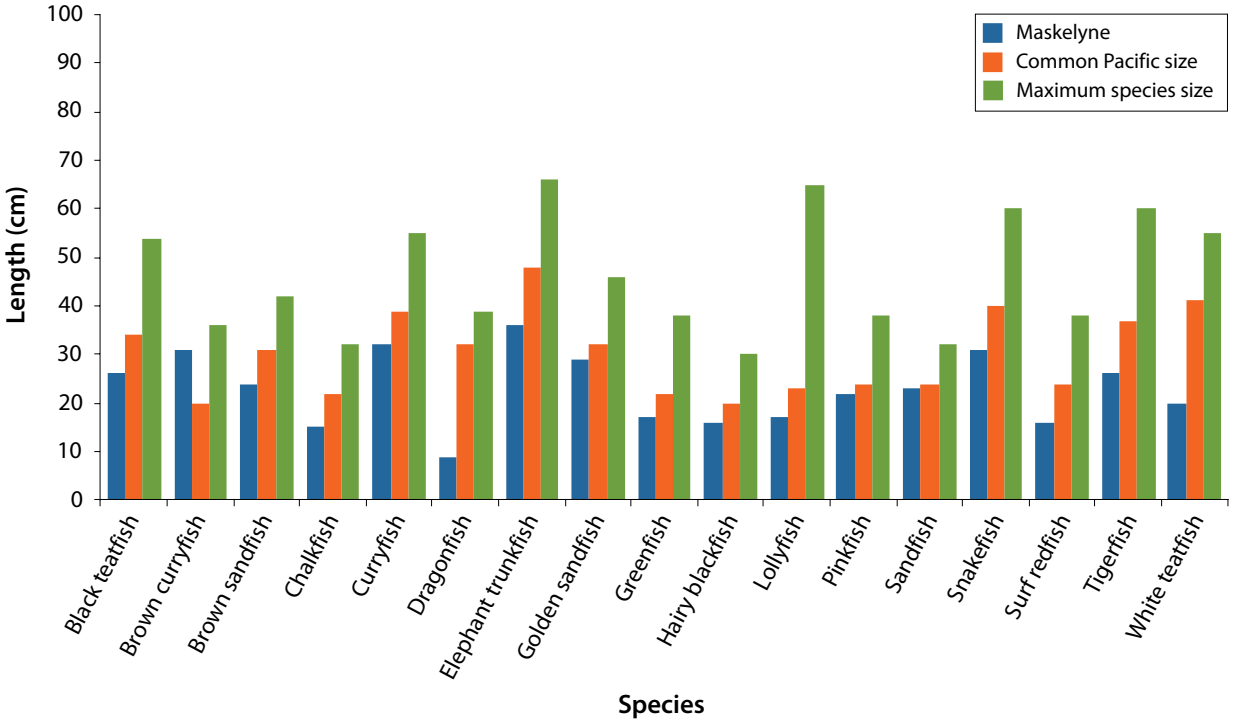

Figure 18. Mean size of sea cucumbers at Maskelyne.

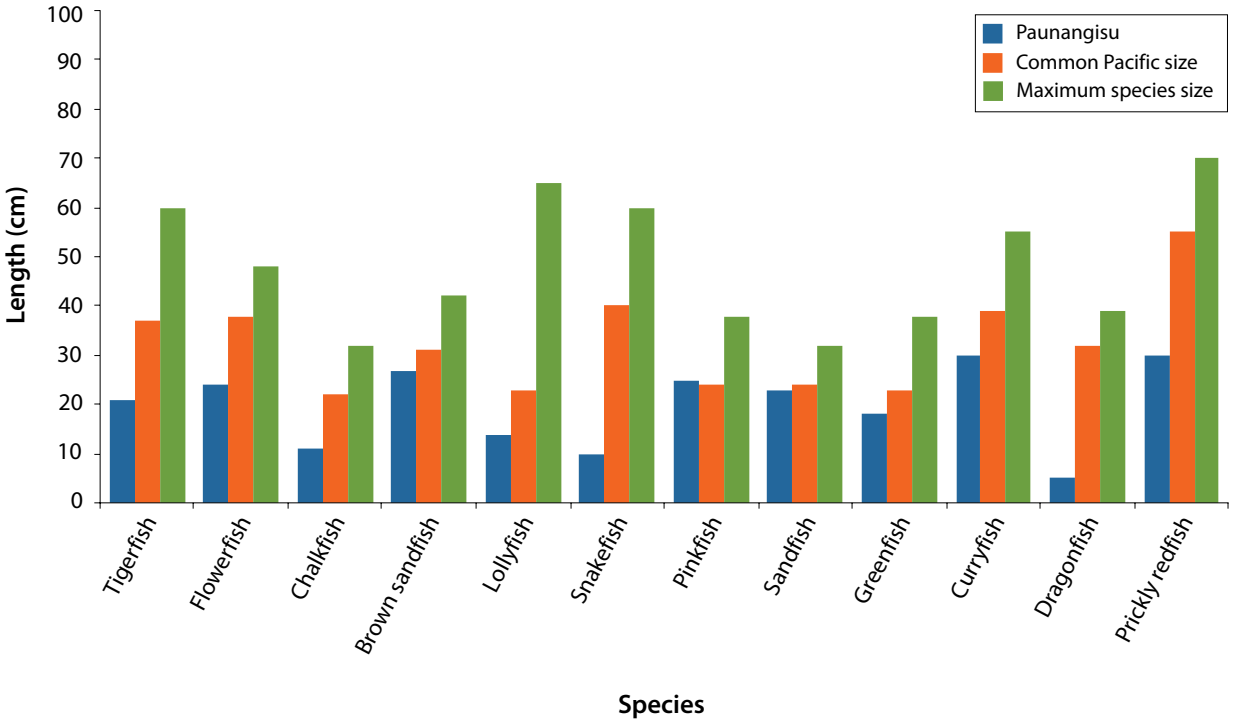

Figure 19. Mean size of sea cucumbers at Paunangisu.

3.4.2 Sandfish and golden sandfish

Sandfish is an indicator species to gauge the impact of fishing and the effect of management due to its high value; the species is easily fished in shallow waters and can recover to high density if managed well. Sandfish is well known by the people of Maskelyne as one of their main products but its density indicates it has been overfished. Past surveys indicated relatively healthy stocks present at Uliveo Island and Avokh restricted access area (Fig. 20). The communities of Pellonk, Peskarus and Lutes on Uliveo Island had an enforced harvest ban on sea cucumber for some years prior to the 2003 surveys, while the restricted access

area at Avokh has been in force for the last 15 years. Size distribution analysis from this assessment (Fig. 21) reveals an impacted population, in particular the sizes <200 mm, due to the 2006 fishing season.

The size distribution for protected versus open access areas shows clear differences; the majority of sandfish measured in this assessment were from Avokh Island restricted area (Fig. 22). The area of lagoon at Avokh, Lembong and adjacent mainland (Fig. 10) was closed by the Malekula Island Court in 1988 due to a customary ownership dispute; this closure remained effective during this present assessment (Yaxly Bob, personal comments). The sandfish stock at Avokh has maintained the same size structure since 2003, indicating minimal disturbance from fishing. Recent sea cucumber fishing occurred in all other areas of Maskelyne Islands but Avokh was a restricted area. The court order limiting access to the disputed area of Avokh has been effective in protecting sea cucumbers.

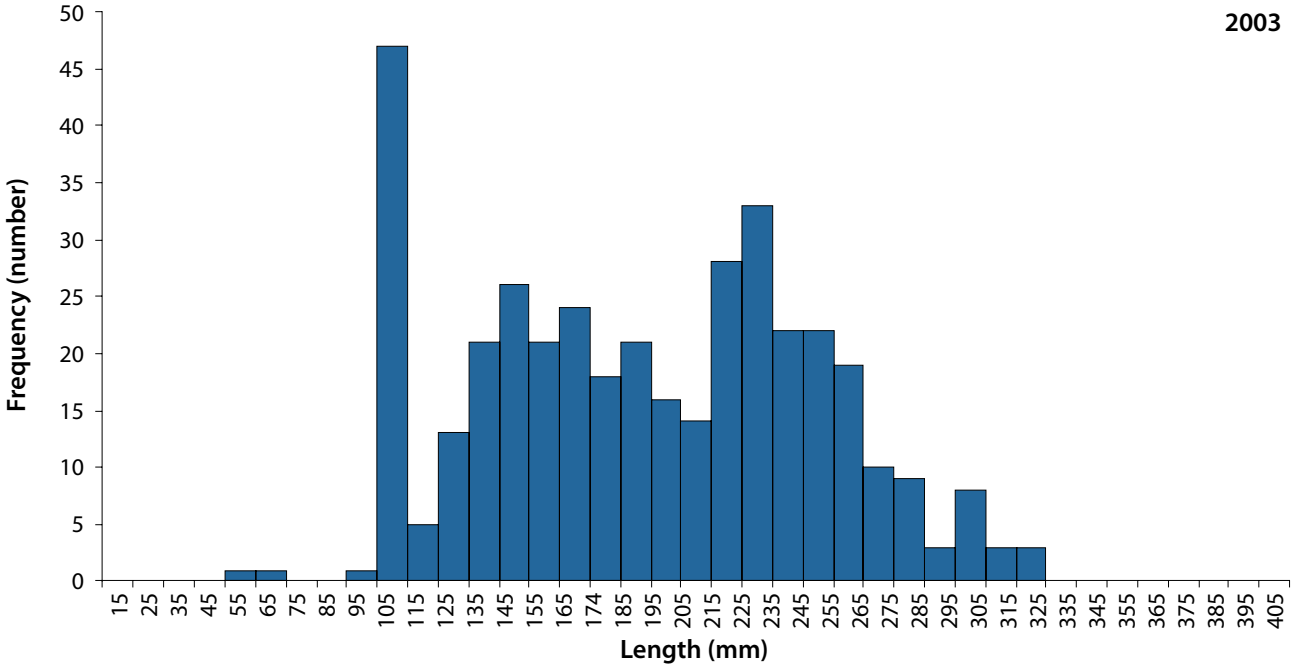

Figure 20. Sandfish size structure at Maskelyne Islands in 2003.

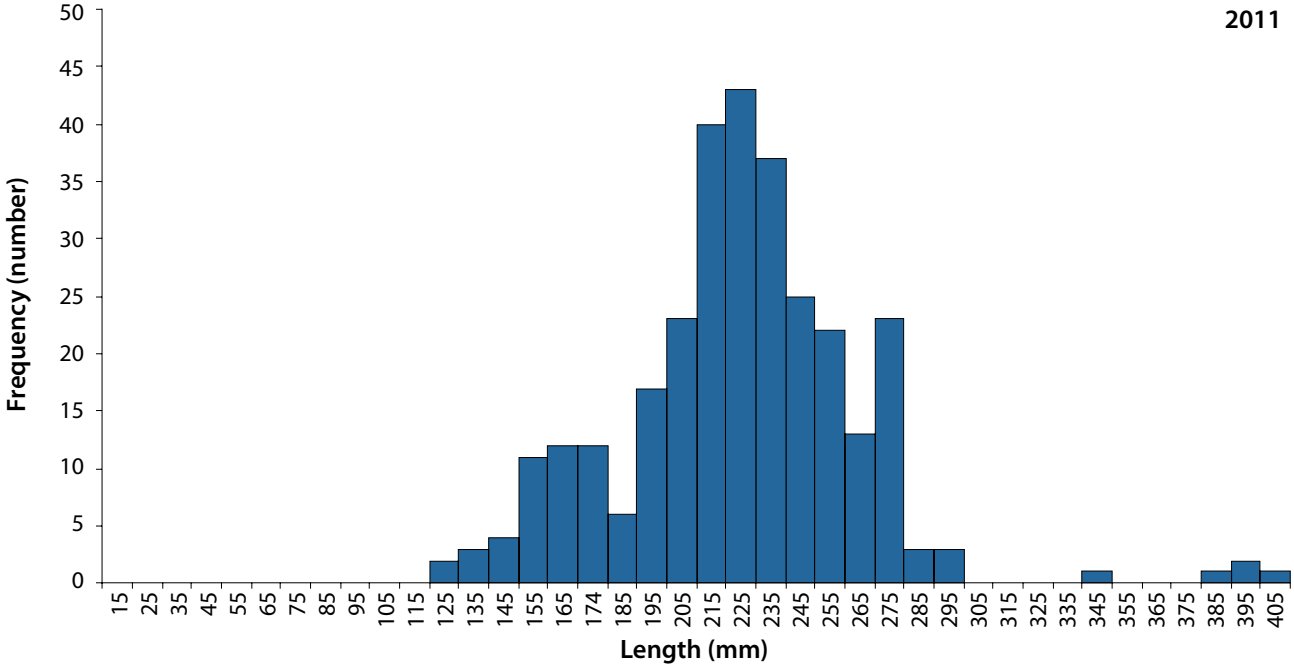

Figure 21. Sandfish size structure at Maskelyne Islands in 2011.

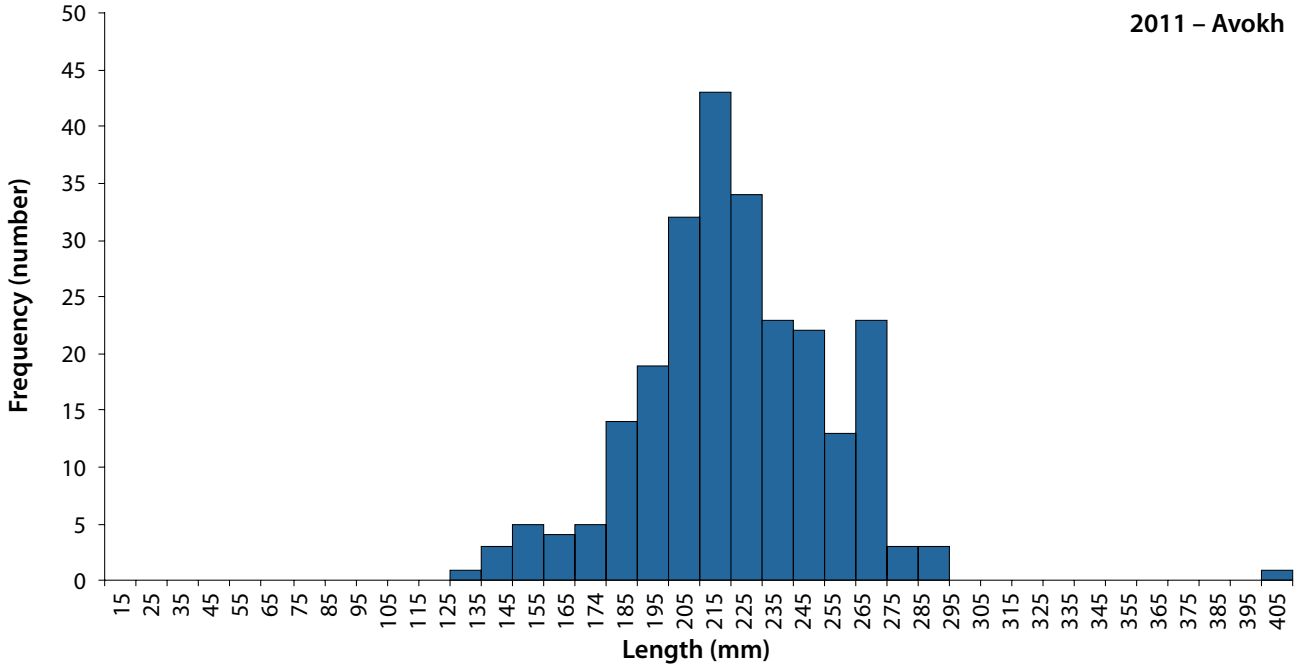

Figure 22. Sandfish sizes at Avokh restricted area in 2011.

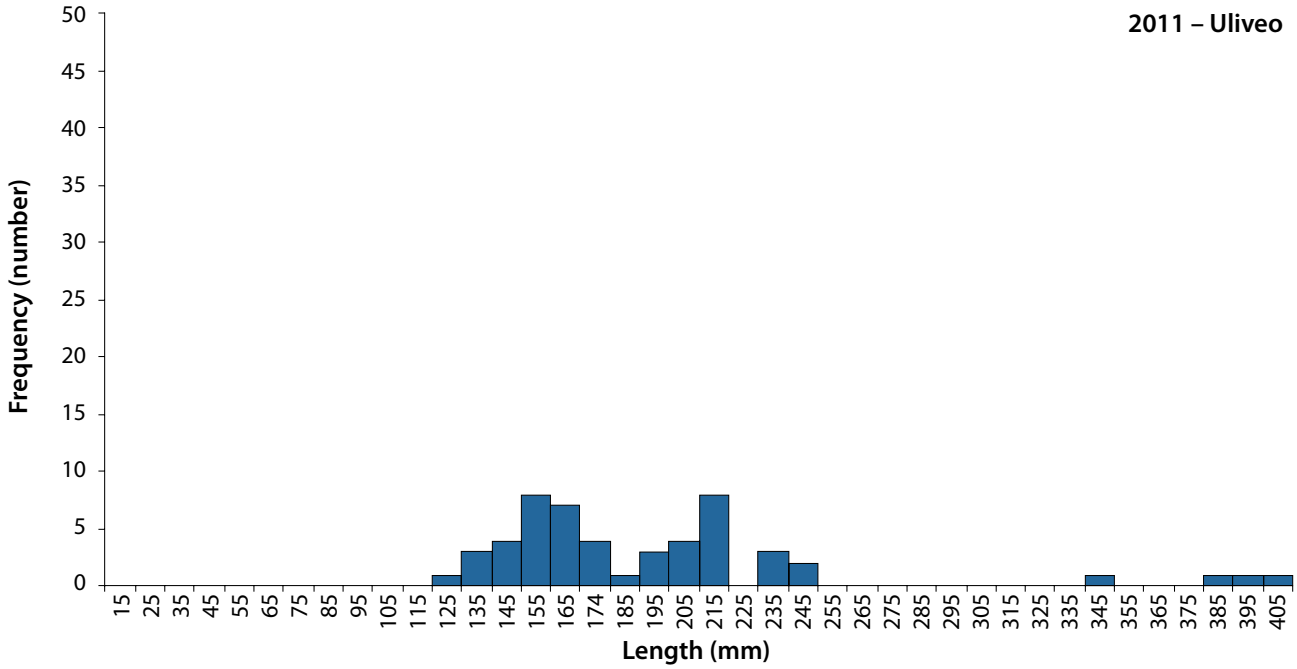

Figure 23. Sandfish sizes structure at open access areas at Uliveo Island in 2011.

In contrast, sandfish stocks in open access areas at Uliveo Island, including the ringi te suh permanent community protected area, have been seriously depleted (Fig. 23). A total of 46 specimens were recorded in 19 stations covered at Uliveo Island. *Ringi te suh* was established in 1992, covering roughly half a hectare, to preserve giant clams and sandfish. Being a community-managed area, it is subject to periodical fishing, as is the case for community marine protected areas or community species protected areas (an area of reef where certain species are protected).

Sandfish can be present at high density and its rapid breeding capacity can recover stocks quite quickly after being fished, provided there is sufficient breeding stock remaining (Conand and Sloan 1989). Despite

the large soft benthos habitat of Uliveo Island, the lack of juveniles (Fig. 23) points to recruitment failure. Remaining adult stocks were scattered far apart, making successful spawning and fertilisation difficult. The Uliveo community may have to wait much longer for their sandfish to recover at least to the 2003 level. Furthermore, the *ringi te suh* protected area may have been lifted to allow sandfish harvest in 2006 or, if not, poaching may have occurred, leading to removal of the protected stock. Thus the "permanent" closure of an area does not fully qualify as the modern definition of a permanent closure; rather it is typically a closure to accumulate resources for future use.

Some of the largest sandfish specimens were recorded; the largest size documented was 320 mm recorded at Palau (Pakoa et al. 2008; Purcell et al. 2008). Sizes of sandfish recorded in this assessment were larger — 400 mm (undisturbed size) at Avokh restricted area and Uliveo Island. Similarly, golden sandfish specimens were measured at 400 mm also (see Fig. 24). For golden sandfish, a total of 28 specimens were measured with a mean size of 284 mm. Extended periods of protection at Avokh have allowed specimens to grow to their full size potential and they are now recruiting to other areas.

Figure 24. Large sandfish specimens (left) and golden sandfish (right) recorded at Maskelyne Islands (all specimens 400 mm in size).

3.5 Estimating the standing stock

Due to low densities, a stock estimate was not estimated, but it must be noted that this can be performed by extrapolating the overall mean species densities produced in the report. Mean densities and mean sizes have indicated low abundance and young sea cucumbers, which indicated that resources remain depleted. The advisory issued to the Vanuatu Department of Fisheries in March 2012, was based on these same results from which the recommendation was made to extend the ban. Stock estimates will be needed in future when the resources have recovered to a healthy abundance and stocks have become larger and more mature. The procedure to estimate stock in an area is provided in Appendix 4 and detailed in the Invertebrate Assessment Manual (SPC in press).

3.6 Community views and experiences

Maskelyne communities have been managing their marine resources through the customary practice of a *tabu*, but in 2007 they were led to believe that the reseeding of sea cucumbers would help restore sandfish populations. Juvenile sea cucumbers imported from outside were reseeded on Uliveo reef by an investor who then applied for a license to harvest wild stocks for the sea cucumber trade. The community learned

months later that their wild stock of sandfish had been fished out and the introduced juveniles had all died. The people of Maskelyne Islands have seen many sea cucumber traders come by their area but they have never come across such a scam. At a meeting held after the survey in June 2011 (Pakoa 2011), community leaders expressed their concerns and shared their views on how they would like the sea cucumber fishery to be managed. Their views are summarised below.

(a) Leaders and the people of Maskelyne were happy their sea cucumber resources were assessed and the results presented to them. For many of them, it was the first time to learn of the many species of sea cucumbers in their area. Golden sandfish in particular was of interest to the community; many people in Maskelyne were not familiar with this species. Some elders of Avokh Island had seen this species but it has been a while since it re-appeared. The people of Avokh Island were particularly happy to learn of the recovery of golden sandfish and, importantly, the effect of their protecting both golden sandfish and sandfish.

(b) On hearing the assessment results, the leaders and people of Pallonk, Peskarus and Lutes on Uliveo Island were not encouraged by the low numbers of sea cucumbers, especially sandfish. Sandfish was their preferred species because of its high price but their stock was fished heavily in 2007. The stock is only starting to recover and it may take several more years to reach good recovery status. They blame the deal they had with the investor, which resulted in overharvesting of their wild sandfish stock.

(c) The chiefs on Maskelyne rally behind the government in support of the national five-year ban on the sea cucumber fishery; they say the ban saved their resources from further fishing pressure, which they had little control of. Their community management practice did not prevent an investor or his agent entering the village to buy sea cucumber in 2006. The community leaders requested stronger controls of traders by the government through the Fisheries Department and the Provincial Council of Malampa.

(d) Community leaders knew their sea cucumbers were not going to recover within the five-year period as they have not seen the numbers they used to see. The communities of Uliveo are concerned about their sandfish as they have not seen the recovery of their stock since the ban. They strongly recommend extension of the current ban to allow full recovery of their resources. They said larger sea cucumbers make good weight and more money so they are prepared to wait longer to get a better income.

(e) The community leaders would like to see some of their people, rather than foreigners, exporting sea cucumber. They compared sea cucumber with kava, saying some local people from Malekula had been exporting kava; they therefore can export sea cucumber. They said they would request the Vanuatu Fisheries Department for a license to harvest, process and export their sea cucumbers.

(f) On the question of whether the communities will be affected by the extension of the ban, the leaders say agriculture is their main source of income from crops such as kava, copra, root crops and livestock. Sea cucumber and finfish are important but are not the main income earners. Nevertheless, they also think it is important to manage the sea cucumber fishery now for their children to benefit from in future.

(g) The community regretted their involvement with a sea cucumber export company in 2007. The exporter introduced baby sandfish in their lagoons in return for the buying of their wild sandfish stock. They blame the current poor state of sandfish at Uliveo Island on this deal. They would like the Vanuatu Fisheries Department to control such investors in order to avoid these experiences.

4. Discussion

4.1 Sea cucumber resources

Areas of limited reef habitat offer little opportunity for diverse species to thrive, which is a natural limitation in many of Vanuatu's islands. In-water resource surveys undertaken in 1990, 1998, 1999 and 2000 document species present but there have been few follow-up surveys to reliably establish the number of species present. Species not captured in past surveys, such as sandfish at Paunangisu and golden sandfish at Maskelyne, have now been confirmed to exist. Sandfish and golden sandfish are of increasing interest for aquaculture research and development; information about existing stocks is important. Stocks of sandfish located in others sites such as Vaitini and Siwo on Emae, Crab Bay and Port Stanly on Malekula, should be assessed.

The SPC assessment in 2003 was followed by recommendations in 2006, but it was not until 2007 that action was taken to enforce the five years' closure as of January 2008. While the ban came rather late, it was a timely decision to control further degradation of resources. Resources have begun to recover, as noted by increased densities. Of special interest is the sighting of golden sandfish in Maskelyne Islands; protected stock held in the Avokh restricted area have began to recruit outside the restricted area. Sighting of sandfish at Paunangisu is a positive sign of recovery on Efate and further assessments of potential sites on Efate are needed to ascertain stock size and location.

The sandfish stock of Uliveo Island (Peskarus, Pellonk and Lutes) is of particular concern. Healthy stock abundance recorded in the past (Saunders et al. 2000; Friedman et al. 2008a) has been overexploited. The presence of a few adults (46 specimens recorded) scattered far apart from each other has adversely affected spawning, egg fertilisation and recruitment. Stock that was protected inside the *ringi te suh* community protected area at Pellonk has also been overfished. With this lack of protected breeding stock, the people of Uliveo Island will have to wait longer for the resources to recover or look at the option of bringing in adults from other areas to improve the breeding capacity of their existing stock.

The big question is: Are the sea cucumber stocks ready for harvest? The answer for now would be no; the resources remain depleted. None of the stocks are present in sufficient abundance and individuals are too small to support an economically viable fishery. Densities for the fast-growing lollyfish at the two sites were poor in contrast to healthy densities of 5,600 ind. ha^{-1} and 2,400 ind. ha^{-1} in both reef transect and manta tow surveys respectively. The fishery has been fished continuously in the last 25 years; some slower-growing species, such as black teatfish (*H. whitmaei*), can take up to ten years to recover; five years is barely enough time to see significant change. The five years of closure does not provide sufficient time to allow strong population recovery for all sea cucumber species.

The populations of sea cucumbers at the two sites are comprised entirely of smaller animals, which are either sexually immature or just entering maturity and so have weaker spawning capacity (the majority of sizes recorded were below the common sizes recorded in the Pacific). These small sea cucumbers would make low quality products in terms of size (length and width) and meat content (lower weight) and so are worth much less at the market than fully grown sea cucumbers. The confiscated sea cucumber consignment is proof of this; the majority of sea cucumbers that were illegally harvested and about to be smuggled out of the country were all under existing size limit regulations.

Sustainable monitoring mechanisms of resources and fisheries, and timely use of information in management have been lacking. Resources information collected in the past used different assessment sample areas which produced incomparable densities. Furthermore, using a variety of methods and sampling strategies is counterproductive to sustainable capacity building of fisheries officers. The demise of the sea cucumber fishery in the Pacific is testament to poor knowledge, inadequate information and lack of management response. Therefore, agreeing to a set of survey protocols and using them over time is the way forward for the Vanuatu Fisheries Department.

4.2 Fishery status

Sea cucumber fishery has been around for a long time, yet fishing activities have not being monitored as well as they should have been. Fishing of sea cucumber does not require a license because resources are within the customary owned areas of communities. Past fishing activities are decided by resource owners themselves, as well as who to sell the catch to. There are limited harvest controls at the national and provincial levels.

While co-management arrangements provide the avenue for the Fisheries Department to work with community, it is not a formal arrangement. Issuing an export license and permit provides the avenue for data collection, yet this was underutilised. Product prices separated by species were not available, data on catches by buyers and by fishing areas or provinces were not being collected.

The sea cucumber fishery in Vanuatu is reserved for local Ni-Vanuatu, as is the case for all fishing activities within the archipelagic waters under the Marine Zones Act 1981. Joint venture arrangements have been a feature of sea cucumber exports, allowing foreigners into the business, with the foreign partner contributing capital and therefore controlling the financial dealings of the trade. Trade in sea cucumber has been a closely guarded secret in terms of product value for many years. Local Ni-Vanuatu entrepreneurs who have been successful in kava and copra exports should be given the opportunity to invest in the sea cucumber export business.

Sea cucumber is a lucrative commodity in the Pacific Islands, but for many years little has been done to ensure the best prices are paid for products by exporters. Fishers at the lower end of the product chain have not had the opportunity to get maximum value for their resources. Fishery management needs to look at product price improvement as a management measure. Producing a small catch and receiving a higher return for it helps to reduce the need to harvest more resources. The 2012 sea cucumber purchase price estimates for the Melanesian countries (Carleton et al. 2013) is a useful benchmark for the approach.

At the national level, the Fisheries Department should look into opportunities to raise resource rentals in terms of licensing fees. The experience in Tonga is a useful lesson; sea cucumber license fees increased 15 fold in the 2010 open season, yet it did not restrict interested investors (Sione Vailala Matoto, former Secretary of Fisheries, Tonga personal comm.). This indicates that, with healthy resource conditions and good monitoring systems, Pacific Island fisheries agencies such as Vanuatu Fisheries can generate higher revenue from sea cucumber export license fees.

Improving prices and quality go together; many village-based fishers process their own products their own way and this has been a key feature of poor quality. Restricting sea cucumber processing to licensed processors should help to improve the quality and therefore the price.

4.3 Management measures

The decision to close the fishery in 2008 was the best option to control further degradation of stocks. While it has helped stabilise the resources, it did not provide resources sufficient time for stocks to fully recover to their optimum fishing potential. The decision taken to extend the closure for another five years was a sound decision; it was in the best interests of stock rehabilitation and is protecting community livelihoods. The draft Vanuatu national sea cucumber management plan needs to be progressed to the final stage. Measures in the plan, such as national and provincial open seasons, control on the number of exporters,and species catches quotas are important in the effective monitoring of the fishery.

Community-based management can assist in controlling fishing pressure but these practices are largely periodical (closed for some years and open for fishing whenever the community decides) and their long term potential in preventing stock depletion are limited. Effective control through national or provincial closed seasons should help prevent community-managed areas from extended exposure to fishing pressures. In addition, effective monitoring of fishing activities during the open season can help control poaching

in community areas. The depletion of sandfish at *ringi te suh* in Maskelyne is a classic example of fishing pressure which led to the over harvesting of stocks in the protected area. On the other hand, the success of the Avokh restricted area provides a useful contrast; this is an area restricted by law (a court order restricting access to the area). The Avokh restricted area is an example of a regulated protected area being more effective than traditional periodical fishing closures.

Finalisation and implementation of the national sea cucumber management plan should provide a way forward for sustainable management of this fishery. In addition, the new aquaculture licensing system should help control aquaculture and ranching activities and the utilisation of broodstock for research purposes.

5. Recommendations

1. ***Moratorium:*** The five-year moratoria period initiated in 2008 is barely enough to allow sea cucumber stocks to fully recover. Extending the closure for a further five or more years is recommended.
2. ***Illegal fishing activities:*** Illegal harvesting and smuggling of beche-de-mer is happening and likely to increase. Illegal fishing and exporting activities should be severely dealt with to deter more such activities happening during the moratorium period.
3. ***Rare species:*** Golden sandfish is confirmed to be present in Maskelyne Islands and has begun to recruit to surrounding areas. The long-term restriction placed on the Avokh area is working to preserve stocks of valuable sea cucumbers and should be maintained. Golden sandfish should be placed under a restricted species list should the fishery re-open.
4. ***Uliveo sandfish stock collapse:*** The stock of sandfish at Uliveo Island has collapsed as a result of heavy fishing. Fishing of sandfish is not recommended in Uliveo Island (Pellonk, Peskarus, Lutes). Translocation of adult sandfish could be considered in order to increase existing spawning biomass.
5. ***IUCN listing:*** Nine species — golden sandfish, sandfish, black teatfish, curryfish, hairy blackfish, prickly redfish, surf redfish, deepwater redfish and white teatfish — are listed under the IUCN Red List of threatened and endangered species. These nine species should not be fished until their stocks fully recover.
6. ***Product prices:*** Sea cucumber buying prices increased by over 100% between 1990 and 2006. The recent beche-de-mer buying price estimates for 2012 in Melanesian countries should be used as a benchmark for setting minimum product prices in future. A set of minimum buying prices for dried and semi-processed sea cucumber should be established and enforced in future fishing seasons.
7. ***Product quality and packaging:*** Improved product packaging methods, such as the use of transparent plastic packaging by standard quantity units in either vacuum or air sealed packaging, are recommended. The recently seized products packed in sealed plastic packages of 1 kg and 0.5 kg sizes by product is a good example of the way these products should be treated. The Vanuatu Fisheries Department should adopt and enforce new packaging methods for dried or partly processed products in future.
8. ***Local participation in export:*** Participation of local Ni-Vanuatu citizens in undertaking sea cucumber export business as fully locally owned business (100% Ni-Vanuatu owned exporters) should be given special preference over joint venture arrangements. The Vanuatu Fisheries Department should work with relevant agencies to assess opportunities to fully localise the sea cucumber export business.
9. ***Monitoring and compliance:*** Products leaving provinces or islands for Santo or Port Vila should be accompanied by a certificate issued by a Fisheries Authorised Officer. Consignments should be cross-checked on arrival in Port Vila or Santo and any discrepancies corrected. The cost of inspections can be recovered through permit fees charged to the exporters.
10. ***Community-based management:*** Fishing, sale and processing of sea cucumber by communities are covered within the draft national sea cucumber management plan. Development of community management areas to preserve sea cucumbers is encouraged. The Fisheries Department should continue to encourage community management activities.
11. ***Aquaculture and sea ranching of sea cucumbers:*** Investors interested in breeding and sea ranching of sea cucumber should seek advice from the Vanuatu Fisheries Department and apply for a specific aquaculture license to operate a hatchery or farm. Sea cucumber export licensing should be restricted to product storage and exporting only and not cover any activities that are aquaculture oriented.
12. ***Aquacultured products:*** Aquacultured sea cucumber should be accompanied by an official certification as proof of the farm, the farmer responsible, farming sites, and livestock information such as species, sizes, weights and farming treatment. The current size limit regulation should apply to all sea cucumbers produced in Vanuatu.

13. ***Resources assessment surveys:*** Vanuatu Fisheries is currently using two assessment protocols for assessing sea cucumber resources. It is recommended that the Vanuatu Fisheries Department decide on a set of assessment methods and continue to use it over long term to improve resource knowledge and capacity. SPC will continue to adopt the same resources survey protocols for invertebrate resources as part of the regional approach in improving sea cucumber management across the Pacific. Vanuatu Fisheries Department should also make use of the Reef Fisheries Integrated database installed by SPC to facilitate data flow to SPC Noumea Office for back-up and safekeeping.

14. ***Sea cucumber fisheries management plan:*** The draft Vanuatu national sea cucumber fishery management plan must be finalised and appropriate measures developed into regulations prior to the opening of the fishery. All necessary preparations and enforcement arrangements should be made before the fishery re-opens.

15. ***Sea cucumber conservation areas:*** Vanuatu does not have a dedicated area set aside as a national marine protected area to conserve marine species, especially threatened species such as some sea cucumber species, and as a field research station for the Fisheries Department. One such area was identified at Maskelyne Islands — Vulai Island makes an excellent candidate for a national marine conservation area. Traditional leaders of the island have been approached and are very supportive of the idea. The Fisheries Department should pursue this development with Malampa province and the community.

    In addition, two community-managed protected areas are recommended for Paunangisu and Emae:

    Paunangisu: Major developments planned at Takara pose a threat to the mangrove system of the Paunangisu-Takara area. A community-based marine protected area is recommended for this area to protect species such as sandfish and golden sandfish present in the area. Such protection would encourage research activities and reseeding trials for sandfish and other potential invertebrate and fish species.

    Emae: Emae Island and Cooks reef are of interest as a productive reef system near the main capital of Port Vila. Emae is currently one of the main suppliers of fish to Port Vila and is also one of the main suppliers of sea cucumber, trochus, green snail and land crab. A community-based marine protected area is recommended for Emae in areas such as Vaitini reef to preserve the sandfish stock and other marine species.

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Appendix 1.

Analysis of data collected by Fisheries Department in 1998, 1999 and 2000 at Shepherds Group, Malekula and the Banks and Torres Islands (from the preliminary reports of Gibbs et al. (1998), Lamont et al. (1999) and Saunders et al. (2000))

The invertebrate resources assessments project funded by the Forum Fisheries Agency collected underwater data from 1998 to 2000. The objective is to provide resource status of sea cucumbers, giant clams, trochus and green snail, rock lobster and coconut crab in the provinces of Tafea, Shefa, Malampa and Torba. Sites assessed were Aneityum and Tanna (Tafea), the Shepherds Islands (Shefa), Gaua and Mota Lava (Banks), Hiu, Metoma, Tegua (Torres islands) and sites in Malekula. The Bay of Plenty Polytechnic Students of New Zealand assisted Vanuatu Fisheries with these assessments as part of their field training in an arrangement with Vanuatu Fisheries. Reef transects and snorkelling were used in this assessment. Sampling stations vary, in the Shepherds Group assessment, 60 m by 5 m wide (300 square metres per station) transects were, 50–60 m x 5 m for the Banks and Torres Islands and 45 m transect estimate per survey from timed swim for assessment in Malekula. Transects were laid perpendicular to the shore and sometime parallel to the shore in places where the reef area was limited and species recorded within 2.5 m width either side of the line. Preliminary reports produced by the New Zealand Bay of Plenty students as part of their field trip reports were provided to Vanuatu Fisheries. The final analysis of these data and reporting were not produced. This analysis is useful for sea cucumber assessment in Vanuatu since some of the sites assessed collected some rare data on sea cucumbers which are important. Data collected at Aneityum are not available in this report.

1. Emae Island invertebrate assessment 1998 (Sea cucumber density analysis)

In the Shepherds Group assessment, sites on the islands of Emae and Cooks reef were analysed. Emae is an important sea cucumber fishing ground in the Shefa Province although actual production quantities are not available. The number of stations completed is summarised in Table 1 and the total number of species observed and density estimates in Table 2.

Table 1. Survey coverage at Emae in 1998.

Sites	Stations	Area (m^2)	Area (ha)
Marae	41	12,300	1.23
Sulua	28	8,400	0.84
Worarana	14	4,200	0.42
Makatea	23	6,900	0.69
Vaitini	15	4,500	0.45
Siwo	22	6,600	0.66
Tongamea	20	6,000	0.60
Cook Reef	14	4,200	0.42

Table 2. Total sea cucumber densities (ind. ha^{-1}) and total individuals observed (in brackets) at Emae 1998 with sample size (n) in brackets.

Species	Marae	Sulua	Worarana	Makatea	Vaitini	Siwo	Cooks reef	Tongamea
Area (ha)	1.2	1.3	0.4	0.7	0.5	0.7	0.4	0.6
Lollyfish	112.2 (138)	2,459.5 (3,099)	114.3 (48)	15,643.5 (10,794)	946.7 (426)	37.4 (46)	24.5 (10)	15,823.3 (9,494)
Greenfish	22.0 (27)	16.7 (21)	19.0 (8)	4.3 (3)	40.0 (18)		53.9 (22)	3,735.0 (2,241)
Tigerfish	19.5 (24)	42.1 (53)	26.2 (11)	11.6 (8)	6.7 (3)	9.8 (12)	39.2 (16)	13.3 (8)
Black teatfish	1.6 (2)	0.8 (1)			8.9 (4)		7.3 (3)	10.0 (6)
Surf redfish	8.1 (100)	2.4 (3)					12.2 (5)	1.7 (1)
Stonefish			2.4 (1)					
Sandfish					4.4 (2)			
Prickly redfish		1.6 (2)			4.4 (2)			
Pinkfish	1.6 (2)	21.4 (27)			51.1 (23)		2.4 (1)	
Deepwater redfish			2.4 (1)					
Curryfish		0.8 (1)						
Brown sandfish		4.0 (5)					19.6 (8)	

2. Banks-Torres Islands invertebrate assessment 1999 (Sea cucumber density analysis)

The assessment at Banks and Torres Islands covered nine sites but sea cucumber was reported in only four sites. Data from other sites could have been lost and the number of sampling stations was not reported in Lamont et al. (1999). From the four sites where data were reported, lollyfish was the main species recorded at Pakea Island in shallow lagoon and green fish was the dominant species on the fringing reef surrounding Ravenga Island in Vanua Lava.

Table 3. Sea cucumber counts at Banks and Torres Islands (sampling area not available).

Species	Hiu	Tegua	Pakea	Ravenga	Totals
Lollyfish	27	17	769		813
Greenfish			8	169	177
Surf redfish	3	36			39
Elephant trunkfish				12	12
Tigerfish	3				3
Black teatfish			1		1
Stonefish			1		1

3. *Malekula Island invertebrate assessment 2000 (Sea cucumber density analysis)*

Malekula is a larger island and the main sea cucumber producer. The 2000 assessments covered sites in Maskelyne Islands: Avokh, Sakau, Uliveo, Doucere point (Lamap), north-east Malekula area (Uri, Litzlitz, Port Stanly and Crab Bay, Tedka and Vao) in the north and two sites (Pinalum, and Lambubu) in the west and southwest of the island. High densities of snakefish, lollyfish, dragonfish and chalkfish were recorded in Avokh with densities in the range of 4 to 10,000 ind. ha^{-1} (Table 4). Golden sandfish was not picked up at Avokh in this assessment. High numbers of sandfish were noted in Peskarus in Uliveo (190 specimens). In northeast Malekula, high densities were reported for lollyfish, greenfish and sandfish at Uri and Crab Bay (Table 5). In the last four sites in west Malekula, lollyfish density was high at Vao and sandfish was noted in Tedka (Table 6).

Table 4. Sea cucumber density for Maskelyne 2000 assessments (sample size in brackets).

Species	Sakau	Peskarus	Soucere	Lamap	Avok
Area (ha)	1.053	0.729	0.36	0.3645	0.216
Black teatfish	0.9 (1)	15.1 (11)		2.7 (1)	458.3 (99)
Brown sandfish	4.7 (5)	49.4 (36)	11.1 (4)		111.1 (24)
Chalkfish		37.0 (27)			4,972.2 (1,074)
Curryfish	2.8 (3)	11.0 (8)		11	120.4 (26)
Dragonfish					5,259.3 (1,136)
Elephant trunkfish		1.4 (1)			
Flowerfish	3.8 (4)	1.4 (1)		5.5 (2)	83.3 (18)
Greenfish	3.8 (4)	1.4 (1)	22.2 (8)		64.8 (14)
Lollyfish	123.5 (130)	856.0 (624)	38.9 (14)	38.4 (14)	4,564.8 (986)
Pinkfish	51.3 (54)	23.3 (17)		16.5 (6)	731.5 (158)
Prickly redfish	0.9 (1)				
Sandfish	2.8 (3)	260.6 (190)		2.7 (1)	291.7 (63)
Snakefish	6.6 (7)	89.2 (65)			10,638.9 (2,298)
Stonefish					9.3 (2)
Surf redfish				2.7 (1)	
Tigerfish		39.8 (29)		2.7 (1)	157.4 (34)
Tiger tail		12.3 (9)			

Table 5. North-east Malekula: Uri to Crab Bay sea cucumber assessments (2000).

Species	Uri	Litzlitz	P/Staley	Crab Bay	Tedka
Area (ha)	0.108	0.126	0.216	0.072	0.216
Black teatfish		7.9 (1)			
Brown sandfish		31.7 (4)		83.3 (6)	9.3 (2)
Curryfish		71.4 (9)	9.3 (2)	222.2 (16)	18.5 (4)
Flowerfish		39.7 (5)			148.1 (32)
Greenfish	157.4 (17)	3,531.7 (445)	1,879.6 (406)		648.1 (140)
Lollyfish	55.6 (6)	3,904.8 (492)	5,310.2 (1,147)	55.6 (4)	648.1 (140)
Pinkfish	46.3 (5)	47.6 (6)	171.3 (37)		64.8 (14)
Prickly redfish		23.8 (3)			18.5 (4)
Sandfish	46.3 (5)			180.6 (13)	37.0 (8)
Snakefish		166.7 (21)			
Surf redfish	9.3 (1)	309.5 (39)	134.3 (29)		4.6 (1)
Tigerfish	18.5 (2)	15.9 (2)			46.3 (10)

Table 6. West Malekula: Vao to Tedka sea cucumber assessments (2000).

Species	Vao	Labubu	Pinalum
Area	0.072	0.072	0.3645 (3,645)
Curryfish	13.9 (1)		
Elephant trunkfish			5.5 (2)
Flowerfish		27.8 (2)	
Greenfish			592.6 (216)
Lollyfish	3,736.1 (269)	138.9 (10)	8.2 (3)
Prickly redfish		13.9 (1)	
Surf redfish	180.6 (13)	41.7 (3)	38.4 (14)
Tigerfish	27.8 (2)	194.4 (14)	13.7 (5)

4. Discussion

In total, 11 species were recorded at Emae, 19 species in Malekula and 12 species in the Banks group. Fishing of sea cucumber was active in Emae during this survey, with Cooks reef being the main fishing ground for the fishers of Emae. The low species presence (seven species) and low densities may indicate fishing pressure in the area. The non-targeted lollyfish was abundant, with notable high densities in Emae and Maskelyne. Lollyfish densities were high at Sulua, Makatea and Tongamea and greenfish density was high at Tongamea. Sandfish (*H. scabra*) was recorded at Vaitini reef; no dedicated assessments were conducted there for sandfish but the findings indicate the presence of this species. Vaitini and Sulua areas are an important mangrove habitat for sandfish. This is a rare set of data on the state of sea cucumbers on Emae, Cooks Reef and Malekula sites. This assessment recorded sandfish at Vaitini, Tedka, Peskarus and Avokh and Crab Bay, in addition to Paunangisu on Efate. Sandfish stocks in these areas need to be monitored to understand the current state. A dedicated assessment on Emae must be undertaken to assess the current state of resources after the ban and proper documentation of sandfish stock of Emae. Sandfish were noted in Peskarus (190 individuals recorded at Tedka Island and Crab Bay). Golden sandfish were not recorded at Avokh in Maskelyne. Management of data and data processing skills were problematic at the time, adding to the problem of the general lack of knowledge on sea cucumber fisheries.

Appendix 2.

Beche-de-mer buying prices in Vanuatu, MSG countries and China

Product	Vanuatu 1990 (Vatu)	Vanuatu 2003 (Vatu)	Vanuatu 2006 (Vatu)	MSG Price (Vatu)	China wholesale price (Vatu)
Amberfish	240		200	1,300	2,900
Black teatfish	400	1,500	1,500	5,000	10,800
Brown sandfish	240	350	500	1,300	4,500
Chalkfish	90	300	200	1,300	4,000
Curryfish	400	850	500	1,900	14,800
Deepwater redfish		500	500	4,200	4,200
Dragonfish			500	1,300	7,700
Elephant trunkfish	80	300	150	1,000	1,700
Flowerfish		259	500	1,300	704
Golden sandfish			2,500	5,700	18,700
Greenfish	560	1,500	1,000	4,700	8,800
Hairy blackfish	400	850	500	1,900	8,500
Lollyfish	80	300	200	1,000	5,800
Pinkfish		300	150	500	5,800
Prickly redfish	400	750	500	4,200	17,200
Sandfish	960	1,800	2,000	8,500	18,700
Snakefish	80	300	150	1,500	3,500
Stonefish		800	500	1,900	10,100
Surf redfish	300	600	500	3,700	7,300
Tigerfish	300	450	500	1,900	5,800
White teatfish	1,000	1,500	1,500	8,000	15,400

Appendix 3.

Sea cucumber density comparisons 2003–2011

Species	2003		2011	
	Mean	SE	Mean	SE
Chalkfish	1,121	444	1,281.0	724.0
Lollyfish	534	191	1,001.3	219.1
Sandfish	734	305	369.0	180.0
Tiger tail	271	211	129.7	104.3
Dragonfish			137.1	80.7
Snakefish	375	294	127.7	63.7
Greenfish	39	22	73.9	27.8
Tigerfish	18	9	71.2	24.1
Curryfish	6	3	41.7	18.8
Pinkfish	39	21	35.6	16.6
Brown sandfish	3	2	55.8	15.9
Hairy blackfish	20	10	44.4	15.0
Red snakefish			19.5	14.9
Golden sandfish			16.8	14.1
Brown curryfish			13.4	13.4
Black teatfish	5	2	20.2	9.9
Elephant trunkfish			7.4	7.4
White teatfish			2.7	1.6
Surfredfish	2	2	0.7	0.7
Deepwater blackfish			0.7	0.7
Stonefish	1	1		

Appendix 4.

Procedure for estimating sea cucumber stock

Step 1. Estimate density from sub-section 3.3. If densities are above the regional reference for most species, progress to step 2, if the densities are below the regional references, stock abundance is not healthy to recommend fishing, fishing should not be allowed.

Step 2. Calculate the reef or habitat area of interest in hectares with the use of GIS mapping software.

Step 3. Calculate the standing stock by multiplying species density by reef habitat area (estimated number of individuals). Caution needs to be exercised here; it is of paramount importance that the variance of density estimates be taken into consideration. A more conservative way to derive standing stocks for harvest recommendation is to apply the lower 95% confidence levels to any extrapolation of mean density.

Step 4. To estimate fishable stock, a proportion of stocks above the minimum species harvest sizes (or size at maturity) is calculated. Multiply this by the total standing stock in step 3 to come up with the total estimated fishable stock.

Step 5. The recommended fishable stock estimates are worked out based on conservative estimates. Here we recommend harvest estimates to be of 30% or less of the total fishable stock. Note that this is to be worked out by site or fishing ground, which can vary from an island as a whole to a specific village reef area.

Step 6. Final fishable stock is then converted to biomass in wet weight and to dry weight, using standard conversion ratios (% weight loss) derived from other geographical locations in the Pacific. A table of sea cucumber conversion ratios is provided in Appendix 5. However, conversion ratio studies for the desired local products should be developed for Vanuatu.

Step 7. The recommended harvest quota is presented to decision makers in a report or advisory sheet detailing the process followed to arrive at the final estimates.

Appendix 5.

Standard conversion ratio for sea cucumber species

Common name	Local name	Unprocessed weight 1 piece (g)	Semi-processed weight (gutted/salted)	Dried weight (beche-de-mer)
Amberfish	Ambafis	3,500	0.5	0.05
Black teatfish	Blak titfis	2,400	0.5	0.10
Blackfish	Blakfis	500	0.5	0.10
Brown curryfish	Braon karifis	650	0.5	0.04
Brown sandfish	Braon sanfis	1,000	0.5	0.04
Chalkfish	Jokfis	750	0.5	0.06
Curryfish	Karifis	2,100	0.5	0.04
Deepwater blackfish	Dipwota blakfis	400	0.5	0.12
Elephant trunkfish	Elefenfis	2,000	0.5	0.13
Flowerfish	Flaoafis	1,000	0.5	0.04
Golden sandfish	Kolten sanfis	1,400	0.5	0.08
Greenfish	Krinfis	300	0.5	0.03
Lollyfish	Lolifis	300	0.5	0.05
Peanutfish	Pinatfis	100	0.5	0.04
Pinkfish	Pinkfis	300	0.5	0.04
Prickly redfish	Paenapolfis	3,500	0.5	0.07
Red snakefish	Red snekfis	300	0.5	0.04
Sandfish	Sanfis	750	0.5	0.05
Snakefish	Snekfis	300	0.5	0.04
Stonefish	Stonfis	650	0.5	0.05
Surf redfish	Sefredfis	850	0.5	0.06
Tigerfish	Taikafis	1,000	0.5	0.04
White teatfish	Waet titfis	2,500	0.5	0.09

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