The status of sea cucumber resources and fisheries management

in Fiji

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by

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Summary

This report presents the results of resource assessments undertaken in Kubulau, Bua, Batiki, Beqa, Ravitaki, Wailevu, Oneata, Naweni and Yalo from August 2012 to June 2013 and describes the present state of sea cucumber fisheries in Fiji. It compares these findings with the results of similar assessments of 10 sites in Lau Province by Jupiter et al. (2013). This information on underwater resources is also cross-checked with fishery landing data collected in the field and export information from the Fiji Fisheries Department and existing reports. In addition, this report presents experiences and perceptions of sea cucumber fisheries shared by communities, fishers, elders and leaders, fisheries officers, exporters, processors and community workers during meetings, visits and discussions.

The team involved in organising these assessments and gathering the information consisted of representatives from the Secretariat of the Pacific Community (SPC), Fiji Fisheries Department, Partners in Community Development Fiji, the Wildlife Conservation Society and other stakeholders who were present at the meeting for the development of a National sea cucumber management plan in Suva in September 2012. This joint effort came about in response to the Fiji Fisheries Department's request for SPC assistance in assessing the sea cucumber fishery and resources in Fiji, as a step towards developing a sea cucumber fishery management plan. Although a sea cucumber fishery has been active for many years in Fiji, there has been concern about unsustainable fishing activities and human health issues related to deepwater fishing activities that use underwater breathing apparatus. Findings of this report provide the basis for actions to improve management to effectively control the fishery.

Resource indicators

A total of 27 species of sea cucumbers are present in Fiji waters, of which around 20 species are important in the commercial beche-de-mer trade and 19 species were recorded from shallow-water assessments; however, fewer than 15 species were present in many of the sites assessed in these surveys. All 27 species (including rare species) are being fished and exported with limited restriction; however, sandfish is prohibited from exports and a 76 mm minimum size applies to all export sea cucumber species. Nine species recently listed as threatened by the International Union for Conservation of Nature (IUCN) (referred to as IUCN Red Listed species) are present in Fiji. Golden sandfish (*Holothuria lessoni*), one of the four species listed as 'endangered to extinction', is rare and although the species was present in the buyers' price list, it was not recorded in recent surveys. The species was also absent from export data for the last 10 years.

Overall lollyfish is the most common species present in most of the sites assessed except in six Lau Province sites (Jupiter et al. 2013). Densities of commercial sea cucumber species across sites assessed in Fiji were some of the lowest recorded among sites in the Pacific Island region from recent SPC assessments and were considerably lower than reference densities for healthy stocks in the region. Densities in a few community-managed areas were slightly higher; one area had high densities for sandfish. However, community-managed areas overall do not have higher densities of sea cucumber stocks than open-access areas. Therefore rebuilding species densities to healthy levels will require the investment of time and effort in additional management approaches.

Across the sites assessed, the majority of the sea cucumbers present in shallow-water fishing grounds are small compared with their common marketable sizes. The number of some species recorded is so low that mean size analysis is not accurate. The sandfish stocks of Kubulau, Wailevu and Nutuvu marine protected area were dominated by young size classes. Although some community-managed areas are helping to slow fishing pressures, these areas were exposed to persistent fishing pressure which is taking its toll on these protected stocks.

Fishery indicators

There were booms in beche-de-mer exports in Fiji in 1986/87 and 1996/97. Production fell between these periods, which is thought to be due to the impact of the Fiji Beche-de-mer Exporters Association's initiative to control the number of exporters during its short existence. After 1998 sea cucumber production again fell to an annual average volume of 243 t and has hovered around this mean production level for more than a decade. The fishery in Fiji has remained open since the last boom period. Exports for 9 out of the 20 commercial species (almost 50% of these species) has declined over the last decade and production of four species — pinkfish, stonefish, dragonfish and

flowerfish — is so low it brings into question the viability of these species. Although sandfish is prohibited as an export, it has appeared in export data in 2003 and 2004, indicating the species has been fished and exported.

The increase in the export of amberfish, brown sandfish, elephant trunkfish and tigerfish is consistent with increased use of underwater breathing apparatus (UBA) for fishing in deeper water. Amberfish export production in particular has increased, which is in line with the finding that this species comprises the highest proportion in UBA fishers' catch. These findings indicate the increased fishing effort in mid- to deep water (10–30 m) and in deep water (>30 m) due to rising number of exemptions granted to use UBA when fishing for sea cucumber.

The number of companies exporting sea cucumbers has increased from 7 in 2003 to 11 in 2013. Data on the number of companies undertaking processing are not reliably collected although the number is expected to be higher than the number of exporters. Many companies have entered and left the Fiji sea cucumber industry due to high competition and limited control on the number of exporters but five companies have been consistently active during the past 10 years. It is often speculated that Fiji's sea cucumber industry is dominated by Asian nationals; however, it was difficult to gather information on company ownership and joint venture arrangements. It is noted that some of the main players in Fiji have been companies owned by Asian nationals, some of whom may be in joint ventures with local partners. The lack of detail on processing and exporting companies is due to the current absence of a licensing system.

A highly complex network links the activities along the production chain, which includs fishing activities, buying, processing, selling and exporting product. Some exporters are also providing incentives to fishers such as the provisions of fishing equipment in return for catch therefor taking exclusive control over the catching and processing of beche-de-mer. The complexity of the network makes it particularly difficult to effectively monitor the flow of products from fishing grounds to export exit points as well as the activities of individual fishers, buyers, processors and exporters. In addition, much of the product value is realised by those involved in the production chain after the product leaves the fishers, who then get low prices for their product. Improving prices for community fishers will require a reduction in the number of levels of middlemen. Currently prices offered for each product vary by area and by buyer, with the result that buyers take advantage of the situation to offer low and irregular prices and on occasion undercut prices.

The number of UBA fishing operators has increased from 9 in 2010 to 25 in 2013. The majority of these operators are based in the Northern Division, where Bua Province is their most popular fishing ground followed by Cakaudrove Province. The use of UBA in the sea cucumber fishery is unregulated, with no limit on species and depth of fishing. Fishing is conducted at wide range depths down to 50 metres and in competition with breath-hold (free) divers. Bad UBA diving practices have resulted in numerous incidents of diving-related harm such as the bends as well as deaths. The high incidence of diving-related accidents in recent times indicates that stocks are being depleted in shallower areas, forcing divers to go deeper and to increase the number of dives per day. This practice is exacerbated by the tendency for middlemen and exporters to lend gear and capital to UBA fishers, which is putting pressure on the fishers to harvest as much product as possible because when they fail to harvest sufficient product, the deal is ended and gear passed on to a new fisher.

The removal of the UBA exemption for fishing sea cucumber will help to stabilise the current situation, protecting sea cucumber stocks in deeper water and eliminating UBA-related accidents for humans.

Community perceptions

Communities in areas assessed agree with the assessment results showing that sea cucumbers are scarce. The fishers are finding it difficult to collect enough sea cucumbers to sell and, although they have tried to establish protected areas, there have been no obvious increases in stock numbers. Community leaders commented that as long as buyers continue to turn up in the village, their people will continue to fish for sea cucumbers. Thus an option to control the fishery is to limit the number of buyers through a licensing system but such regulation is outside the responsibility of community leaders. While some community leaders have decided against the use of UBA, the leaders fear their *qoliqoli* management is at risk from buyers' persistent pressure to gain authorisation for access and their use of cash and the promise of millions of dollars from sea cucumber aquaculture ventures to influence decisions. On the other hand, communities who are exposed to UBA fishing then benefit from the fishery by gaining employment, where their *qoliqoli* owners have decided to allow the use of UBA, other community members do not want to comment on the issue even though they know it is not a sustainable method.

Communities who have taken steps to establish managed areas are concerned about the low number of sea cucumbers and note that it is difficult to conduct surveillance of their area due to the lack of boats and fuel. Community policing is undertaken on a voluntary basis but gaining commitment to this role without a reward or payment is problematic. There are also culturally sensitive issues related to fishing in *qoliqoli* making it difficult to stop a member of the community fishing in a protected area. There was a general lack of information on the minimum size limits for sea cucumbers. Communities do not have access to information on stock status in their area and how much can be harvested. In addition, they do not know standard prices for their product so they cannot tell if the prices that buyers offer are realistic.

Because neighbouring Pacific Island countries have established moratoria on their sea cucumber fisheries, Fiji is now targeted by many beche-de-mer traders as a source of beche-de-mer supplies. The Fiji Fisheries Department recognises that Fiji's sea cucumber fishery is facing rapid depletion of stocks due to heavy fishing pressure including through the increasing use of UBA to collect sea cucumbers for beche-de-mer exports. Given both the increasing fishing pressure and the depletion of resources, the fishery will collapse unless urgent action is taken to control it. Long resting periods will be required to allow stocks to recover; in some cases where stock collapse is extreme, stocks may never recover. In addition, fishery management must address the increasing incidence of dive-related human health issues in the fishery.

For these reasons, it is recommended that:

- the fishery is closed for a period of at least 5–10 years with resources assessed at three-year intervals to determine the status of stock recoveries;
- given that the use of UBA in the fishery is detrimental to deepwater stocks and that, through inappropriate use, it is also detrimental to human health, the use of UBA is banned in the fishery and the ban is effectively enforced;
- the draft National Sea Cucumber Fishery Management Plan is finalised and improved regulatory measures are developed and implemented. Management measures to be incorporated in the plan should include: licences and permit systems for processing and exporting; production quota for licences; licensing and permit fees; gear control; size limits by species; and a prescribed list of species permitted for export;
- operation of the fishery after stock recovery is based on conventional stock assessment and economic valuations of the resources, and opportunities are encouraged for raising the value of the fishery to the local economy through auctioning of licences and/or products or setting minimum product prices; and
- aquaculture and ranching are developed sustainably and broodstock are translocated or introduced.

1. Introduction

1.1 Background

Fiji is a major producer of sea cucumber in the Melanesian region. Sea cucumber is an important source of income for its communities and a few species are consumed locally as food. Nationally sea cucumber is Fiji's second most important commercial fishery after tuna fisheries. For many years the fishery has been operating with few effective management measures. As fisheries in some other Pacific Island countries have been closed to commercial fishing to allow stocks time to recover following overharvesting of resources, beche-de-mer buyers have become increasingly interested in Fiji as they seek other sources of products and therefore the country is under some pressure to harvest its limited resources which are already declining. As with many fisheries in the region, the lack of overall control of the fishery and limited information available are challenges for local fisheries agencies as well as for civil society, making it difficult for them to understand the current state of the fishery and how to improve the situation.

In early 2012 the Coastal Fisheries Programme of the Secretariat of the Pacific Community (SPC) received several requests for technical assistance. In particular, members of the Fiji Locally Managed Marine Area (FLMMA) sought assistance regarding fishing activities using UBA; the Partners in Community Development Fiji (PCDF) regarding resource assessment training needs; and the Fiji Fisheries Department regarding training needs and the development of a National Sea Cucumber Fishery Management Plan for Fiji. SPC's response commenced in August 2012 with resource assessment training followed by consultations in Suva for the development of the National Sea Cucumber Fishery Management Plan. The trained team from Fiji Fisheries Department and the PCDF conducted further assessments over a 12-month period across sites in the provinces of Bua, Cakaudrove, Lomaiviti and Kadavu, as well as Lau and Yako on the western side of Viti Levu.

These assessments generated sufficient underwater information on resources, which was cross-analysed with sea cucumber catch and export information provided by the Fiji Fisheries Department, to determine the current state of the fishery. Some of the information and advisories have been delivered to the Fiji Ministry of Fisheries and Forests as preliminary assessment information to contribute to the development of national policy decisions on UBA fishing. Some management measures have been incorporated in the draft National Sea Cucumber Fishery Management Plan also delivered to Fiji for consideration and broader consultation.

1.2 Sea cucumber resources

Of the 1,200 species of Holothuroidea that have been described globally, 27 species are present in Fiji, of which 20 are important in beche-de-mer production and two are also important food items (Friedman et al. 2008). Sea cucumbers are slow moving and inhabit shallow waters. Most are benthic feeders ingesting sand and detritus matter to digest bacteria and fungi on sediments. Sea cucumbers recycle organic matter on the lagoon bottom and release nutrients, making them available to other organisms and in this way helping to maintain healthy reef systems.

Most species reproduce sexually; however, some of the soft-bodied species of the Holothuridae and Stichopidae families are capable of undergoing asexual reproduction by splitting into two pieces and forming separate animals. Species that adopt both reproductive strategies, such as lollyfish and greenfish, have greater ability to recover after fishing and therefore can be present at high densities (Lee et al. 2008; Friedman et al. 2011). Reproductive maturity is reached at around three to four years of age for most species and spawning occurs during the summer months. A few species have a second winter spawning (Conand 1993). Fertilised eggs drift for several weeks as plankton before settling on the bottom to begin a permanent benthic life. An updated list of commercial sea cucumbers present in Fiji, including their correct common and local names, is provided in Table 1.

Table 1. Sea cucumber species present in Fiji and corresponding value groups.

Code	Trade name	Species	Local name	Value group
AF	Amberfish*	*Thelenota anax*	*Basi*	M
BCF	Brown curryfish	*Stichopus vastus*	*Laulevu*	L
HBF	Hairy blackfish*	*Actinopyga miliaris*	*Dri, driloa*	M
BSF	Brown sandfish*	*Bohadschia vitiensis*	*Vula*	M
BTF	Black teatfish*	*Holothuria whitmaei*	*Loloa*	H
CF	Curryfish*	*Stichopus herrmanni*	*Laulevu, kari, lakolako ni qio*	M
CHF	Chalkfish[#]*	*Bohadschia marmorata*	*Mudra*	M
DWBF	Deepwater blackfish	*Actinopyga palauensis*	*Dri ni cakau*	M
SDWRF	Spiky deepwater redfish*	*Actinopyga* sp. affn. *flammea*	*Tarasea*	H
DWRF	Deepwater redfish	*Actinopyga echinites*	*Tarasea*	H
ETF	Elephant trunkfish*	*Holothuria fuscopunctata*	*Tinani dairo, dairo ni toba*	L
FF	Flowerfish*	*Pearsonothuria graeffei*	*Senikau*	M
GF	Greenfish*	*Stichopus chloronotus*	*Greenfish, barasi*	H
GSF	Golden sandfish[#]	*Holothuria lessoni*	*Dairo kula*	VH
LF	Lollyfish*	*Holothuria atra*[1]	*Loliloli (loli ni cakau)*	L
LM	Loli's mother	*Holothuria coronopertusa*	*Tina ni loli*	L
PKF	Pinkfish*	*Holothuria edulis*	*Lolipiqi*	M
DF	Dragonfish*	*Stichopus horrens*[2]	*Katapila*	M
PRF	Prickly redfish*	*Thelenota ananas*	*Sucudrau*	H
SF	Sandfish	*Holothuria scabra*	*Dairo*	VH
SNF	Snakefish*	*Holothuria coluber*	*Yarabale, ika lo*	M
SRF	Surf redfish*	*Actinopyga mauritiana*	*Tarasea*	H
SSC	Slender sea cucumber	*Holothuria impatiens*	?	-
STF	Stonefish*	*Actinopyga lecanora*	*Dritabua, drivatu*	M
TF	Tigerfish*	*Bohadschia argus*[3]	*Tiger, vula ni cakau, vula wadrawadra*	M
WSF	White snakefish	*Holothuria leucospilota*	?	-
WTF	White teatfish*	*Holothuria fuscogilva*	*Sucuwalu*	VH

Notes:

* The main target species for beche-de-mer.

[#] Species used as traditional/local food.

[1] Lollyfish is present in two different forms, with traders commonly treating the small common lollyfish and large reef lollyfish as separate products even though it is the same *Holothuria atra* species.

[2] Dragonfish is also known as peanutfish or caterpillar.

[3] Tigerfish is also called leopardfish.

1.3 Harvesting activities

All 27 species of sea cucumbers are targeted using a variety of methods, particularly reef gleaning at low tide, snorkelling with the aid of canoes or boats. These fishing methods are used by different groups of fishers to access the different habitats of sea cucumbers (Fig. 1). As many species in shallow water become depleted or difficult to find, fishers are forced to fish more remote reefs and deeper areas through the use of gear such as sea cucumber bombs, long spears, night fishing with torches and, in deep areas, underwater breathing apparatus. Fishing of sea cucumber is conducted within respective *qoliqoli*[1] which encompass several villages.

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

1.4 Processing of products

Processing of sea cucumber into beche-de-mer involves a series of stages, which in Fiji vary depending on the species. Generally the steps are: removing the internal viscera (gutting); rinsing or cleaning; salting; first and second boiling; smoke drying; third boiling; and final drying, which may be by the sun, kerosene or electric heater.

Traditionally fishing households processed sea cucumber and then sold beche-de-mer to middlemen or exporters. Some fishers in rural locations far away from the main transport links still process on a small scale and sell product to roaming or resident beche-de-mer buyers. The more general trend in recent years, however, is to either partly process (gut and salt) harvested products or sell them directly (fresh) to processors or middlemen, who are sometimes based in the community or at provincial towns around Fiji. Centralised processors, which employ labour to process sea cucumber product into beche-de-mer, have been established to improve quality and consistency of product. In Fiji there are three or sometimes four stages of product chain between the fishers and the exporter.

Processing of sandfish for subsistence use involves simply cleaning the sandfish in warm water, scraping the outer body wall and either cooking it or serving it raw.

[1] Customary fishing area.

1.5 Export and domestic sales

Sea cucumber is an old fishery in Fiji. It can be dated back to 1813 and early records show approximately 600 t were exported from 1827 to 1835. In 1834, however, the sea cucumber populations were considered depleted on reefs of the Western, Central and Northern Vanua Levu and Southeast Viti Levu (Ward 1972). The industry then remained quiet for over a century before a moderate increase in production over the late 1970s to early 1980s. In the mid 1980s exports grew rapidly due to resurgence in demand from the Asian (particularly Chinese) market and high beche-de-mer prices. By 1988 production had increased to 717 t (and quite possibly more because a considerable amount of product appeared to go through Customs classified as 'miscellaneous molluscs') before it declined to 149 t by 1993. A second boom in production followed in 1996–1997. In the height of the beche-de-mer trade in the 1980s and 1990s, a total of 13 species were important in Fiji: the high-value hairy blackfish, white teatfish, black teatfish, sandfish and golden sandfish; and the low-value tigerfish, brown sandfish, pinkfish, elephant trunkfish, flowerfish, greenfish, amberfish and prickly redfish (Preston 1988).

Fishing of sea cucumber has continued in Fiji since then and is a common activity involving men and women, young and old, in local communities. Export of beche-de-mer is dominated by local Asian businesses in joint ventures with local partners. There is currently no fisheries export licence for exporting sea cucumber; however, the Fisheries Department keeps records of exporters, based on export permit information. The number of export companies has fluctuated over time with the changing fortunes of the industry. From just three export companies in 1986, the number rose to 24 in 1988 before dropping to 12 in the early 1990s when the Beche-de-mer Exporters Association began to control the number of licences (Adams 1992). By 2003 there were seven registered exporters, which increased to 12 in 2012/13 (Fiji Fisheries Department 2008; Carleton et al. 2013). As reported in Section 4.1.1, however, these official statistics appear to underestimate the number of companies involved in the industry more generally: in 2009, for example, a total of 19 companies were involved in processing and exporting beche-de-mer (Fiji Trade and Investment Board 2009).

China is the main market, importing over 90% of Fiji exports via Hong Kong; other markets are developing in the United States and Singapore.

1.6 Management of the fishery

National management policy and regulations: The sea cucumber fishery has been operating for many years with little formal management apart from measures introduced in the 1980s. In 1984 the Government approved the sea cucumber exploitation guidelines to restrict harvesting and processing of sea cucumber to Fiji nationals. By 1988 a ban on the export of *Holothuria scabra* (sandfish or *dairo*) and a minimum export size limit of 76 mm (3 inches) on all sea cucumber products had been introduced. The prohibition on the export of *H. scabra* came about because of the importance of the species as a local food item (Adams 1992). However, as early as two years after the minimum size regulation came into force, quantities of undersize beche-de-mer export were being reported (Kinch et al. 2008). The lack of effective enforcement of the regulations continues to be evident, with the export of sandfish (*H. scabra*) and of undersize sea cucumbers in recent times (Ram et al. 2010). Moreover, there is no national plan to guide management of the fishery at national, provincial and community levels and to control fishing activities.

Export permit: Under the Customs Act 1986, consignments bound for overseas destinations must be declared. Sea cucumber exports are therefore monitored by export declaration under the Customs Act. The export permit applications provide information on product quantity and prices by species.

Inshore fishing licence: A standard inshore fishing licence is issued for any fishing activity, which covers both finfish and invertebrates and use of motorised or non-motorised boats including canoes. A fishing licence fee is charged for each boat, with charges varying according to the type and number of fishers involved (Table 2). Reef gleaning, including sea cucumber collection, is part of this licensing system although it has not been enforced. Currently fishing and processing of sea cucumbers operate under this same fishing licence. Given the country is spread over such a wide geographical area and a high number of sea cucumber fishers are involved, it is extremely difficult to effectively enforce the current licence system.

Table 2. Standard inshore fishing licence costs in Fiji.

Licence type	Cost (FJD) per annum
Captain licence	$6.08
Crew licence	$1.52/crew
Fishing boat (skiff) licence	$1.52
Fisher with a permit (either fishing from shore, hand line, gleaning or hand collection) and without a boat	$6.08
Vessel registration, captain, skiff and four crew members	$6.08 + $1.52 + ($1.52 x 4) + $6.08 = $31.92
Boat without crew	6.08 + $6.08 = $12.16

Underwater breathing apparatus exemption: An inshore fishing licence holder can use UBA after the written approval of the Permanent Secretary of the Ministry of Fisheries and Forests. The applicant for a UBA exemption must produce a certificate from the Ministry of Labour that certifies the equipment is safe for use. Catch data are to be provided as a condition of the inshore fishing licence but this condition does not apply to UBA use.

Community-based management: Coastal areas and resources are managed at the community level, following a long tradition in Fiji. Many communities throughout the country have marine resource management action plans. These plans identify areas that are closed periodically as well as no-take areas, and provide for education on the need for sustainable resource management. However, poaching in some community-managed marine areas has limited the effectiveness of community management initiatives (Friedman et al. 2008; Sirilo Dulunaqio, WCS Officer, Bua Province, personal communication 2012; Fiji Times 2011). Community fish wardens do not have the funds and equipment needed to effectively protect fishing areas from poachers. In addition, getting communities to manage sea cucumber fishing when it is being driven by external market forces is proving to be a challenge beyond the control of communities.

2. Purpose and objective of this report

Resource assessments in the past have documented high densities of sandfish and hairy blackfish (Preston et al. 1988). Assessments in 2003 and follow-up surveys in 2009 revealed the species remained diverse while their numbers in Muaivuso, Dromuna, Lakaba and Mali were low (Friedman et al. 2008, 2011). Resource assessments undertaken by the partners of the Fiji Locally Managed Marine Area network (FLMMA) were focused on marine resources other than sea cucumbers so provided only limited information on the sea cucumber resources. Sea cucumber landing and export data submitted by licensed fishers, gathered from local markets and from export permits, were available but were not routinely assessed and used for management decision-making.

This report presents the results of the analysis of available fishery-dependent information and results of underwater resource assessments in surveys over the last 12 months (August 2012 to June 2013) and provides recommendations for effective management.

Specifically the report:

1. presents an overview of the current state of the sea cucumber fishery in Fiji by looking at trends in export companies, fishing activities, and export composition and production;
2. evaluates the sea cucumber resources in selected sites, focusing on species presence and rarity in the fisheries, their abundance levels and population size structures across sites and habitats in comparison with healthy stock sizes and densities recorded in the Pacific region;
3. evaluates current national, provincial and community management measures and proposes improvements;
4. as an output of a training process for officers from the government and collaborating partners, serves as the basis for initiatives to improve the assessment protocol, reporting of results and provision of specific management advice on sea cucumber fisheries in Fiji; and
5. provides supporting information on the use of underwater breathing apparatus and the National Sea Cucumber Fishery Management Plan for Fiji.

3. Methodology

3.1 Fishery assessment

Beche-de-mer export data were provided by the Fiji Fisheries Department in the form of both raw data and summarised data for the period 2003 to 2013 from Fisheries Department Annual Reports (2003–2008), Kinch et al. (2008) and Carleton et al. (2013). Catch data were collected in the field by the assessment teams whenever available during assessment visits, as in Kubulau and Bua, the Lau group. Fiji Fisheries Department provided catch data for the Northern Division (Nanise Kuridrani, Fisheries Officer, Northern Division); survey results from the islands of Koro, Gau and Nairai in the Lomaiviti Province (in Fiji Fisheries Department 2010); and data generated from field surveys.

Fishers and community leaders provided information on fishing activities and experiences during informal discussions, as did fisheries officers and participants in the sea cucumber assessment training. Community views and perceptions in Batiki, Serua and 10 islands in Lau Province came from officers of Partners in Community Development Fiji (PCDF), Wildlife Conservation Society (WCS) and the Institute of Applied Science, University of the South Pacific (USP-IAS) through their work in various communities (Jupiter et al. 2013). Stakeholders also expressed their views through the Fiji Locally Managed Marine Area network group and at the sea cucumber fishery management workshop held at Southern Cross Hotel, Suva in September 2012.

3.2 Resource assessment and data presentation

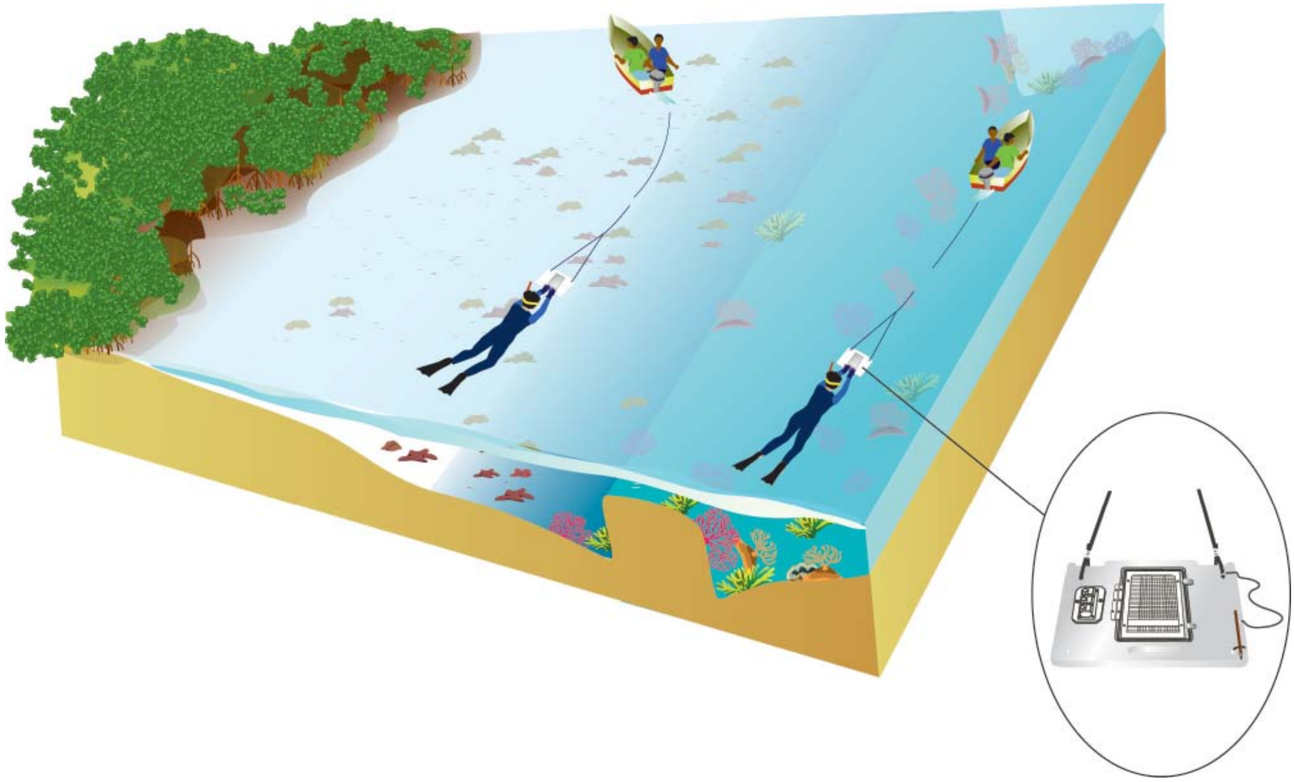
The number of sites selected for this assessment was based on what the partners involved in the assessments (Fiji Fisheries Department, PCDF, SPC) could achieve over the period August 2012 to June 2013. The provinces of Bua, Cakaudrove, Macuata, Lau, Lomaiviti and Kadavu in the Northern and Eastern Divisions of Fiji were the main targeted areas. Shallow-water reefs and lagoons (0–10 metres depth) were the focus as they are the main habitats for over 80% of commercial sea cucumber species.

The assessments in Kubulau and Bua Districts were part of SPC training in invertebrate resource assessment. The two sites differ in their sea cucumber fishery characteristics: conservation measures in Kubulau are relatively common, with many no-take marine protected areas, while they are less common in Bua where fishers use UBA to collect sea cucumber. Additional sites — Wailevu, Naweni, Dakuibega, Oneata and Yalo — were assessed according to the marine resources inventory programme of the Fiji Fisheries Department and Batiki island as part of the PCDF pilot community resource management activity.

Assessment methods follow the standardised assessment protocols that SPC is promoting for Pacific Island sea cucumber fisheries (Fig. 2). That is, over a large area of reef a manta tow is used to assess abundance and distribution of species, while reef transects are used over smaller areas to assess abundance and size distribution (Eriksson 2006; Friedman et al. 2008, 2011; Pinca et al. 2010).

Manta tow surveys, adapted from English et al. (1997), covered 3,600 m^2 of reef area per station; and reef transects (reef benthos transect, RBt, and soft benthos transect, SBt) covered an area of 240 m^2 per station. Data were entered in the Reef Fisheries Integrated Database (RFID) in Fiji and at SPC Noumea during attachment training in March 2013 and analysed to assess species presence, abundance and size distribution. Other data for Fiji sites held in the RFID were extracted and used where necessary in the analysis of trends.

A



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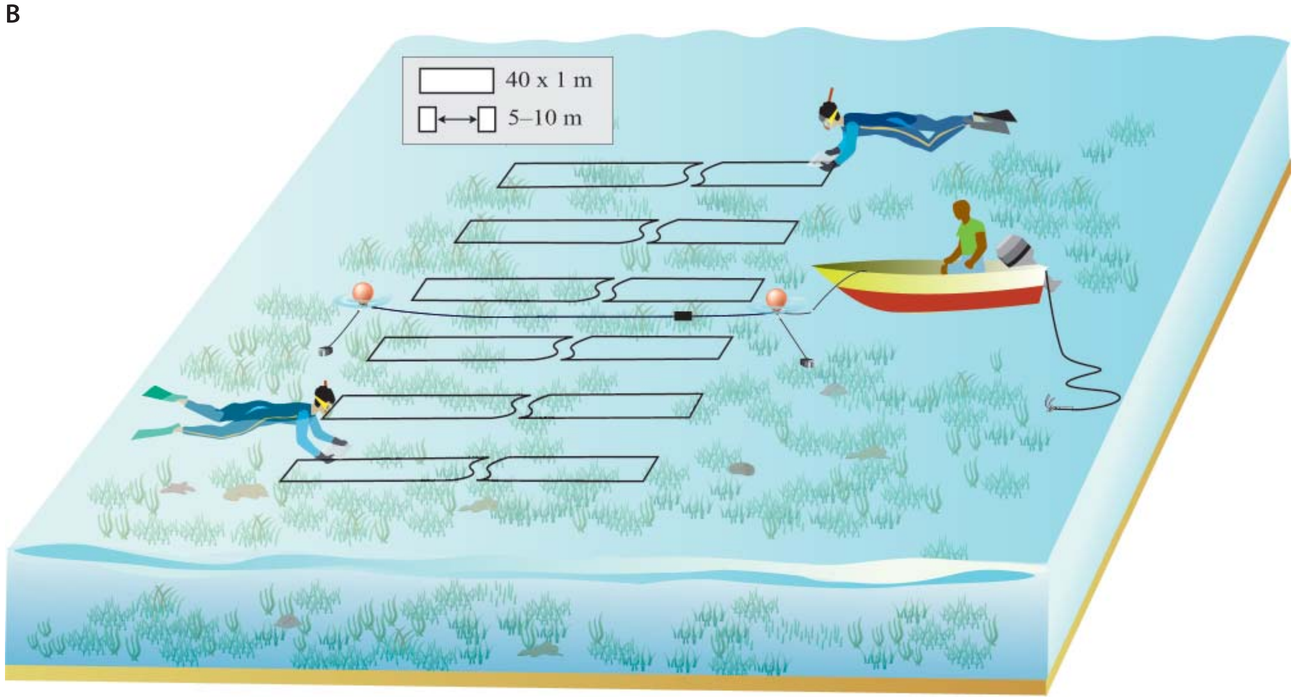

Figure 2. Assessment methods adopted for sea cucumber surveys at sites in Fiji.
A: manta tow; B: reef benthos transects (Illustration by Youngmi Choi, SPC).

4. Results

4.1 Fishery assessment

4.1.1 Export companies and UBA exemption

The number of companies involved in the sea cucumber industry in Fiji is not correctly reported. According to the Fiji Trade and Investment Board (2009), a total of 19 companies were involved in buying, processing and exporting beche-de-mer in 2009 although it is not known how many of them were involved in exporting activities specifically. In 2011 the Mai Life magazine reported 23 companies were active in the trade, of whom 14 were exporting beche-de-mer (Mai Life 2011). Based on the Fiji Fisheries Department's records in its Annual Reports, sea cucumber export companies increased from seven in 2003–2008 to 11 in 2013 and five companies have been continuously active during the period 2008 to 2012 (Fig. 3).

The number of new companies entering the industry rose from three to six over the period 2008–2009 (while others left the industry, reducing the overall total to 10). Detailed information about these companies is not available although there are indications that foreign and local citizens of Asian ethnicity are operating major exporting business, and some Fijian and Indo-Fijian business owners are in various forms of joint venture arrangements.

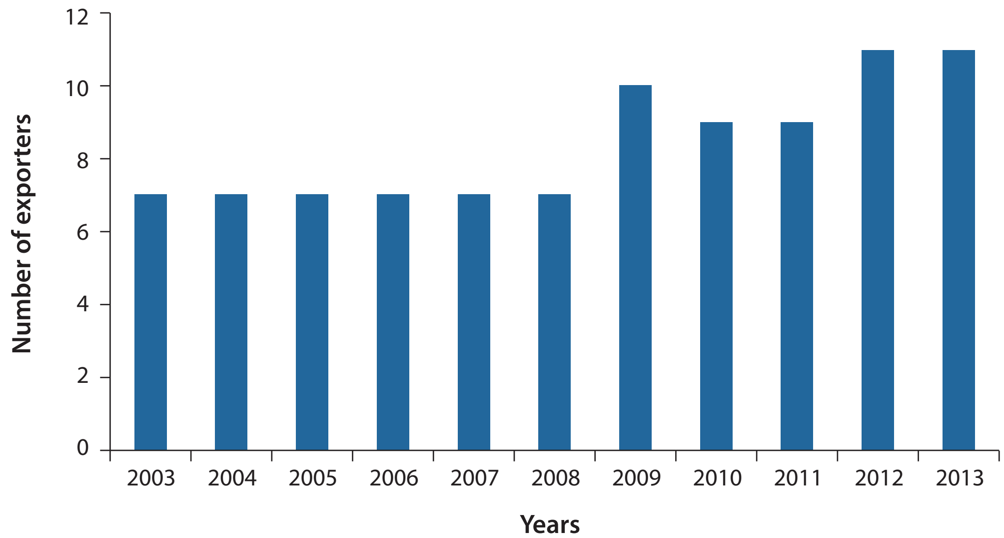

Figure 3. Number of sea cucumber exporting companies in Fiji, 2003–2013 (Fiji Fisheries Department).

Fishing for sea cucumber with UBA (Fig. 4) is an organised operation in which the participants use bathymetry maps, global positioning system (GPS) and depth sounders to identify a suitable location and depth for fishing. People who hold an exemption to use underwater breathing apparatus to harvest holothurians are known as operators or middlemen and are generally Fiji nationals. The exemption holders (or other middlemen) employ boat drivers, divers and processors; in many cases, they supply the fishing gear such as boat(s), compressor(s), and snorkel/diving and UBA. They also often pay the operational costs, recovering them from the catch value or processed product value. In this way, the gear owners have exclusive control over the fishing and processing operations until they have recovered all operational costs and cost of fishing equipment, and they can set or enter into an agreement on, product prices. Such arrangements put the UBA fishers under pressure to produce a high-value catch as, if they cannot repay the equipment and operational costs as agreed, the operator or middlemen may reposess the equipment and lend it to other fishers instead.

Employees of UBA operators are paid based on the value of daily catch landed at a typical share of 60% for the operator, 20% for the fisher and 20% for the boat owner (Lui, Bua Province Fisheries Officer, personal communication 2012). UBA fishing is conducted from small fibreglass banana boats or skiffs with an engine size of 40 hp or more and with four to five divers plus a boat driver per trip. A typical fishing trip begins at around 9 a.m. and ends around 1 p.m., with a maximum of three hours of fishing. Sea cucumber UBA fishers will dive to great depths (50–70 m) with minimal surface resting periods between dives. Increased use of UBA fishing has greatly increased the incidence of the bends and paralysis and has led to some deaths, primarily because fishers have not followed safe diving practices. Reported dive-related cases admitted to Colonial War Memorial Hospital in recent years up to 2012 stand at 108 (William Saladrau, personal communication 2012) and two UBA fishers died in June 2013 in Lau Province (Jupiter et al. 2013; Sanaila Naqali, Secretary of Fisheries, personal communication May 2013).

The use of UBA has increased over four years from nine operators in 2010 to 25 in 2013 (Fig. 5, left bar chart). The majority of these operators (60%) were based in Northern Division (Vanua Levu in Bua and Cakaudrove Province) (Fig. 5, right bar chart). Appendix 2 outlines a detailed breakdown of distribution of UBA survey coverage by Province.

Figure 4. UBA fishing gear at a sea cucumber fishing campsite in Fiji.

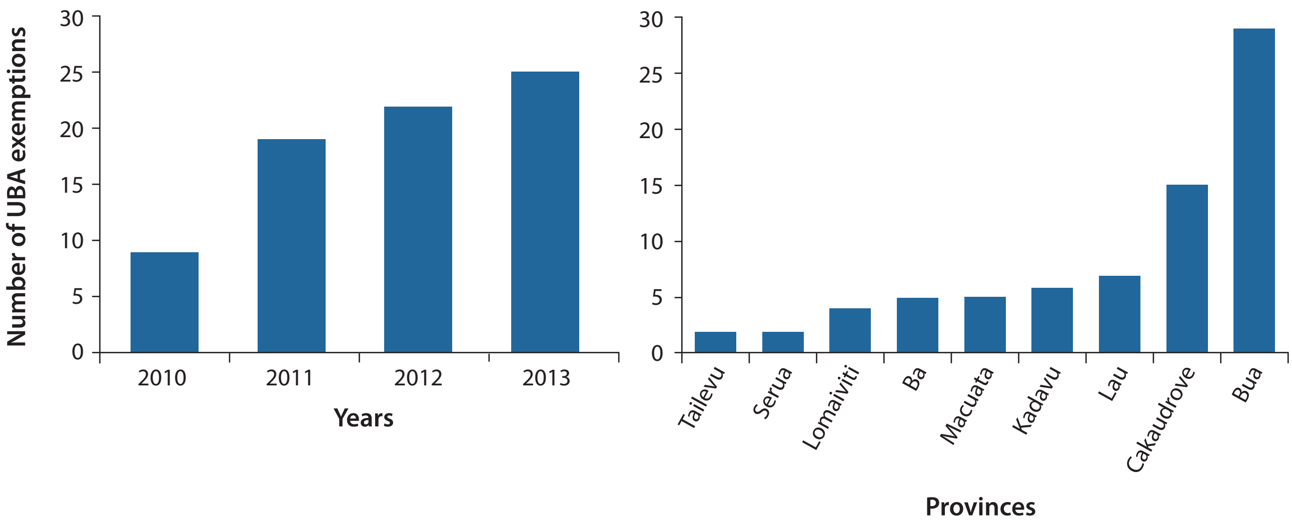

Figure 5. Number of UBA operators, 2010–2013 (left) and distribution by province (right).

4.1.2 Sea cucumber processing and quality control

Sea cucumber processing includes processing for human consumption or processing into beche-de-mer for export to overseas markets.

Processing of *dairo* (*H. scabra*) for local consumption is a simple process involving gutting, removal of outer skin layer, cleaning and cooking or consuming raw.

Processing of beche-de-mer entails a sequence of actions to turn wet products into a dry commodity. Key steps include caring of the catch during fishing operation, gutting, rinsing and cleaning, salting, first boiling, second boiling, smoke drying, third boiling, sun drying and drying using kerosene or electric heaters. Traditionally fishing households processed sea cucumbers to make fully dried products. But, over the years, exporters and buyers have slowly taken over processing in Fiji in an effort to improve quality. Middlemen processors, stationed in the villages, often buy raw products and process them to the finished stage.

However, various arrangements are possible in the complex processing and marketing chain in Fiji, in which different combinations of players are fishing, buying, processing, selling and exporting. Because of this complexity, it is difficult to trace products from fishing grounds, fishers, processors to an exporter for effective monitoring purposes. Moreover, many fishers in Fiji still produce low-quality beche-de-mer in this multi-layered system (Ram et al. 2010).

To assist understanding of the complex processing system, three levels are described below: (1) village-based processing, (2) processing by UBA operators; and (3) processing by export operators. With better understanding of the chain and players involved, it can be easier to create a more organised system of product development to improve the quality and value of the product.

Level 1: Village-based processing

These are individual fishers, households or small-scale, village-based processors (Fig. 6) normally in remote areas away from main transport links. Fishers in this situation process their catch to fully dried products although consistency and quality may be an issue.

Figure 6. Fisher processing the catch at village level.

Level 2: Sea cucumber processing by UBA operators

The UBA operators near the main highway can sell their raw catch directly to a processor. In areas away from the main road, buyers visit on a weekly basis to buy fresh and semi-processed products (Fig. 7). Boiling requires a lot of fuel wood which can be difficult to supply in a village; operators often prefer to set up fishing camps close to fishing grounds and near forest areas for easy access to fuel wood.

Figure 7. Processing of sea cucumbers by a UBA operator at a fishing campsite.

Level 3: Sea cucumber processing by exporting companies

Export companies based in a town centre such as Labasa, Suva or Lautoka also buy raw or partly processed products and undertake processing to the final drying state. These processors employ workers to gut, clean, salt, boil, smoke and dry products using a range of drying methods — such as firewood smokers, kerosene or gas heater, sun drying and / or electric oven — to bring products to the required moisture level (Fig. 8).

Figure 8. Processing of sea cucumbers by an exporter in the main town.

4.1.3 Domestic market landings and local sea cucumber prices

Sandfish (*dairo*) is an important subsistence species in Fiji. Landings at local markets dropped from an average of 34 t in the period 1986–1991 to an average of 14 t in 2003–2005 (Fig. 9) (Richards et al. 1994; Fiji Fisheries Department 2003, 2004, 2005). Sandfish has been prohibited from commercial exports since 1988; however, production up to 1991 is likely to be mixed with other beche-de-mer exports. A noticeable drop in sales in 1992 could have resulted from the enforcement of the ban on sandfish exports. Consistent landing data would have provided better information on production trends for this species.

The mean price of *dairo* in 1992 was FJD 1.77 per kg; it increased to FJD 4.00 per kg in 2003 (FJD 2.50 Northern, FJD 5.00 Western and FJD 4.00 Central Divisions) and dropped to FJD 3.16 per kg in 2004. Estimates of landings for home consumption and direct sale to restaurants are not available.

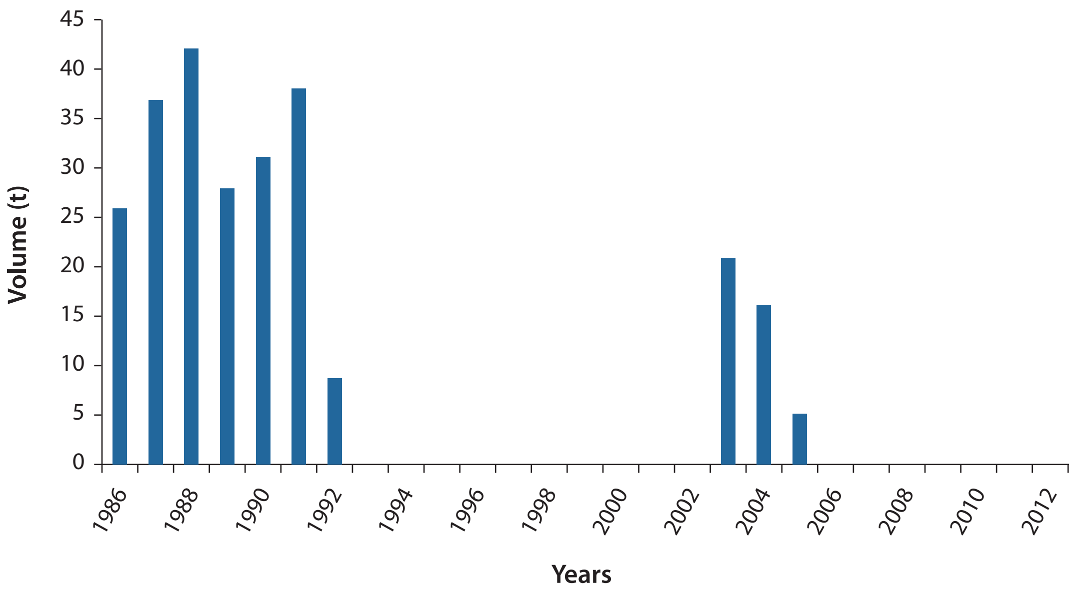

Figure 9. Landing of sandfish (*dairo*) at markets in Fiji, 1986–2012.

Sea cucumber prices vary according to:

- species — different species command different prices;
- processing stages — which range from raw / unprocessed to partly processed to fully dried product; and
- the size and weight of sea cucumbers — smaller specimens contain less flesh and are lighter, therefore fetch a lower price. Conversely the larger the specimen, the higher the price. For instance, the larger white teatfish (*sucuwalu*), known as 'jumbo' by Fiji operators, can fetch FJD 150.00 per piece in live or unprocessed form.

Table 3 provides price information from Bua in the Northern Division based on the maximum price reported by fishers and middlemen buyers in August 2012.

Table 3. Sea cucumber prices per kilogram (partly and fully dried products) in Bua Province, Fiji, 2012 and average regional export price paid to fishers for high-grade, fully dried product.

Trade name	Fijian name(s)	Price in Bua# (FJD)	Regional price (FJD)	Regional price (USD)	Value group
Sandfish*	*Dairo*	25	169	90	VH
White teatfish	*Sucuwalu*	150	157	84	VH
Golden sandfish	*Dairokula*	100	112	60	H
Black teatfish	*Loaloa*	120	99	53	H
Greenfish	*Greenfish, barasi*	90	94	50	H
Prickly redfish	*Sucudrau*	80	84	45	H
Deepwater redfish	*Tarasea*	60	84	45	H
Surf redfish	*Tarasea*	60	73	39	H
Stonefish	*Dritabua, drivatu*	85	37	20	M
Hairy blackfish	*Dri*	80	37	20	M
Tigerfish	*Tiga, vula ni cakau*	45	37	20	M
Curryfish	*Laulevu, lokolokoni qio*	30	37	20	M
Snakefish	*Samu ni uti*	25	30	16	M
Flowerfish	*Senikau*	60	26	14	M
Brown sandfish	*Vula*	35	26	14	M
Dragonfish	*Katapila*	25	26	14	M
Amberfish	*Amber, 4 corner, basi*	20	26	14	M
Chalkfish	*Mudra*	7	26	14	M
Elephant trunkfish	*Tinani dairo, dairo ni toba*	25	20	11	L
Reef lollyfish	*Loli ni cakau*	25	20	11	L
Lollyfish	*Loliloli*	15	20	11	L
Pinkfish	*Lolipiqi*	25	11	6	L
Loli's mother	*Tinani loli*	10			

Source: Carleton et al. (2013)

Notes:

* Species protected from exports.

Bua Province prices are maximum prices reported for product stages.

A challenge for fishers is that local buying prices vary between buyers and between areas, and they lack information on international market prices, so many fishers do not know what realistic selling prices are. For example, sandfish (*dairo*) is sold for FJD 25.00 per kg for fully dried product and FJD 4.00 per kg for wet product in Bua Province yet this high-value product is ranked as the most valuable product in regional terms, fetching FJD 169.14 per kg (USD 90.00 per kg) (Carleton et al. 2013). Moreover, even though this species is prohibited from exports, beche-de-mer buyers are purchasing it from fishers.

4.1.4 Beche-de-mer export quantity

Two booms in beche-de-mer export production were experienced, first in the mid 1980s and again in the mid 1990s, with lower levels of production between these periods (Fig. 10). Some of these production figures are likely to be slightly underreported as some beche-de-mer products were exported as 'miscellaneous molluscs' (Adams 1992). One reason why production fell during the late 1980s to early 1990s is that the Fiji Beche-de-mer Exporters Association prevented new export operators from entering the market, which kept the number of exporters at 12 (Adams 1992). Despite the effectiveness of this initiative, the Government discouraged it and ultimately discontinued the Fiji Beche-der-mer Exporters Association in an effort to open up the industry to local participants. The removal of this barrier resulted in the second boom in export production from 1995 to 1997.

Exports have levelled off since then, averaging 243 t annually over the last 13 years. The increase in UBA exemptions after 2009 may have led to the increase in production of deepwater species such as amberfish, brown sandfish, elephant trunkfish, tigerfish and white teatfish. As for most sea cucumber fisheries in the Pacific region, Fiji export production is now in a 'bust' period, with many of the fisheries with similar stock status being placed under moratoria.

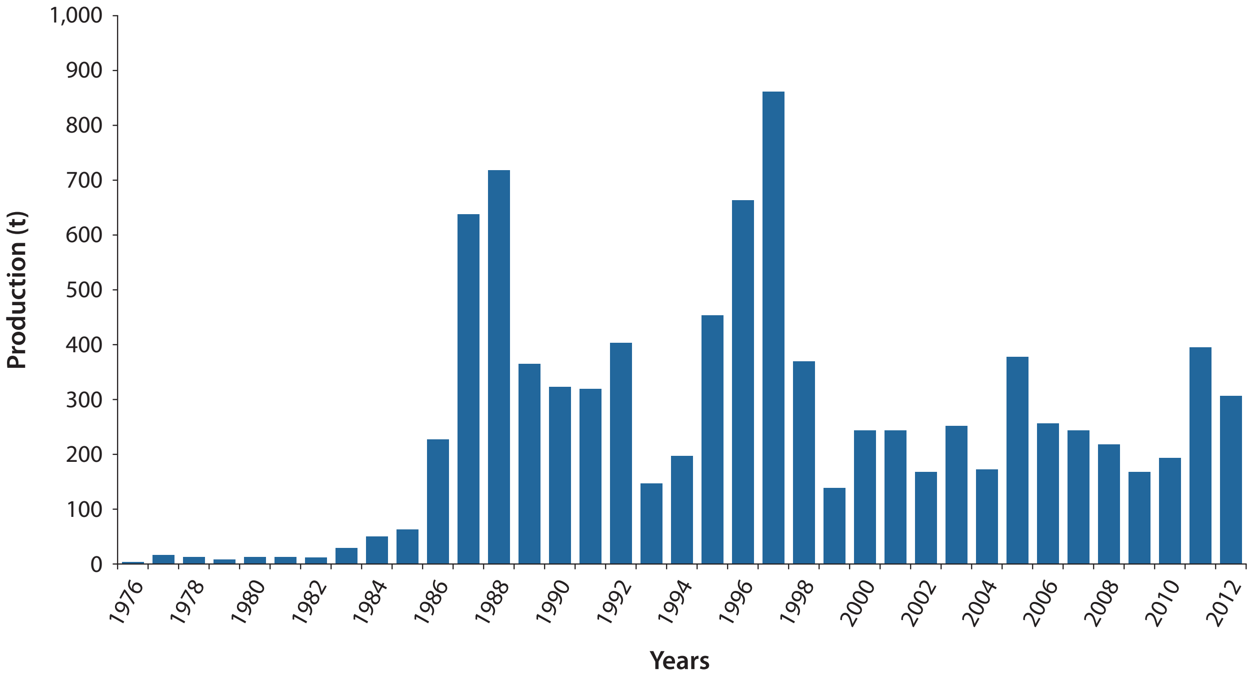

Figure 10. Beche-de-mer exports from Fiji, 1976–2012 (Fiji Fisheries Department).

Exports of beche-de-mer are recorded in dry weight and its corresponding wet or unprocessed quantity is not known. Converting export dry weight to wet weight is useful to understand wet weight production in relation to export commodities of other fisheries such as fresh tuna. In Figure 11, dry weight export production of beche-de-mer for the past 10 years has been converted to wet weight, using best available species conversions, and compared with total tuna catch (combined Fiji longline and pole-and-line catches). Fiji tuna production includes catch from the Fiji exclusive economic zone (EEZ), other EEZs and international waters accessed by Fiji-based fishing vessels (Western Central Pacific Fisheries Commission 2012) while sea cucumbers were exclusively taken from Fiji's coastal reef systems.

Production of beche-de-mer in wet weight fluctuated over the 10-year period from 4,014 to 9,763 t, with an average of 6,600 t over the period 2003–2012 (Fig. 11). Compared with tuna fisheries production as measured by wet weight, sea cucumber production is around 47% of fresh tuna production for the period 2003–2008. The sea cucumber fishery is therefore important in contributing to export production and thus to the national economy, and effective management is needed to ensure its sustainability into the future.

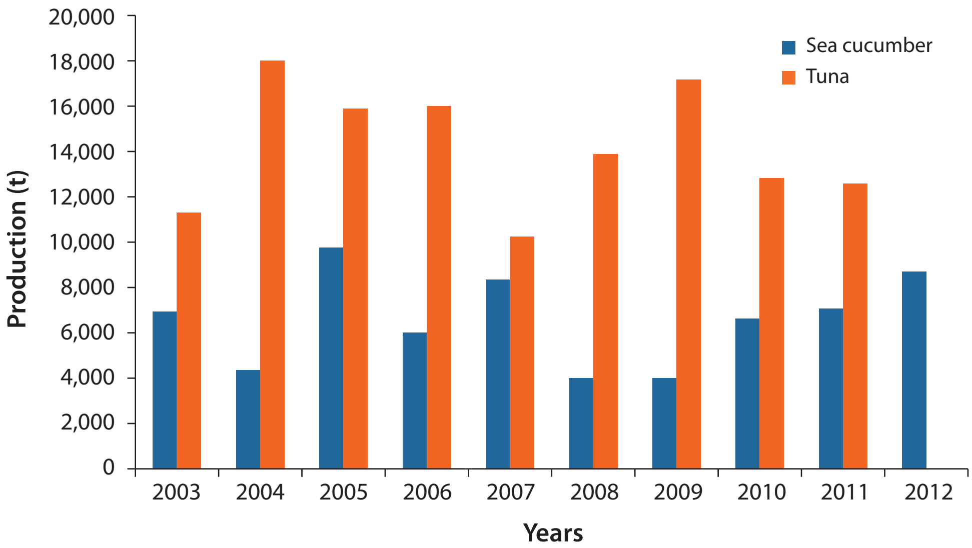

Figure 11. Total export of sea cucumber (left bar) and tuna (right bar) from Fiji, 2003–2012.

4.1.5 Catch and export composition

The main species targeted before 1988 were hairy blackfish, white teatfish, black teatfish and sandfish for the high-value groups and lollyfish, stonefish and deepwater redfish for the medium- to low-value groups of species (Kinch et al. 2008). Hairy blackfish or *dri* comprised 90% of sea cucumber exports in 1988 (Preston 1990); however, in the 10 years from 2003–2012 the proportion fell to 6%.

In recent years all species of sea cucumbers have been targeted in response to the increasing demand and higher prices paid to fishers. From 2003–2012 production trends were in decline for nine species: average exports have fallen annually for black teatfish, hairy blackfish, curryfish, deepwater redfish, greenfish, chalkfish and prickly redfish; for lollyfish and white teatfish they fell in the second five years (Fig. 12 and Appendix 4). A further four species (dragonfish, flowerfish, stonefish and pinkfish) had very low production levels during the same period (Fig. 12) and their populations may have collapsed.

Given that amberfish and white teatfish are deepwater species, their production levels indicate that fishing in deep water (>25 m depth) increased in the four years from 2009 to 2012. Moreover, increases in the catch of shallow- to mid-water species such as brown sandfish, tigerfish, elephant trunkfish, and curryfish over the same period indicate that while white teatfish and amberfish are the main target species, mid-water species are also being collected (Fig. 12). High production levels of low-value species such as lollyfish and snakefish are typical of a heavily exploited fishery and the increase in mean exports over 10 years (Fig. 12) suggests high production of these fast recovery species may not last.

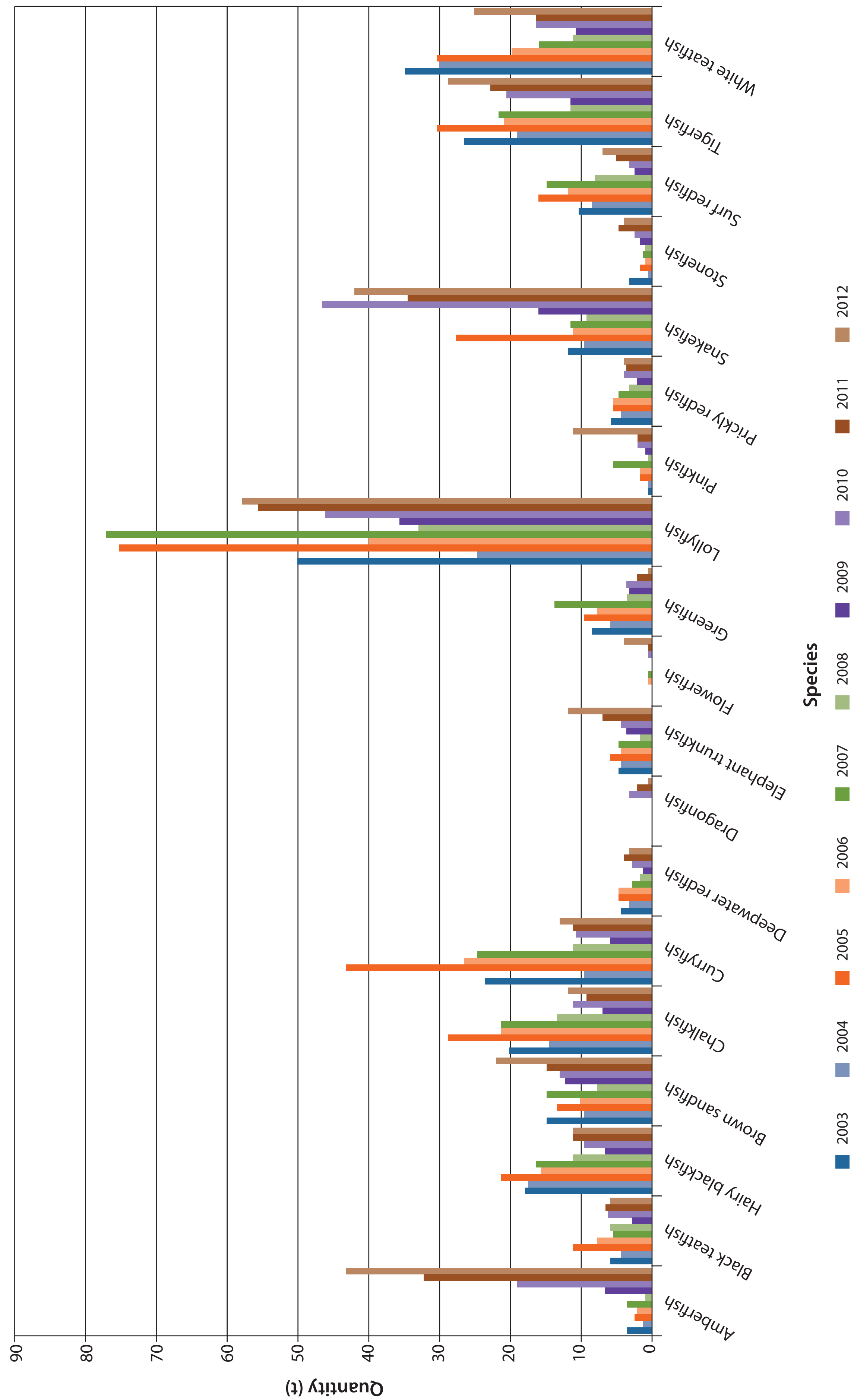

Figure 12. Beche-de-mer export composition for Fiji, 2003–2012 (Fiji Fisheries Department).

Catch composition for gleaning fisheries is dominated by lollyfish as in Bua (90% of catch recorded), in Oneata, Koro Island (Fiji Fisheries Department 2010) and in Lakeba, Lau (Friedman et al. 2008). Fishers using a combination of reef gleaning, night fishing, spears and bombs caught more species — for example, 15 different species were recorded in Kubulau catches (Fig. 13, bottom graph). Elephant trunkfish, tigerfish, brown sandfish and curryfish are harvested in mid-water (10–30 m) habitats. High catches of white teatfish and amberfish dominated the catch of fishers who used UBA (Fig. 13, top graph). Fishers who use UBA to harvest stocks in deeper areas have higher catches than glean and snorkel fishers and can access many larger specimens in deeper water that are important for reproduction.

The value of sea cucumber fisheries declines as the quantity of high-value products decreases and supply shifts to medium- to low-value species. For this reason, the price of medium- to low-value species has increased in recent years and some species have graduated to a higher-value group. Production quantity is assessed by four value groups based on current Fiji prices from this study and from Carleton et al. (2013), who used low-, medium-, high- and very high-value groups (see Table 3 in Section 4.1.3). Based on this grouping system, the production of the low- and medium-value species increased from 71% of exports in 2003 to 85% in 2012 (Fig. 14). The production of very high-value species decreased from 15% of exports in 2003 to 8% in 2012. These trends are an indication of change in catch composition due to higher value species become rare and harder to find.

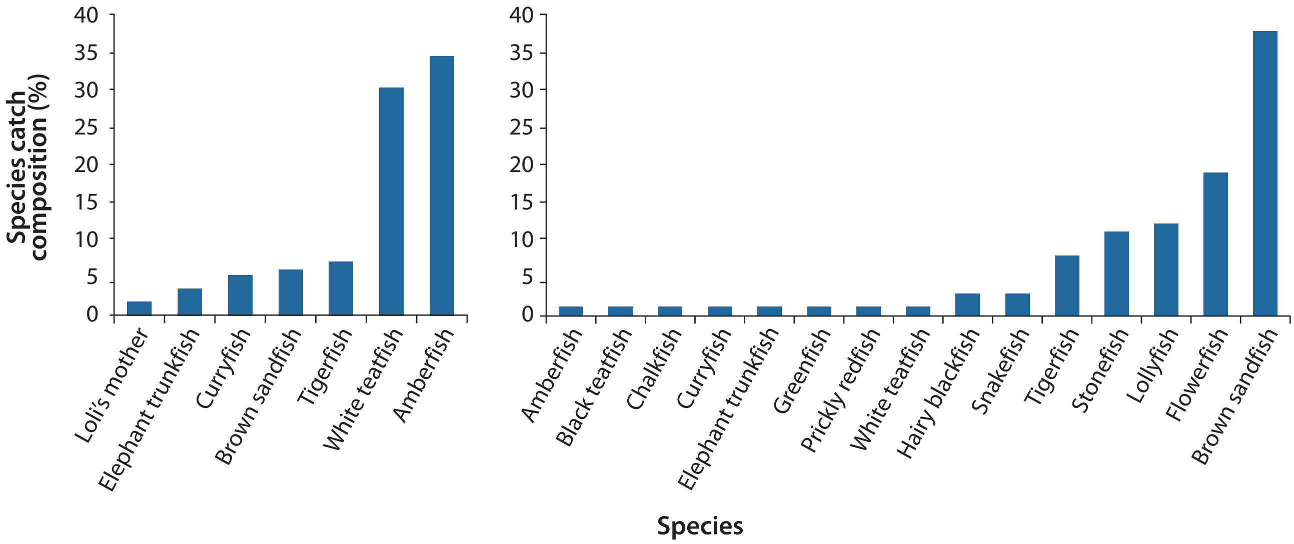

Figure 13. Typical catch composition for UBA fishing (left) and other methods combined (right).

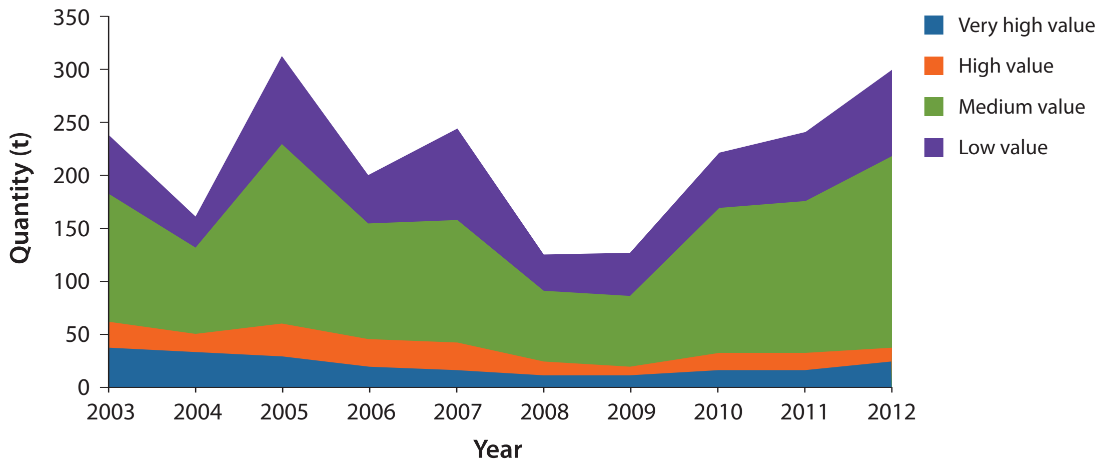

Figure 14. Export quantity by value groups, 2003–2012.

4.1.6 Beche-de-mer product sizes

The existing regulation imposing a minimum size limit of 76 mm for all beche-de-mer products has not been adequately enforced for beche-de-mer exports. Having a single size limit for all species is inappropriate due to differences in species biology, particularly the age and length at which species reach full maturity. For example, studies of size at maturity indicate that the minimum harvest size limit for white teatfish (*H. fuscogilva*) should be 350 mm for wet length or 150 mm for dried length. Sea cucumbers of all species and sizes (juveniles to adults) are being harvested, processed and exported, as observed in these assessments (Fig. 15) and as reported in earlier studies (Adams 1992; Kinch et al. 2008; Ram et al 2010; Purcell et al. 2011).

Figure 15. Varying sizes of sea cucumbers being processed for export: prickly redfish (left); white teatfish juveniles indicated by white circle (middle); and dried dragonfish smaller than the minimum legal size of 76 mm (right).

4.1.7 Landing of rare sea cucumbers species and bycatch

As a result of deeper-water fishing, catches have included rare species and species that were previously not harvested. For example, *H. coronopertusa*, known locally as loli's mother, was observed in the catch of fishers in Bua who used UBA at depths of 40 to 50 metres (Fig. 16, left). Another rare species to be collected is the deepwater spiky redfish (*Actinopyga* sp. affinity *flammea*) (Fig. 16, middle), which has been observed at a Suva-based processor, collected from around the Viti Levu area, and recorded by Dr Paddy Ryan at Namena in Kubulau (http://www.ryanphotographic.com/holothuroidea.htm) on September 2013. The species has also been found in Nukualofa, Tonga (Poasi Ngaluafe, personal observation).

While this study did not collect accurate information on the bycatch of UBA fishing activities, there are signs that other invertebrates and finfish have been harvested as bycatch for food or for sale by fishers for extra income. For example, the remains of shells of *Cassis cornuta* (Fig. 16, right) were observed at one of the many fishing campsites, and fishers returning from UBA dives were observed with stings of reef fin-fish. Helmet shell (*Cassis cornuta*) is found in the sandy bottom of deep lagoons, which can be easily accessed by fishers using UBA.

Figure 16. Rare sea cucumbers being harvested from deep waters of Fiji: *H. coronopertusa* (left) and *Actinopyga* sp. affinity *flammea* (middle); and a harvested byproduct — shells of helmet shell, *Cassis cornuta* (right) at a fishing campsite.

4.1.8 Economic analysis

The activity of collecting sea cucumbers and converting them into highly valued beche-de-mer provide an important source of cash income for coastal communities in Fiji. Given the lack of export price data, it is difficult to estimate the value of beche-de-mer exports. However, it is reasonable to assume that since 2003 the beche-de-mer trade has provided an average annual income of approximately FJD 10 million in total to households that collect sea cucumbers and process them into beche-de-mer. Therefore this resource is socioeconomically significant for coastal communities, such as those in the Lau Islands, who often use the cash income to pay for household, school and medical expenses.

To gain more precise information on the value of exports to the Fijian economy, it is recommended that exporters of beche-de-mer, as a licensing condition, are required to submit a commercial invoice as part of the documentation they need to submit to gain export permission. With a better understanding of the value of the trade, the Government of Fiji may gain the opportunity to extract rents by applying export duties.

For this section, due to the lack of export price data, the value of the trade can only be reported as value to those who collect sea cucumbers and process them into beche-de-mer for sale to middlemen or exporters. That is, price data only allow us to estimate the income generated by the collectors and primary processors of sea cucumbers. These estimates should be treated with some caution as domestic prices vary by species, location, processing stage and quality of processing. For example, areas close to trading centres tend to enjoy higher prices than remote locations, which incur additional marketing costs such as the cost of transporting the product to the exporter. Within these limitations, however, the results are indicative of the income generated by Fijian coastal communities that exploit this resource.

A recent study of the countries that are the main sea cucumber producers in the Pacific Island region (Papua New Guinea, Solomon Islands, Vanuatu, Tonga and Fiji) estimated the price paid to fishers for processed sea cucumbers by species (Carleton et al. 2013). These prices were used to conduct the following analysis. To facilitate this analysis, beche-de-mer species have been classified into four price categories: very high, high, medium and low (Table 3).

The volume and value of production

From 2003 to 2012 the annual volume (and associated value) of beche-de-mer production varied significantly from a low of 130 t in 2009 to a peak of 340 t in 2005, which translate to an annual value of FJD 5.5 million and FJD 16.5 million respectively. Even over this short period, the boom-bust production cycle that is common in this trade is demonstrated.

Figure 17 displays Fiji's beche-de-mer exports, as a proxy of production, by value category and by the total value of this production.

Aside from the boom-bust pattern noted above, the time series is too short to allow any meaningful comparison between current and historical production levels. The quantities of beche-de-mer exports from Fiji from 1976 to 2012 are based on Carleton et al. (2013)[2], Kinch et al. (2008) and recent data submitted by Fiji Fisheries Department as shown in Figure 10. According to these data, the export volume peaked at 862 t in 1997 and the low — since 1986 when the trade experienced significant growth — was 141 t in 1999. These figures differ from the data reported in Figure 17 because the analyses that produced Figure 17 left out records of some sea cucumber species that were exported as 'miscellaneous' product and species that were grouped and recorded as sea cucumber. Nonetheless, peak production of 862 t in 1997 against a peak of 398 t in 2011[3] demonstrates how significantly production volumes (and associated values) have declined over the past 30-odd years. The longer time series presented in Figure 10 also demonstrates a boom-bust pattern of production.

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[2] Sourced from: FAO; Preston 1993; Gaudechoux 1993; Qalovaki 2006; Fisheries Department 2005–2011.

[3] Carleton et al. report 378 t in 2005.

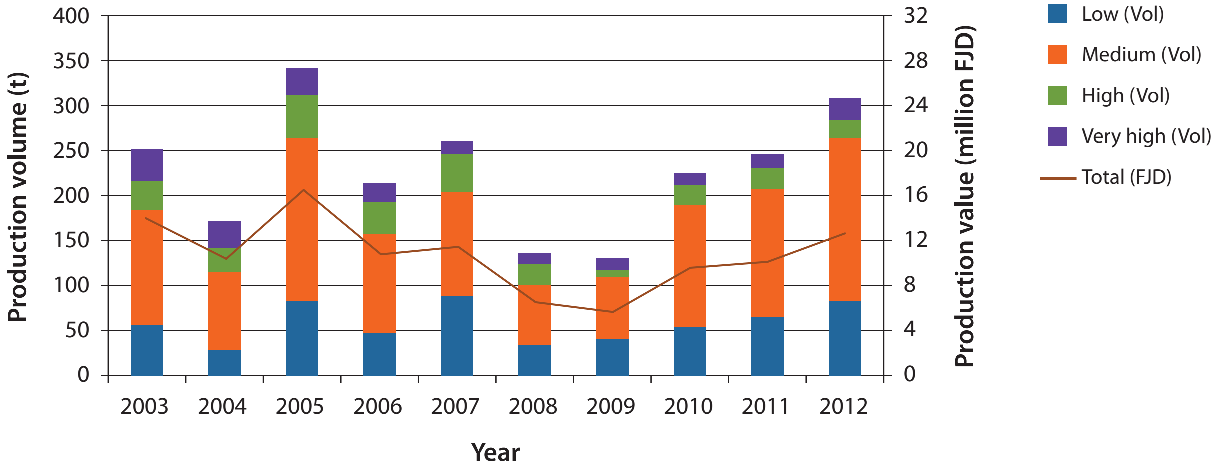


Figure 17. Total beche-de-mer production by value category (t, left axis) and by production value (million FJD, right axis), 2003–2012.

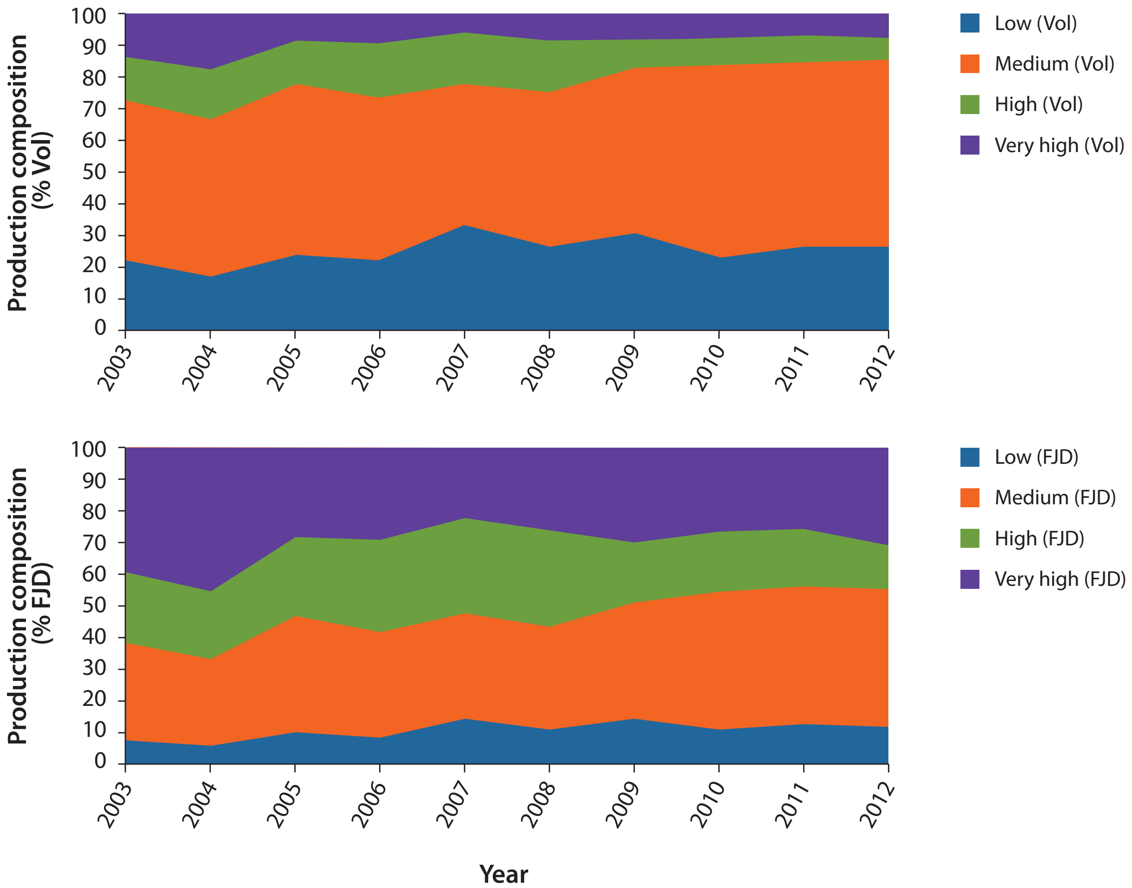


Figure 18. Beche-de-mer production composition by volume (top) and value (bottom), 2003–2012.

With the species categorised into four value groups, in combination with export data reported by the Fiji Fisheries Department (as summarised in Table 3), it is possible to gain an understanding of the composition of exports by volume and value in each value group, as presented in Figure 18. Although the time series is not long enough to make any statistically significant conclusions, it is apparent that exports have shifted from high- to lower-value species since 2003. For example, the export volume of very high-value species declined from 14% to 8% from 2003 to 2012, while for medium-value species it increased from 50% to 59%.

A similar trend is evident in terms of export value: very high-value species declined from 40% to 31% of total export value while medium-value species increased from 31% to 44% from 2003 to 2012.

It is clear therefore that both the volume and value of very high- and high-value species have declined while they have increased for low- and medium-value species since 2003. This switch from high- to lower-value species has occurred throughout the Pacific region and is well documented in Carleton et al. (2013), who state that species composition of exports may inform stock status.

Carleton et al. (2013) document the evolution of exploitation as follows:

- Fishing effort steadily increased in early years of the trade, going beyond levels that could be readily replaced over a year or two, and building to levels of extraction way beyond the replacement capacity of the resource.
- In subsequent years harvests of those species initially targeted are much reduced — both in volume and size — and effort shifts to other species; these latter species are then also fished down.
- Exploitation of lower-value species has proceeded throughout the cycle, but is stepped up once the higher -value species become difficult to find; but in time these resources have also been run down, and effort re-oriented to species that were not formerly exploited.
- As the high-value species have once again become abundant on the grounds, this has attracted more fishing effort; following a long period of relatively flat prices, from the mid-2000s the prices paid for most high-value species have steadily increased up to five-fold — and lower-value species two- or three-fold; this has encouraged fishers to focus more effort on harvesting high value species, and once again taking extraction levels far beyond anything that can be sustained; to achieve this fishers have increased effort as catch per unit of effort has declined, and they have also sought the assistance of technology to access resources not otherwise available to them — using high powered boats to exploit new and more distant areas, and UBA gear to exploit resources at depths inaccessible to free diving.
- It is at this point in the exploitation cycle that most countries have found it necessary to close fisheries in order to allow exhausted fisheries to recover; in Fiji, where no closures have been put in place, the statistical record indicates that the underlying scale of harvests is in steady decline — buoyed up, to an extent, by the official licensing of UBA fishing.

Figure 19 demonstrates the evolution of the trade by value category and species respectively.

As reported above, the export data (in this case, applied as a proxy for production) indicate that there has been an evolutionary switch from high- to lower-valued species. To prevent further stock declines and allow stocks to rebuild, there is a need to manage exploitation levels. The importance of such measures to local communities can be demonstrated by trends in the average production value (Fig. 20), which is simply calculated as the total production (in kilograms) divided by the value of production.

Figure 20 shows that, on a per unit basis, the value of the beche-de-mer trade to coastal communities who collect sea cucumbers and process them into beche-de-mer is steadily falling. The price communities received has fallen by about FJD 15 to FJD 20 per kilogram over a 10-year period, wholly due to the switch from high- to low-value species[4]. The socioeconomic implications of this trend, as indicated by Carleton et al. (2013), are that if communities are to generate the same level of income from the beche-de-mer trade as they did in 2003, they will need to increase their level of production. The sustainability of this exploitation pattern is questionable and it has potentially major economic implications. The opportunity cost of overexploitation, as demonstrated above, is a reduced income to the coastal Fijian population and to national export revenue. This loss is magnified by a switch to lower-value species, reduced size of individual sea cucumbers collected and reduced replacement capacity leading to lower productive capacity in the future.

[4] Note that neither the time value of money, nor the change in price as a result of supply and demand interactions has been accounted for, and the prices paid to collectors for each year are assumed to have been those presented in Table 3.

Figure 19. Beche-de-mer production by volume (t; left axis) and value (million FJD; right axis) by each value category, 2003–2012. A = very high value; B = high value; C = medium value; D = low value.

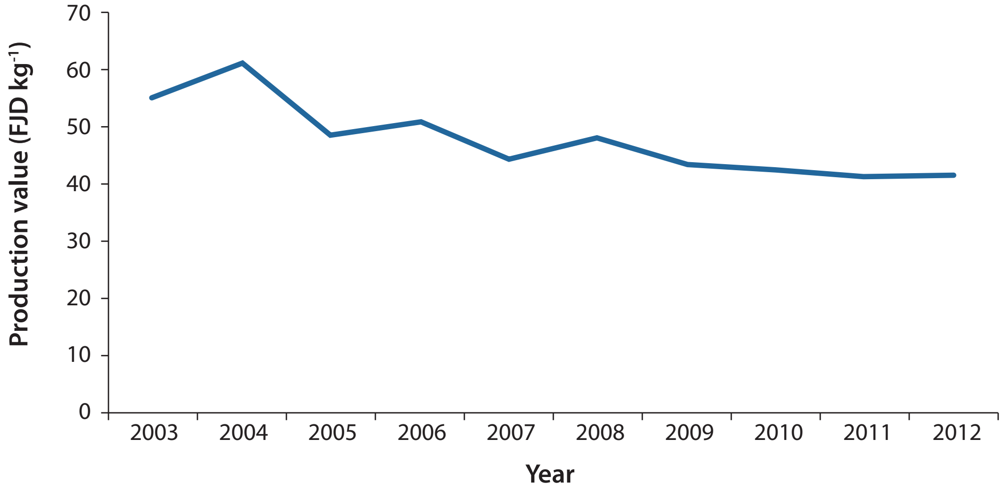


Figure 20. Average production value (FJD kg^{-1}) of beche-de-mer, 2003–2012.

Sea cucumber pricing has long been an issue in the Pacific sea cucumber fisheries. Despite the increasing market demand, little attempt has gone into stabilising prices or setting minimum prices for the benefit of fishers. As a consequence, prices have varied widely, disadvantaging fishers. One aim of fisheries management should be to improve landing prices, which requires a good understanding of local, regional and international market prices. Figure 21 compares maximum prices offered in Bua Province, which are taken to represent the local prices offered in Fiji as a whole, with the regional prices reported by Carleton et al. (2013) and wholesale prices in Guangzhou, China (Purcell et al. 2012). Overall there is a relationship between the three prices and the prices offered in Bua are lower than regional price estimates. Local sea cucumber prices in Fiji, such as those offered in Bua Province, may need to be raised to a more realistic level, namely the Melenesian Spearhead Group (MSG) regional price estimates (Carleton et al. 2013), as the first step towards improving prices.

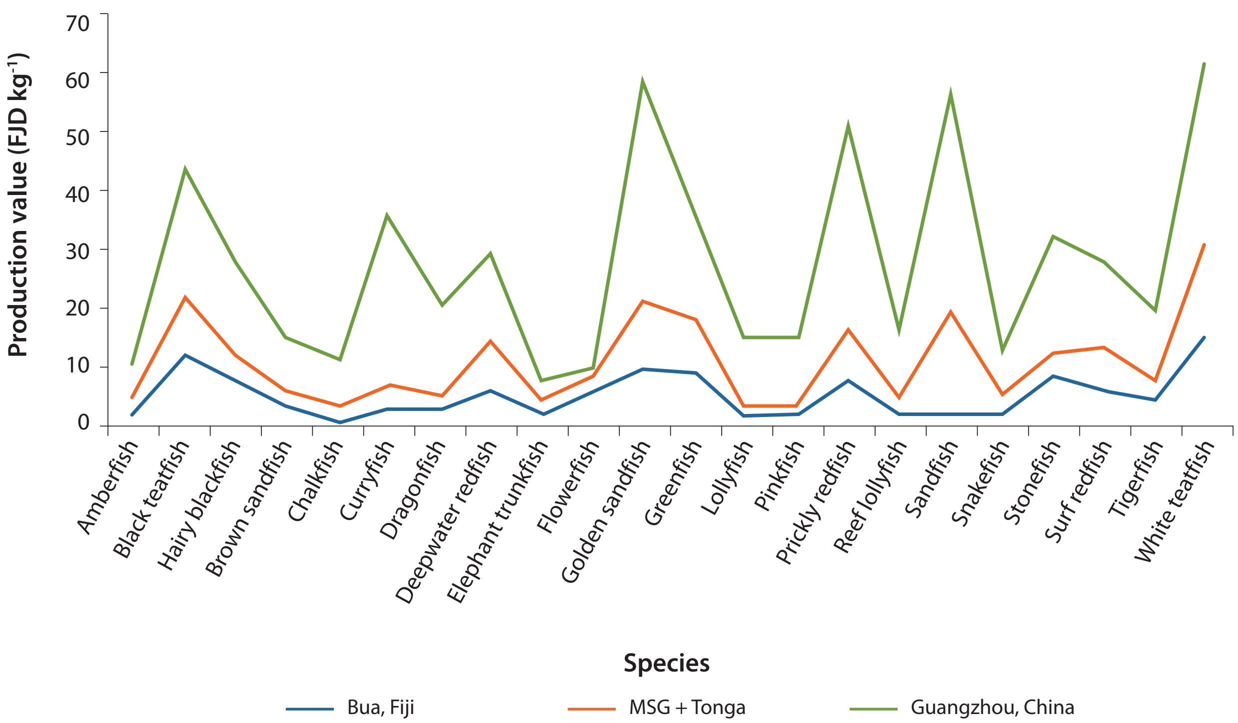


Figure 21. Product price in Bua, Fiji compared with regional and wholesale market prices.

4.2 Resource assessment results

4.2.1 Survey sites and coverage

A total of nine sites were assessed by the Secretariat of the Pacific Community, Fiji Fisheries Department and Partners in Community Development Fiji. The sample stations differed in a variety of ways, such as in *qoliqoli* area (size), reef complexity, timing of surveys and resources. In total, 292 stations (Fig. 22; 87 manta, 163 RBt and 42 SBt stations) were completed, covering 53 hectares of habitats of sea cucumbers (for a detailed breakdown of survey coverage by site, see Appendix 1).

A further 10 sites were assessed in the Lau Group by a joint team from the Fiji Fisheries Department, Wildlife Conservation Society and USP-IAS. The results are reported in Jupiter et al. (2013).

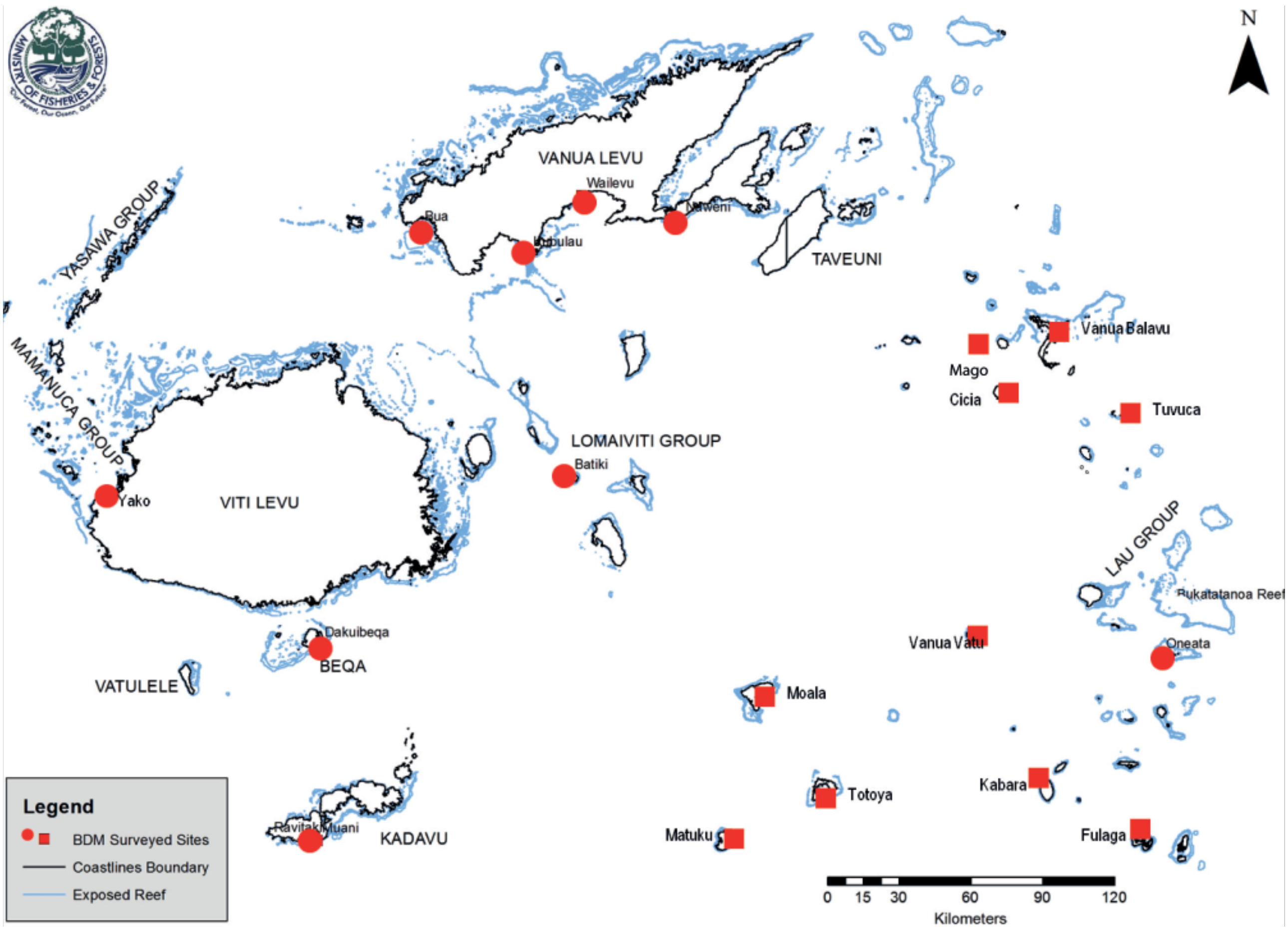


Figure 22. Sea cucumber resource survey sites: red circles show sites assessed by Secretariat of the Pacific Community, Fiji Fisheries Department and Partners in Community Development Fiji; red squares show sites assessed by Fiji Fisheries Department, Wildlife Conservation Society and University of the South Pacific-Institute of Applied Science (Jupiter et al. 2013).

4.2.2 Presence and occurrence of species, and threatened species

By monitoring species present in shallow-water habitats over time, it is possible to learn about the condition of the resources. Analysis of species presence by site is based only on underwater assessments in shallow waters (0–10 m in depth). Although 27 sea cucumber species are present in Fiji, fewer than 15 species were present in many of the sites assessed (Fig. 23). Current diversities did not reflect the rich habitat systems supporting sea cucumber resources in most of these sites.

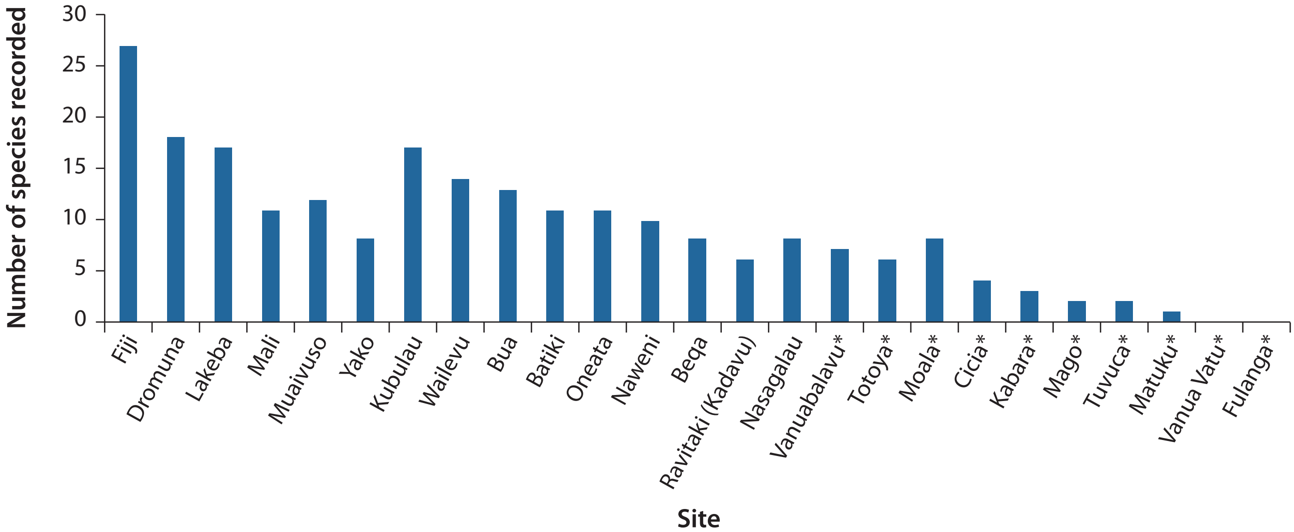


Figure 23. Sea cucumber species present by site in Fiji (data for Dromuna, Lakeba, Mali and Muaivuso come from 2009 surveys). Data from * are from Jupiter et al. 2013.

Figure 24. IUCN Red Listed sea cucumber species present in Fiji: golden sandfish (GSF), sandfish (SF), black teatfish (BTF) and prickly redfish (PRF) are 'endangered to extinction'; and curryfish (CF), white teatfish (WTF), deepwater redfish (DWRF), surf redfish (SRF) and hairy blackfish (HBF) are 'vulnerable to extinction'.

Numerous reports have documented the threat posed by overfishing sea cucumber resources across their geographical range (Lawrence et al. 1994; Uthicke 2004; Hasan 2005; Kinch et al. 2008; Friedman et al. 2011; Purcell et al. 2011). After many studies on stock status trends, the International Union of Conservation of

Nature (IUCN) has recently placed nine sea cucumber species present in the Pacific Islands region under the IUCN Red List of Threatened Species (Fig. 24). Four of these species — sandfish (*Holothuria scabra*), golden sandfish (*Holothuria lessoni*), black teatfish (*Holothuria whitmaei*) and prickly redfish (*Thelenota ananas*) — are listed under 'endangered with extinction', which is the category for species that are at a very high risk of extinction throughout their range. The other five species — deepwater redfish (*Actinopyga echinites*), surf redfish (*Actinopyga mauritiana*), hairy blackfish (*Actinopyga miliaris*), white teatfish (*Holothuria fuscogilva*) and curryfish (*Stichopus herrmanni*) — are 'vulnerable to extinction', meaning they are likely to become endangered if no management action is taken to protect them.

All these species are present in Fiji: six species inhabit shallow waters (with a depth of less than 10 metres) and three species inhabit depths greater than 10 metres. Golden sandfish (*Holothuria lessoni*), one of the species listed as 'endangered with extinction', was last recorded at Muaivuso, Viti Levu in 2009 and was not recorded in these surveys. Any risk assessment regarding aquaculture development and stock translocation of these endangered species will need to take this recent IUCN listing into consideration.

Lollyfish and pinkfish were the most widespread species, with specimens recorded in all sites (Table 4). Lollyfish was the most commonly recorded species across all sites combined (1,257 specimens), although sandfish was the most commonly recorded species (824 specimens) at Wailevu in particular. Overall the highest number of specimens was counted in Wailevu, where 1,813 specimens were recorded, mostly from a community-managed area.

Table 4. Total count (occurrences) of commercial sea cucumbers recorded by species and site.

Species	Bua	Wailevu	Naweni	Oneata	Beqa	Batiki	Ravitaki	Kubulau	Total
Lollyfish	336	455	77	136	29	18	12	186	1,257
Sandfish		824				1		166	991
Brown sandfish	41	14	7	218		4		3	288
Chalkfish		268		2				3	273
Flowerfish	138	22				2		23	205
Pinkfish	31	30	2	8	10	4	1	46	149
Greenfish	22	1		2		58	23	4	114
Curryfish	45	14		2				20	82
Black teatfish				50		2			53
Tigerfish	14	13	5			6		6	47
Snakefish	1			2	1		22	13	39
Dragonfish		23	6						29
Elephant trunkfish	10		4		2	1		3	21
Surf redfish		3	1	10	1				15
Amberfish	5				1		2	2	13
Prickly redfish	2			6		1		1	11
Hairy blackfish	5					1		2	9
White teatfish	1	1		2		1		1	7
Stonefish	2	1						1	4
Red snakefish			1						1
Deepwater redfish								2	2

Note: Species absent from the assessments were not included in this table.

4.2.3 Density and abundance

Densities of sea cucumber species (individuals per hectare with standard error) are presented for broad-scale manta tow surveys (Table 5) and fine-scale transect surveys (Table 6). Species density data from both assessments methods are complementary as both sets of data contribute to the overall understanding of resource abundance across the sites and level of aggregation across habitats. Stock reference densities for 17 sea cucumber species have been developed for use in the absence of site-specific density references. These figures were derived from individual species densities across 91 sites assessed in 17 countries over the period 2002–2012. Effectively, they are an average of the 25% of the highest densities from the Pacific Island dataset held by SPC.

These regional densities can be used as a baseline to check or compare abundances of sea cucumbers. Fiji sea cucumber species densities are compared with regional reference densities to better understand the status of stocks. Densities for all species in all sites assessed were lower than the reference densities for healthy abundance in both assessment types. As an indicator for population health, reference density alone does not indicate healthy fishable stock; this assessment will need to take into consideration of population size structures.

Table 5. Species densities (ind ha^{-1}) for broad-scale manta tow assessments.

Species	Kubulau	Bua	Naweni	Wailevu	Dakuibeqa	Muania	Ravitaki	Oneata	Batiki	R\Reference density
Lollyfish	9.6	37.7	19.4	14.4	2.1	6.9	3.5	4.6	5.9	2,400
Greenfish		0.9		0.6	2.8	2.8	11.8		8.1	1,000
Snakefish	0.2						15.3	0.3		350
Pinkfish	4.7	4.5	1.4	2.5	4.9			1.3	0.6	250
Brown sandfish	0.2	5.1	2.1	3.1				35.6		160
Curryfish	1.1	2.2	2.1					0.3		130
Flowerfish	4.7	15.9		3.1					0.6	50
Tigerfish	0.2	1.8	0.7	2.8					0.5	50
Amberfish	0.2	0.8			0.7					20
Surf redfish				0.3	0.7					20
Black teatfish						1.4		1.0		10
Elephant trunkfish		1.7	2.8		1.4				0.2	10
Prickly redfish	0.4	0.3						1.0	0.3	10
White teatfish	0.2	0.2		1.9				0.3	0.2	10
Chalkfish								0.3		na
Dragonfish			2.1							na
Deepwater blackfish	0.2									na
Stonefish		0.2								na

Table 6. Species densities (ind ha^{-1}) for reef transect assessments (SBt and RBt combined).

Species	Kubulau	Bua	Naweni	Wailevu	Dakuibeqa	Ravitaki	Oneata	Batiki	Yako	R\Reference density
Lollyfish	172.9	321.6	117.2	333.3	325.4	48.6	112.5	216.7	5.2	5,600
Greenfish	3.1	26.7	2.6			41.7	2.1	29.2		3,500
Chalkfish	1.0			738.1						1,400
Snakefish	4.2		2.6						31.3	1,100
Sandfish	159.4			1,991.0					281.2	700
Pinkfish	15.6	7.5		17.2		6.9		16.7		260
Surf redfish			2.6	7.2			10.4			200
Hairy blackfish	1.0	2.1						4.2		150
Tigerfish	3.1	4.3	5.2							120
Brown sandfish	3.1	12.8	5.2	222.7				20.8	15.4	100
Curryfish	24.0	24.6		17.2				47.9	26.0	100
Flowerfish	8.3	33.1						4.2		100
Black teatfish							45.8			50
White teatfish										20
Elephant trunkfish	1.0				10.4					10
Stonefish	1.0			1.4					10.4	10
Amberfish						13.9				na
Dragonfish				33.1						na
Prickly redfish									15.6	na

Note: Reef transect mean densities are combined densities for soft and reef benthos transects (SBt and RBt).

Site densities for lollyfish (*H. atra*) for reef transects are presented in Figure 25 to demonstrate the gap between current densities and the reference density. Lollyfish is a good indicator of exploitation levels due to its relatively fast growth rate (reproducing at a relatively early age, or by fusion) and its status as a common, low-value species found in shallow habitats. The large gap between current densities at each site and the healthy density reference of 5,600 individuals per hectare (ind ha^{-1}) for RBt and SBt assessments indicates that the lollyfish stock is heavily fished and that management measures are needed to improve its status. The assessment surveys recorded no lollyfish at any of the eight Lau Province sites (Fig. 25), suggesting that where limited reef systems are subjected to persistent fishing pressure, they are at greater risk of species extirpation (Jupiter et al. 2013). Restoring densities to the reference level would require a longer period of no fishing. Moreover, if low-value species densities are a concern, then there is a very high probability that medium- to high-value species are also in trouble.

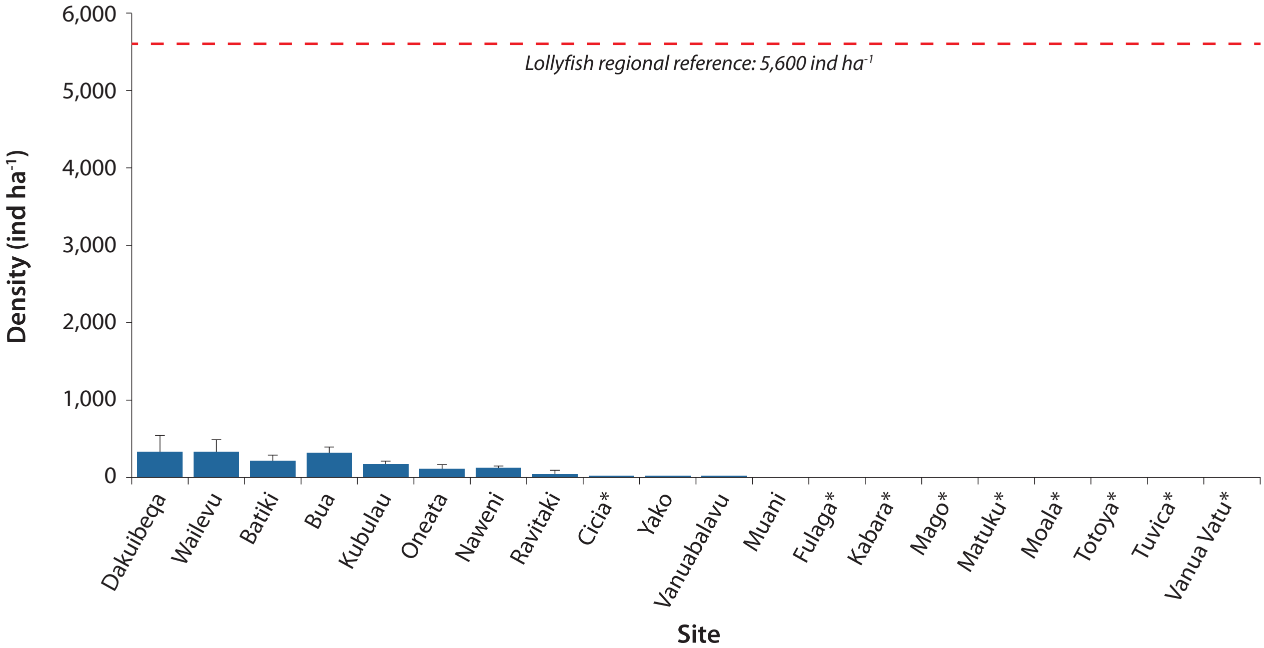


Figure 25. Lollyfish densities for shallow-water transect across sites in Fiji compared with regional reference density (*sites are from Jupiter et al. 2013).

4.2.4 Densities in marine protected areas

Assessment surveys covered some marine protected areas (MPA) in Kubulau, Bua, Naweni, Batiki and Wailevu. While broader-scale assessments showed no difference in stock densities, soft benthos transect revealed notable differences in the transect densities at marine protected area at *qoliqoli* Wailevu, Vanua Levu (Fig. 26).

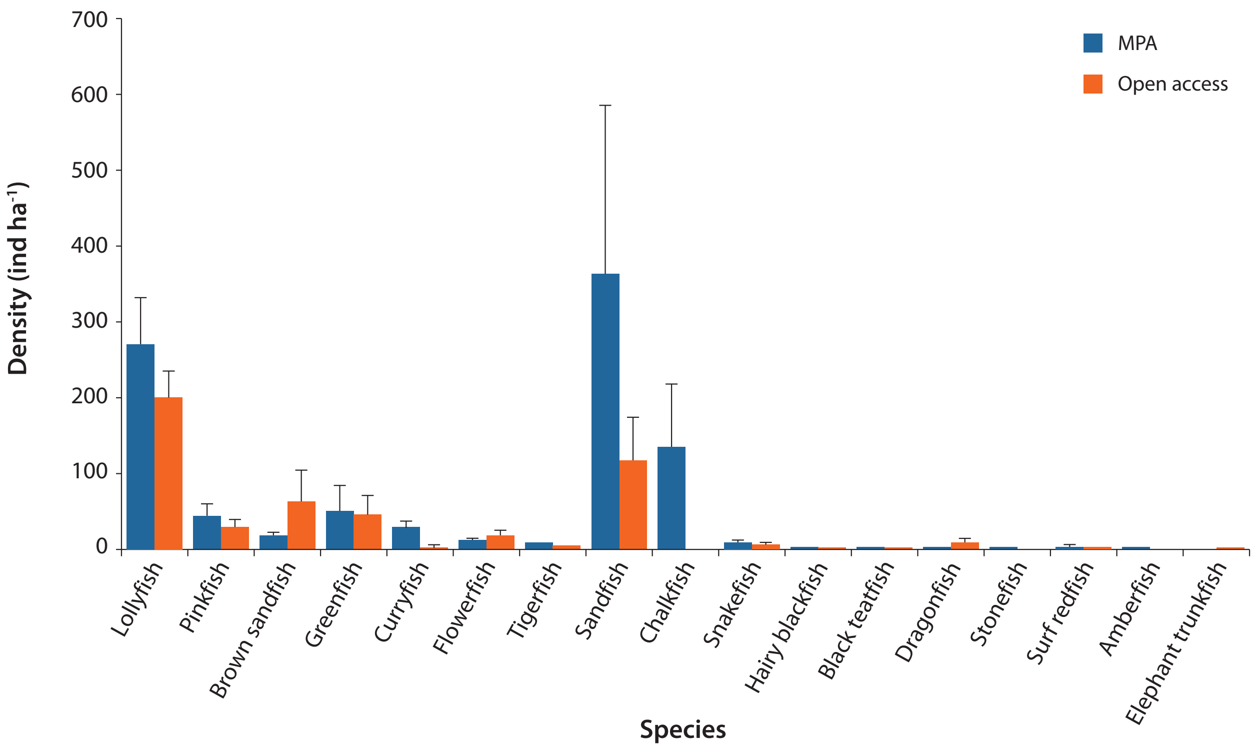


Figure 26. Densities inside MPA (left bar) and open access areas (right bar) at Wailevu, Fiji.

Mean densities for sandfish were 360.6 ±227 ind ha^{-1} inside the MPA and 115.8 ±59 ind ha^{-1} in the open access area, and mean densities for lollyfish was 271 ±36 ind ha^{-1} inside the MPA and 201.0 ±86 ind ha^{-1} in the open access area. Natuvu MPA covered almost half of the *qoliqoli* area, including seagrass habitat, and is controlled by village fish wardens (Hair et al. 2011). The site is also a source of sandfish broodstock, supplying some 333 adult sandfish for hatchery breeding in Fiji (Hair et al. 2011) as well as 85 young sandfish broodstock (200–300 g) for introduction to Kiribati in July 2012 (Ruth Gomez, SPC Aquaculture Officer, personal communication 19 July 2013).

4.2.5 Size structure and mean sizes

The mean sizes of species were assessed and compared with commonly fished sizes and maximum sizes for sea cucumber species observed in the Pacific Island region (Purcell et al 2008). The mean sizes of sea cucumbers recorded for sites in Fiji are lower than commonly fished sizes throughout the region (Fig. 27). Protected or well-managed stocks are expected to consist of a full range of sizes; however, Fiji does not have this range. For example, the mean size (length) for sandfish recorded in these assessments is 124 mm, below the size at which sandfish reach sexually maturity (160 mm). Continuous fishing at smaller sizes is not permitting the full growth potential of sandfish. For more information on the mean sizes of sea cucumbers in Fiji, see Appendix 3.

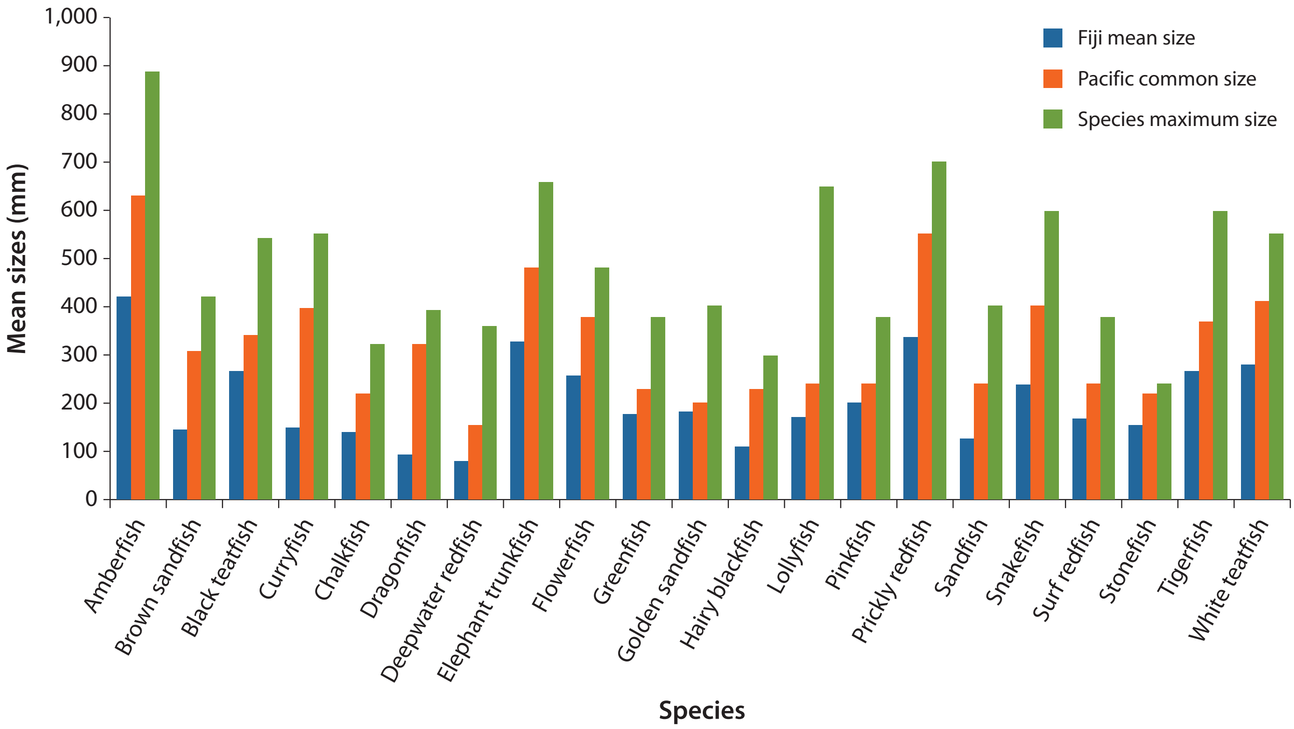


Figure 27. Mean size in Fiji (left bar), size in regional common harvest (middle bar) and maximum size (right bar) of each sea cucumber species.

To assess stock condition more precisely, Figure 28 presents the overall size distribution for Kubulau and Wailevu. The Wailevu sandfish stock were slightly larger (mean size 124 mm, n = 822) (Fig. 28, top graph) whereas in Kubulau sandfish stock were smaller (mean size of 97 mm, n = 464) (Fig. 28, bottom graph). Overall stocks in both areas are dominated by young, sexually immature sandfish, smaller than the maturity size of 160 mm (Conand 1993). These small specimens would constitute low-grade products if they were being harvested commercially. Sandfish inside the MPA and in open access areas did not differ greatly in size (124 ±3 mm inside the MPA and 127 ±3 mm in open access areas) (Fig. 29).

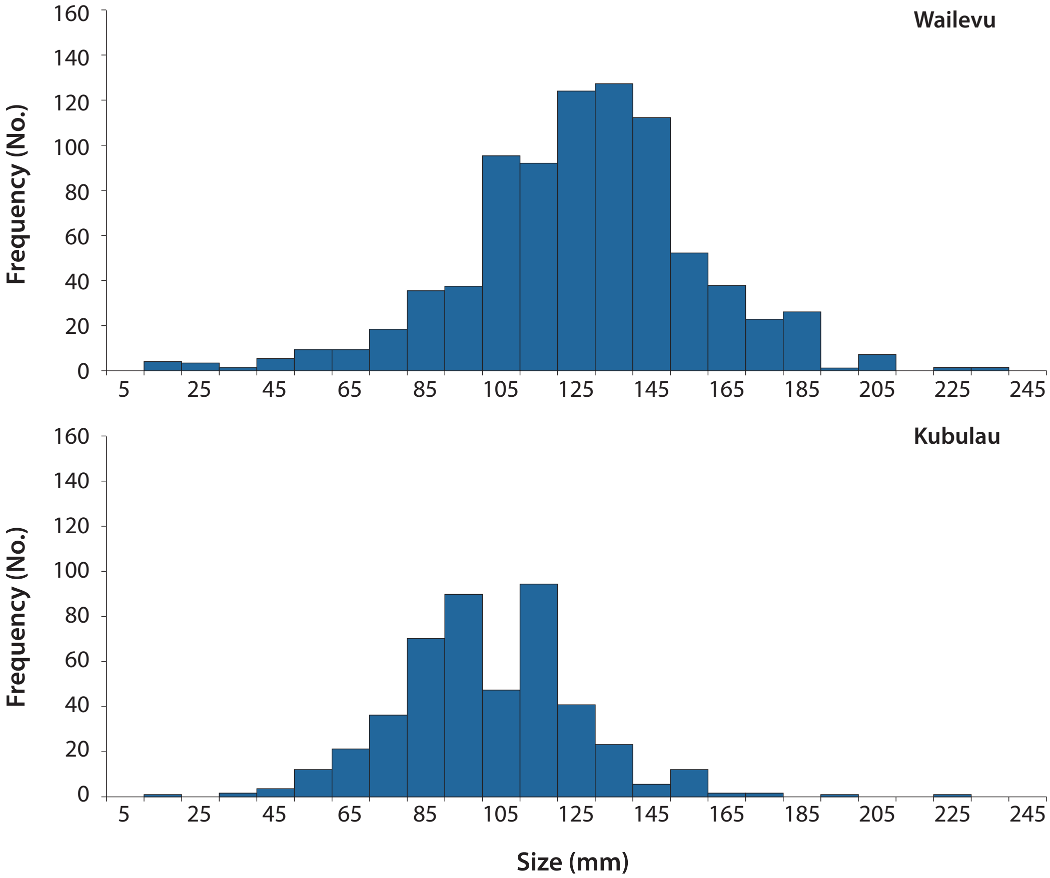


Figure 28. Overall distribution of sandfish sizes at Wailevu and Kubulau.

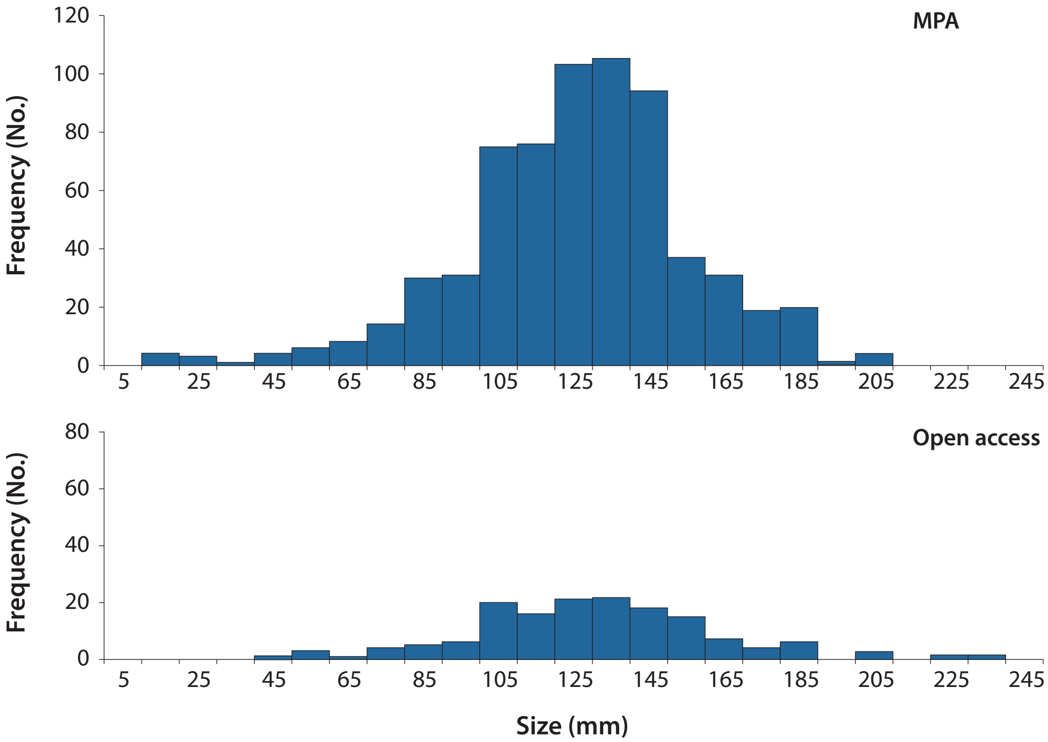


Figure 29. Sandfish size distribution inside MPA (top) and in open access areas (bottom) at Wailevu, Vanua Levu.

Sandfish is a delicacy in Fiji and juvenile sandfish is harvested for its soft meat which is consumed raw. The low numbers in open access areas indicate the impact of subsistence fishing on young sandfish. Although the high abundance of juvenile sandfish is a positive sign of recruitment, large adult sandfish such as the specimen recorded at Batiki (length 250 mm) (Fig. 30, left) are rare and stocks in Kubulau and Wailevu may take some years to reach their full adult size.

Figure 30. A large sandfish (*Holothuria scabra*) specimen (250 mm) recorded at Batiki (left); and juvenile sandfish (mean size 97 mm) recorded at Kubulau (right).

5. Discussion of main findings

5.1 Resource assessment discussion

From the fishery-dependent information reported in Section 4.1, it is apparent that the sea cucumber fishery in Fiji has experienced 'boom-and-bust' cycles. In-water assessments (Section 4.2) indicate that densities are low across all sites and for some species they are critically low. Average sizes for sea cucumbers are smaller than the common size observed in the Pacific Island region as a whole. A few species such as lollyfish, prickly redfish, sandfish and black teatfish are no longer present in some sites. These findings highlight how fishing pressures have had a serious impact on the resources and how, without effective management, there is a risk that stocks for some species will be severely depleted or collapse. Although most species of sea cucumber are present in many sites, and pre-fishery baseline information is absent, it is clear that densities are significantly lower than healthy density levels determined by SPC (in press).

We were unable to locate a site in Fiji that had a similar range of habitats but had not been fished, which we might have used to assess stocks for comparison with fished areas and to determine reference densities for Fiji. The absence of sandfish in some suitable habitats and the absence of larger adult stock (>200 mm) indicate range restriction of the species. Local extirpation of species has begun to be apparent in small island systems as in Lau Province, where lollyfish was not recorded (Jupiter et al. 2013), while high extraction rates in larger systems as in Bua are not allowing stock to recover. The easily fished *dri* (hairy blackfish or *A. miliaris*), which was present at high densities (24,000 to 78,000 ind ha^{-1}) in the past (Preston 1990), is now rare, with densities of less than 5 ind ha^{-1}. Golden sandfish (*H. lessoni*) is also now rare in Fiji. Almost all the sea cucumber stocks assessed are underperforming, with low stock densities compromising the ecological resilience of the resource and its social and economic benefits for coastal communities. The majority of stocks present consist of small, young animals. Their continued exposure to fishing would put breeding and recruitment at risk.

In sites protected from fishing by communities, such as the marine protected area, some species were somewhat more abundant. Yet these few protected stocks are also exposed to the impact of fishing, which distorts their population so that it contains exclusively young stocks. The potential of community-managed areas in protecting localised breeding stocks of sea cucumbers is not being fully realised because of the pressures to harvest remaining resources. It appears that the community management system is weakened by excessive commercialisation pressure and unregulated management of the sea cucumber fishery. In the long-term interests of Fiji communities, this important resource needs more effective management.

5.2 Fishery status and community perceptions

Large increases in the export of amberfish (*T. anax*), white teatfish (*H. fuscogilva*), brown sandfish (*B. vitiensis*), tigerfish (*B. argus*), elephant trunkfish (*H. fuscopunctata*) and curryfish (*S. herrmanni*) in the last four to five years indicate that fishing activities in the mid- to deepwater fishing grounds of Fiji are increasing. This trend is consistent with the increased use of UBA to harvest sea cucumbers during the same period and the low numbers of these species recorded from underwater assessments of shallow-water habitats. Lollyfish and snakefish are under increased fishing pressure, with high production levels over the last 10 years. Lollyfish production has fallen in the last five years and specimens are now rare in some sites. There are anecdotal reports of crowbars being used to extract snakefish hidden inside the reef structure in some areas.

Subsistence use of sandfish (*dairo*) contributes to food security in Fiji. However, because harvesting for household consumption and for sale at local markets is not regulated, juvenile sandfish are being harvested and sold. Sale of sea cucumber at the local market is a commercial activity and therefore should not be classed as subsistence activity. A reduction in local sales of sandfish and rising prices may be due to increased fishing pressure although more consistent information is needed to confirm these trends. The apparent export of sandfish (currently banned from commercial exports), as reported previously (Adams 1992; Ram et al. 2010), indicates that enforcement of the regulations is weak. Given both the growing demand for aquaculture development of sandfish and golden sandfish and the domestic importance of the species, a more focused approach is needed to control the pressure on these species.

The improper use of underwater breathing apparatus is a 'human and environmental disaster' because it puts divers at risk of accidents and involves indiscriminately harvesting sea cucumbers (Eriksson et al. 2012). The increase in the use of UBA and in the number of beche-de-mer processing and exporting companies in Fiji follows similar experiences in Egypt, where the sea cucumber fishery collapsed in 2002 (Lawrence et al. 2004). Inadequate fishery monitoring leaves open the risk of further over-exploitation of existing resources without the knowledge of resource managers. Moreover, using UBA to harvest other non-targeted species such as finfish, lobster, octopus and shellfish for food and for sale for extra income, as noted in these surveys, adds pressure to these non-target species which can intensify once sea cucumber diving starts to become uneconomical (Eriksson et al. 2012).

In regard to human health, there have been 108 accidents related to UBA use in Fiji in recent years while the number of related fatalities is not known. Recently two people have died in Lau Province as a result of their use of UBA (Jupiter et al. 2013). There is a high probability that many more sea cucumber divers will be harmed or die if this method of fishing is allowed to continue uncontrolled. Deepwater diving with the aid of UBA is therefore undesirable and should be prohibited from use for fishing activities.

Fiji reef systems are relatively large and complex, supporting rich habitats and a larger sea cucumber resource base with potential for sustainable production. Fishing over the last 30 years has produced high volumes of exports, demonstrating the power of the reef systems and the potential of sea cucumber stocks to reproduce and sustain productivity. But the results of this assessment show that sustained production cannot continue in its present form and in a few more years the fishery will collapse if urgent action to manage the fishery is not taken.

5.3 Management measures

Placing a moratorium on the fishery is the best option to rebuild the resources. The experiences of Egypt — which allowed its fishery to collapse in the early 2000s (Lawrence et al. 2004) and has taken necessary steps to enforce moratoria — offer a useful lesson for Fiji. A total resting period provides ample time to develop effective stock rehabilitation programmes and management strategies, put in place implementing facilities and technical capacities, and establish efficient monitoring mechanisms before re-opening the fishery.

Despite the good intentions of community-based management, its potential for managing sea cucumber stocks and preserving pockets of breeding stocks is not being realised. The weakness of control measures is not helping to diffuse escalating fishing pressures that community management systems are not designed to accommodate. The cost of undertaking surveillance of community areas and enforcing community rules is too high and communities lack the resources and equipment to do this effectively. Furthermore, stopping a member of the *qoliqoli* from taking fish from a protected area, or penalising them for it, is a culturally sensitive issue and therefore difficult to do.

The community management system therefore appears to be eroded by the sustained pressure on sea cucumber stocks. Moreover, the country as a whole would face a huge economic burden if it were to fund the cost of getting all the districts or *qoliqoli* (over 400 fishing areas are *qoliqoli*) in Fiji to undertake surveillance and enforcement of fisheries regulations and community bylaws in their respective areas. For these reasons, a cost-effective management approach is to strengthen the national government management systems by implementing an effective National Sea Cucumber Fishery Management Plan and enforcing associated regulatory measures.

6. Community views and experiences

Communities have good knowledge of their fishing grounds and resources and therefore are able to manage resources at the community level. The surveys capitalised on local knowledge to identify fishing grounds and species aggregation areas. Community views were gathered through consultations with the District of Kubulau, the community of Navatu island, the community of Navunievu and Bua village in the District of Bua, and additional information gathered by Fiji Fisheries Officers and PCDF from other sites assessed. Those views are summarised below:

1. There is wide concern over the low numbers of sea cucumbers. People observe that it is hard to find sea cucumbers on the reef nowadays compared with past years when they were everywhere on the reef.
2. Effective enforcement of MPAs is a challenge due to cost and time involved in surveillance activities, considering that communities have other commitments. These problems have led to a lack of effective policing and increased poaching by outsiders and from within the community.
3. Communities would like to enforce minimum size limits for live and dried sea cucumbers but this information is not available to them; they want the responsible authorities to make this information available to them.
4. Communities are aware sandfish is a protected species but it is hard for them to stop their people from harvesting and selling their catch. They think the responsible authorities should enforce the ban to stop buyers from buying sandfish.
5. Leaders of Kubulau District have agreed not to allow the use of UBA in their district but they fear persistent pressure from buyers could result in some of their leaders agreeing to allow the use of this fishing method as has been experienced in other communities. They think the Government should do something about UBA use.
6. One community identified the need for advice on stock assessment of sea cucumbers at *qoliqoli* level, available stock by species and how much to harvest. They also would like to have information on the best price of products to help them decide on whether to fish or not and to ensure they only harvest the recommended quantity. They have heard of advice such as catching enough and leaving some behind to reproduce but they do not know exactly what the sustainable catch limit is for sea cucumbers.
7. Community members and fishers who are more directly involved in the UBA fishery tend to be quiet, preferring not to talk about controlling the fishery. This response is to be expected as they derive economic benefit from employment opportunities the fishery offers. Also the community have a lot of respect for their paramount chief who is the *qoliqoli* custodian and who decides whether to allow UBA fishing and what access fee is to be paid.
8. Some women sea cucumber fishers think that night fishing and spear fishing for sea cucumbers are not as destructive as UBA fishing and should not be restricted.
9. The community of Navunievu in Bua have set aside one of their main sea cucumber fishing grounds (lagoon patch reef) as a protected area but they are not seeing recovery of *dri* (hairy blackfish or *A. miliaris*) stocks. In the past, a fisher would easily catch two canoe loads during low tide. The community would like to know if their *dri* is going to recover. A possible solution would be to collect large, mature *dri* and place them within the MPA at a density of >150 individuals per hectare to improve spawning success. However, the community would need to ensure these protected stocks are not harvested for the beche-de-mer trade.
10. The community of Navatu, Kubulau had recently established an MPA over their main sandfish breeding area but poaching by members of the community and from outside communities puts the recovery of their stock at risk. The community need advice on the best areas to set aside for sea cucumber protection.

Further community views have been gathered from sites in Lau Province and presented in Jupiter et al. (2013). These are summarised below to broaden understanding of what communities are going through with this fisheries:

1. The majority of fishers in Lau believe sea cucumbers are getting scarcer and species sizes are getting smaller while product prices have increased.
2. Sea cucumbers are an important source of income security for these islands communities where other opportunities are limited.
3. Lollyfish, brown sandfish and surf redfish are commonly collected. Lollyfish is a high-recovery species, brown sandfish burrow in the sand at daytime and surf redfish inhabit surf zone habitat (reef crest and reef front) which is accessible only at low tide and in calm seas, thus limiting fishing activities which explains why they are still being caught.
4. As Kubulau communities stated, these communities lack information on sea cucumber stocks and harvest quantity. Again the need for information should be considered in the future.
5. There are irregularities in business dealings such as false promises of donations for supply of sea cucumbers, short-changing on sea cucumber prices, removal of catch records, lack of agreement, and underpaying products at very low prices.
6. Deepwater fishing activities using UBA have been allowed in some *qoliqoli* areas in the Lau Group, while some *qoliqoli* owners do not permit UBA use and some are planning to allow it. Persistent pressure from buyers pushing to secure stocks in remote locations through cash payouts can influence decisions to give access to protected areas.
7. Two deaths from deep diving using UBA were reported in June 2013 at Oneata. Communities reported that more have been related to sea cucumber fishing although this information could not be verified.

7. Recommendations for management

1. ***Sea cucumber, one of few income options?*** There is a general feeling that because the sea cucumber fishery supports the livelihood of many rural communities in Fiji, the fishery should not be closed (moratoria should not be enforced) until alternative income activities are developed. In focusing on a fishery itself based on 27 biologically different species, managing the sea cucumber fishery is a separate issue and should be viewed in isolation from any other development issues in order to gain a better understanding of and appreciation and concern for what is required for effective management. Therefore the lack of or slow progress in developing other livelihood options in rural areas should not be used as a reason for taking no management action in regard to sea cucumbers.
2. ***Moratoria and short open season:*** Production levels for the two lowest-value species (lollyfish and snakefish) remain high overall, although there are signs they will be short-lived. Moreover, production levels for the majority of the species are in decline, the size of current stocks in targeted fishing grounds is small and fishing of the last remaining breeding stocks is intensifying through the use of UBA in deeper and more distant habitats. All these developments are sure signs of a looming fishery collapse. The quality of the Fiji sea cucumber fishery has steadily deteriorated over time. The current rate of fishing is compromising the resilience of the resources to recover and the future livelihood of the Fiji people. A moratorium (total ban) for at least for 5 to 10 years is recommended as the best solution to ensure stocks recover. Once stock recover, the future operation of the fishery should be based on resource assessments and the outcomes from a short open fishing season with effective monitoring and compliance.
3. ***UBA:*** The use of underwater breathing apparatus to access deepwater fishing grounds will take divers into ever-deeper waters as resources become depleted in shallow fishing areas. Diving-related accidents and deaths will remain high as fishers continue to experience sustained pressure to use this gear and maximise the number of dives per day with minimal rest periods. To save human life and the remaining breeding stocks of sea cucumbers in deeper waters, the use of UBA should be totally banned as a method of fishing for sea cucumber in Fiji.
4. ***Sea cucumber management plan:*** The draft National Sea Cucumber Fishery Management Plan should be finalised and implemented. Control measures to include in the plan are: licensing and permits, access limits, gear limits, limits on species for exports, size limits and reporting (as detailed in separate recommendations below). In addition, associated regulations should be developed and enforced. The best time for responsible authorities to make these changes is during a sea cucumber moratorium when there is total control of the situation, allowing new measures and regulations to be put into effect and necessary capacities to be established before the fishery re-opens.
5. ***Licensing and permit systems:*** One reason why it is difficult to monitor the fishery is that the processing and marketing chain is complex. To alleviate this complexity, two separate licensing systems are recommended: one for processing products and the other for exporting products, both with associated conditions for compliance. Processing and exporting licence holders should not be permitted to undertake, support or subsidise fishing of sea cucumbers. Fees should be charged to cover the cost of managing the fishery. The licences and export permits should be incorporated into regulations to enable effective enforcement of license conditions and monitoring of the fishery.
6. ***Limiting the number of exporters:*** The sea cucumber fishery is a lucrative industry that can be managed effectively. Rising demand and prices and falling production of these products can be seen as an opportunity to look for other ways to raise the industry's value to the Government and resource owners, such as via an auctioning scheme for licences or products. If such alternative approaches are to be successful, there need to be clear policies in place to facilitate this development. A policy that limits the number of exporters is highly recommended.

7. ***Other fishing gear limitations:*** Other fishing practices and gear used in the fishery — such as 'sea cucumber bomb' spears and night fishing, trawl net and submersible equipment — are destructive to sea cucumbers and need to be regulated.
8. ***Minimum size limits:*** The current regulation setting a minimum size limit of 76 mm for all species is inappropriate. Species-specific size limits for live and dried products are recommended to encourage effective compliance by fishers, processors and exporters.
9. ***Local participation in the industry:*** The sea cucumber export industry in Fiji is dominated by foreigners, mainly Asian nationals, who are involved in joint ventures with local partners. Incidents of unfair treatment of local partners and dominance of the trade by a few large companies have created an uncompetitive climate for aspiring local entrepreneurs in the business and prevented their participation. Opportunities for full localisation of the industry should be assessed with necessary regulatory changes in favour of local interests.
10. ***Monitoring and compliance:*** Weak monitoring and compliance are common in sea cucumber fisheries across the Pacific Island region. A more effective coastal fisheries monitoring and compliance programme needs to be established. It may be more cost-effective to expand the roles of tuna fisheries compliance personnel within the Fisheries Department to cover coastal fishery activities as well.
11. ***Community management:*** The community-based management system is being eroded and therefore weakened by the persistent fishing pressure and high prices of products and the weak regulation at the national level. Existing community-managed areas are not fully realising their potential due to poaching and because periodic bans on fishing certain species are rarely practised. Sea cucumber is a commercial fishery which needs to be controlled at a national level while community systems work best when focused on preserving resources for food security needs.
12. ***Aquaculture and ranching:*** Sea cucumber aquaculture and ranching, especially for sandfish (*Holothuria scabra*), have been trialled in Fiji; these trials have yet to produce conclusive results to determine the effectiveness of these methods in rebuilding stocks. At the same time Fiji has begun to export sandfish broodstock for introduction to Kiribati. In view of the past illegal exporting of the species, the continued harvesting pressure for food security, and the poor state of existing sandfish stocks (primarily young immature populations), it is recommended that any further translocation or introductions of wild harvested stock of the species should be discouraged for the near future while further assessments are conducted to gather more information on stocks in other areas of the country. A second recommendation is to include stock assessment surveys in the risk assessment process for broodstock translocation or introductions of sandfish and as well other IUCN Red Listed species. Finally, sea ranching trials of hatchery-produced sea cucumbers should collect information on survival rates with the aim of rebuilding stocks.
13. ***Golden sandfish:*** Golden sandfish (*Holothuria lessoni*) was last reported in 2009 at Muaivuso; the species is likely to have disappeared in sites where it naturally exists. Assessments across the country should try to locate any remaining stocks and recommend any stocks found for protection and aquaculture development.
14. ***Aggregation of broodstock:*** Aggregation of stocks is used in sedentary resources to improve breeding capacity of species. Practised largely with giant clams, the technique has not been well studied in sea cucumbers but represents a potential study topic in Fiji. With existing persistent fishing pressure, aggregation of stocks in an area can become stockpiling of sea cucumbers as it attracts the attention of poachers. Any attempt to aggregate adult stocks in Fiji should be undertaken in an established MPA with strong protection and enforcement.
15. ***Beche-de-mer Exporters Association:*** The Beche-de-mer Exporters Association was effective in slowing the boom production of the 1990s. Such industry associations can help the national government in controlling the industry and should be encouraged where possible.

16. ***Sea cucumber prices:*** The present variability in product prices and the many stages of middlemen have helped to keep down the prices that fishers receive for their product. Product prices in Fiji are lower than the estimated regional buying prices in Melanesian countries; efforts should be made to raise the prices to the regional price estimate levels as a step towards improving prices.

    In addition, the rise in sea cucumber prices to the consumer and in consumer demand justifies an assessment of the potential to increase the value of products to fishers through licences, improvement in processing beche-de-mer products and by setting floor product prices to reduce unnecessary fluctuations. These improved values are best achieved when there are healthy stock levels in the fishery after the resources have had sufficient time to rest and recover.

17. ***Monitoring information:*** Fiji Fisheries Department and the Ministry of Fisheries and Forests collect export permit data on beche-de-mer and landing data from local markets but have not analysed these data to inform management. Current export data need to be properly analysed with correct species names, and consistent landing data by Division need to be improved. This information should be presented in Annual Reports.

18. ***Collaboration with partners:*** Collaboration of SPC, Fiji Fisheries Department, the University of the South Pacific, PCDF and WCS and others with an interest in the management of the sea cucumber fishery offers a good opportunity for Fiji. The use of standardised resource assessment protocols, and comparable results have contributed to the delivery of effective fishery management advice to improve the management of the sea cucumber fishery. This good collaboration is to be encouraged to cover other fisheries in the future.

8. References

Adams T. 1992. Resource aspects of the Fiji beche-de-mer industry. SPC Beche-de-mer Information Bulletin 4:13–16.

Agudo N. 2006 Sandfish hatchery techniques. Noumea: Australian Centre for International Agricultural Research, Secretariat of the Pacific Community and the WorldFish Center. 44 pp.

Carleton C., Hambrey J., Govan H., Medley P. and Kinch J. 2013. Effective management of sea cucumber fisheries and the beche-de-mer trade in Melanesia. SPC Fisheries Newsletter 140:24–42.

Conand C. 1993. Reproductive biology of the holothurians from the major communities of the New Caledonian Lagoon. Marine Biology 116:439–450.

English S., Wilkinson C. and Baker V. 1997. Survey manual for tropical marine resources, 2nd edition. Townsville: Australian Institute of Marine Science. 390 pp.

Eriksson H. 2006. Sea cucumber abundance, diversity and fishery in Samoa. Minor field study 122. Sweden: Committee of Tropical Ecology, Uppsala University. 73 pp.

Eriksson H., De la Torre-Castro M. and Olsson P. 2012. Mobility, expansion, and management of a multi-species scuba diving fishery in East Africa. PLoS ONE 7(4): e35504. doi:10.1371/journal.pone.0035504

FAO 2012. Report on the FAO workshop on sea cucumber fisheries: An ecosystem approach to management in the Pacific (SCEAM Pacific), Nadi, Fiji, 15–18 November 2011. FAO Fisheries and Aquaculture Report. No. 1003. Rome, Italy.

Fiji Fisheries Department. 2003. Annual Report 2003. Suva: Ministry of Fisheries and Forests, Government of Fiji.

Fiji Fisheries Department. 2004. Annual Report 2004. Suva: Ministry of Fisheries and Forests, Government of Fiji.

Fiji Fisheries Department. 2005. Annual Report 2005. Suva: Ministry of Fisheries and Forests, Government of Fiji.

Fiji Fisheries Department. 2006. Annual Report 2006. Suva: Ministry of Fisheries and Forests, Government of Fiji.

Fiji Fisheries Department. 2007. Annual Report 2007. Suva: Ministry of Fisheries and Forests, Government of Fiji.

Fiji Fisheries Department. 2008. Annual Report 2008. Suva: Ministry of Fisheries and Forests, Government of Fiji.

Fiji Fisheries Department. 2010. Status of sea cucumber in lomaiviti i *qoliqoli*. Case study: Koro, Batiki and Nairai i *qoliqoli*. Marine resources inventory survey project. Suva: Ministry of Fisheries and Forests, Government of Fiji.

Fiji Times. 2011. $16m from slugs. Monday, 30 May 2011.

Fiji Trade and Investment Board. 2009. Investment opportunities in sea cucumber industry. Profile on sea cucumber in Fiji prepared by the Fiji Trade and Investment Board.

Friedman K., Eriksson H., Tardy E. and Pakoa K. 2010. Management of sea cucumber stocks: Patterns of vulnerability and recovery of sea cucumber stocks impacted by fishing. Fishing and Fisheries 12(1):75–93.

Friedman K., Purcell S., Bell J. and Hair C. 2008. Sea cucumber fisheries: Manager's toolbox. Canberra: Australian Centre for International Agriculture Research. 36 pp.

Friedman K., Kronen M., Vunisea A., Pinca S., Pakoa K., Magron F., Chapman L., Sauni S., Vigliola L., Tardy E. and Pierre L.F. 2008. Fiji country report: Profiles and results from survey work at Dromuna, Muaivuso, Mali and Lakeba (November 2002, April to June 2003, June and July 2007 and February 2009). Noumea, New Caledonia: Secretariat of the Pacific Community. 467 pp.

Hair C., Pickering T., Meo S., Vereivalu T., Hunter J. and Cavakiqali L. 2011. Sandfish culture in Fiji. SPC Beche-de-mer Information Bulletin 31:3–11.

Hasan M H. 2005. Destruction of a *Holothuria scabra* population by overfishing at Abu Rhamada Island in the Red Sea. Marine Environmental Research 60:489–511.

Jupiter S.D., Saladrau W. and Vave R. 2013. Assessment of sea cucumber fisheries through targeted surveys of Lau Province, Fiji. Suva, Fiji: Wildlife Conservation Society, University of the South Pacific, Fiji Fisheries Department and Khaled bin Sultan Living Oceans Foundation. 22 pp.

Kinch J., Purcell S., Uthicke S. and Friedman K. 2008. Population status, fisheries and trade of sea cucumbers in the Western Central Pacific. pp 7–55. In: Toral-Granda V., Lovatelli A. and Vasconcellos M. (eds). Sea cucumbers. A global review of fisheries and trade. Fisheries and Aquaculture Technical Paper No. 516. Rome, Italy: FAO.

Lawrence A.J., Ahmed M., Hanafy M., Gabr H., Ibrahim A. and Gab-Alla A. 2004. Status of the sea cucumber fishery in the Red Sea: The Egyptian experience. In: Lovatelli, A., Conand, C., Purcell, S., Uthicke, S., Hamel, J.-F. and Mercier, A. (eds). Advances in sea cucumber aquaculture and management. FAO Fisheries Technical Paper No. 463. Rome, Italy: FAO.

Lee J., Byrne M. and Uthicke S. 2008. The influence of population density on fission and growth of *Holothuria atra* in natural mesocosms. Journal of Experimental Marine Biology and Ecology 365:126–135.

Mai Life magazine. 2011. April. The quiet trade. No. 47.

Pakoa K. and Bertram I. 2013. Management state of Pacific sea cucumber fisheries. SPC Beche-de-mer Information Bulletin 33:49–52.

Pinca S., Kronen M., Friedman K., Chapman L., Tardy E., Pakoa K., Awira R., Boblin P. and Lasi F. 2010. Regional assessment report: Profiles and results from survey work at 63 sites across 17 Pacific Islands countries and territories. Noumea, New Caledonia: Secretariat of the Pacific Community. 540 pp.

Preston G., Lokani P., Vakamoce V. and Viala F. 1988. Beche-de-mer Exploitation in Fiji. Report to Chief Fisheries Officer, 9 December, Secretariat of the Pacific Community, Noumea, New Caledonia. 17 pp.

Purcell S., Tardy E., Desurmont A. and Friedman K. 2008. Commercial holothurians of the tropical Pacific. Noumea, New Caledonia: WorldFish Center and Secretariat of the Pacific Community.

Purcell S.W., Mercier A., Conand C., Hamel J-F., Toral-Granda M.V., Lovatelli A. and Uthicke S. 2011. Sea cucumber fisheries: Global analysis of stocks, management measures and drivers of overfishing. Fish and Fisheries 14(1):34–59.

Purcell S.W., Samyn Y. and Conand C. 2012. Commercial important sea cucumbers of the world. FAO Species Catalogue for Fishery Purposes. Rome, Italy: FAO. 223 pp.

Ram R., Friedman K. and Sobey M.N. 2010. Impacts of harvesting and post-harvesting processing methods on the quality and value of beche-de-mer in Fiji. SPC Beche-de-mer Information Bulletin 30:21–24.

Richards R., Lagibalavu M., Sharma S. and Swamy K. 1994. Fiji fisheries resources profiles. FFA Report No.94/4 1Research. 231 pp.

Secretariat of the Pacific Community (SPC). In press. Manual for assessing tropical marine invertebrate resources for management purposes in the Pacific islands. Noumea, New Caledonia: Coastal Fisheries Science and Management Section, Secretariat of the Pacific Community.

Uthicke S, Welch D, Benzie JAH. 2004. Slow growth and lack of recovery in overfished holothurians on the Great Barrier Reef: Evidence from DNA fingerprints and repeated large-scale surveys. Conservation Biology 18:1395–1404.

Ward R. 1972. The Pacific beche-de-mer trade with special reference to Fiji. pp. 91–123. In: Ward R. (ed.). Man in the Pacific: Essays on Geographical Change in the Pacific Islands. Oxford: Clarendon Press.

Western and Central Pacific Fisheries Commission. 2012. Tuna fisheries year book 2011. Version v1.0. Western and Central Pacific Fisheries Commission.

Appendix 1.

Number of stations by survey type and sampled reef area by site

Site	Partners	Survey type	Stations	Replicate	Area (m^2)	Area (ha)	Total area (ha)
Bua	SPC, FD	Manta tow	16.5	99	59,400	5.94	6.88
	PCDF	RBt	33.0	198	7,920	0.79	
		SBt	6.0	36	1,440	0.14	
Kubulau	SPC, FD	Manta tow	13.0	78	46,800	4.68	5.64
	PCDF	RBt	26.0	156	6,240	0.62	
		SBt	14.0	84	3,360	0.34	
Wailevu	FD	Manta tow	9.0	54	32,400	3.24	3.94
		RBt	17.0	102	4,080	0.41	
		SBt	12.0	72	2,880	0.29	
Naweni	FD	Manta tow	4.0	24	14,400	14.40	18.24
		RBt	8.0	48	1,920	1.92	
		SBt	8.0	48	1,920	1.92	
Ravitaki	FD	Manta tow	6.0	36	21,600	2.16	2.31
		RBt	4.0	24	960	0.10	
		SBt	2.0	12	480	0.05	
Oneata	FD	Manta tow	19.0	114	68,400	6.84	7.8
		RBt	40.0	240	9,600	0.96	
Batiki	PCDF	Manta tow	13.0	78	46,800	4.68	5.16
		RBt	20.0	120	4,800	0.48	
Dakuibeqa	FD	Manta tow	6.0	36	21,600	2.10	2.46
		RBt	15.0	90	3,600	0.36	

Note: SPC = Secretariat of the Pacific Community; FD = Fisheries Department; PCDF = Partners in Community Development Fiji; RBt = reef benthos transect; SBt = soft benthos transect.

Appendix 2.

Distribution of UBA operators, 2010–2013

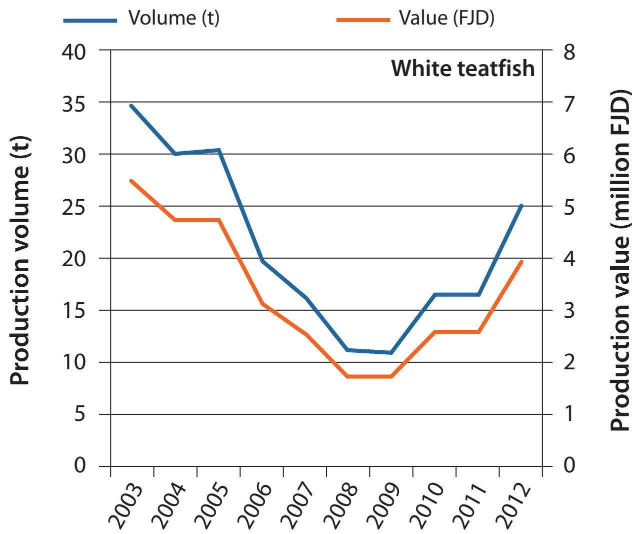
Year	Division	Province	Fishing area(s) or *qoliqoli*	Number	Total
2010	North	Cakaudrove	Naweni, Savudrodro, Cakaudrove	3	9
	North	Macuata	Naividamu, Dreketi	2	
	North	Bua	Yadua	4	
2011	Eastern	Lau	Matuku, Moce	3	19
	North	Cakaudrove	Qamea, Naqelelevu, Matei, Taveuni	4	
	North	Macuata	Benau, Labasa	1	
	North	Bua	Koroinasolo, Lomanikoro, Vuya, Bua	5	
	Central	Tailevu	Dawasamu	1	
	Central	Serua	Deuba (Serua)	1	
	West	Ba	Lautoka, Yasawa	4	
2012	Eastern	Lau	Moce, Komo	2	22
	North	Bua	Raviravi, Navakasiga, Koroinasolo, Bua	10	
	North	Cakaudrove	Tunuloa, Naweni	4	
	Eastern	Lomaiviti	Nairai, Ovalau	2	
	Central	Kadavu	Yale, Ono, Naocovonu	4	
2013	Eastern	Kadavu	Yale, Ono, Naocovonu	2	25
	Eastern	Lau	Moce, Fulaga, Kabara	2	
	Eastern	Lomaiviti	Nairai, Ovalau	2	
	North	Bua	Bua, Raviravi, Navakasiga, Koroinasolo, Bua	11	
	North	Macuata	Wainikeli, Laucala	1	
	North	Cakaudrove	Qamea, Naqelelevu, Matei, Taveuni, Cakaudrove	4	
	Central	Tailevu	Dawasamu, Serua	2	
	West	Ba	Lautoka, Yasawa	1	

Mean sizes (mm) of sea cucumbers recorded in Fiji (all sites assessed since 2003)

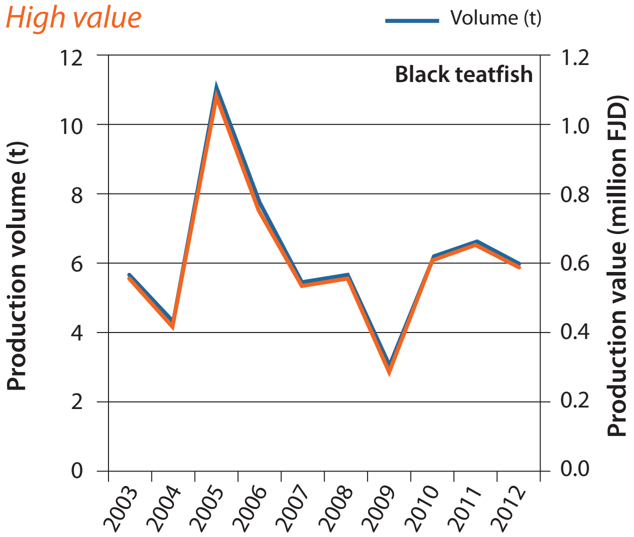
Code	Species	Mean length (mm)	Standard error	Total measured	Total recorded	Common size (mm)	Maximum size (mm)
AF	*Thelenota anax*	422	17	18	27	630	890
BSF	*Bohadschia vitiensis*	144	3	250	615	310	420
BTF	*Holothuria whitmaei*	268	10	54	72	340	540
CF	*Stichopus herrmanni*	150	5	165	199	390	550
CHF	*Bohadschia marmorata*	141	2	527	598	220	320
DF	*Stichopus horrens*	93	9	34	391	320	390
DWRF	*Actinopyga echinites*	79	1	279	605	150	360
ETF	*Holothuria fuscopunctata*	328	17	15	37	480	660
FF	*Bohadschia graeffei*	258	7	98	308	380	480
GF	*Stichopus chloronotus*	179	4	189	394	230	380
GSF	*Holothuria lessoni*	180		1	1	200	400
HBF	*Actinopyga miliaris*	111	4	114	120	230	300
LF	*Holothuria atra*	170	1	2,541	7,678	240	650
PF	*Holothuria edulis*	202	1	1,127	1,493	240	380
PRF	*Thelenota ananas*	336	31	12	28	550	700
SF	*Holothuria scabra*	124	2	1,102	1,103	240	400
SNF	*Holothuria coluber*	237	16	26	139	400	600
SRF	*Actinopyga mauritiana*	170	10	24	35	240	380
STF	*Actinopyga lecanora*	152	38	6	11	220	240
TF	*Bohadschia argus*	265	8	82	161	370	600
WTF	*Holothuria fuscogilva*	281	24	13	23	410	550

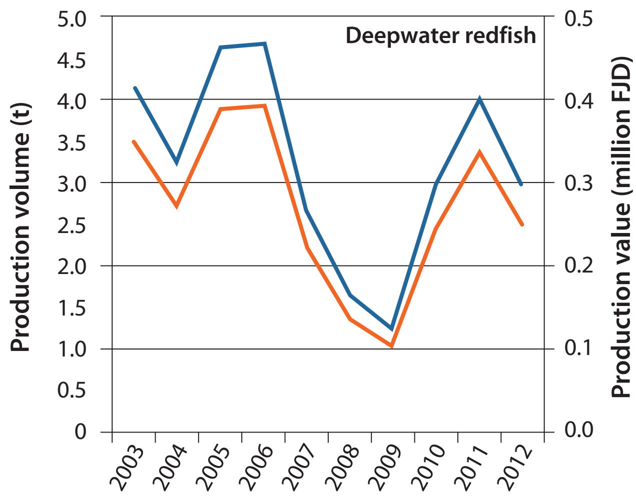
Production volume (dried weight, t) and value (million FJD) of the main traded sea cucumber species (excluding sandfish)

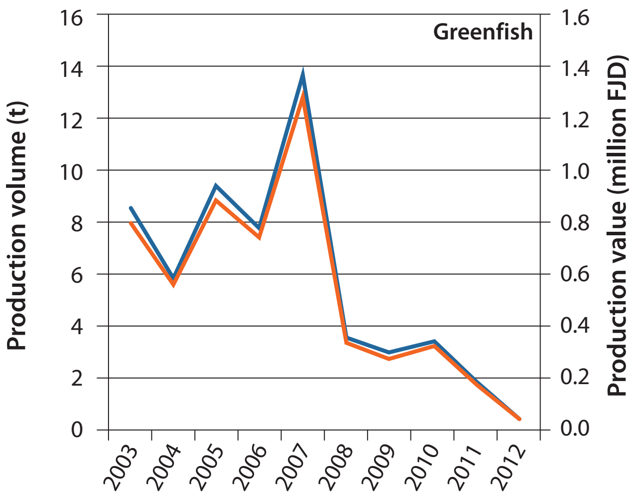
Very high value

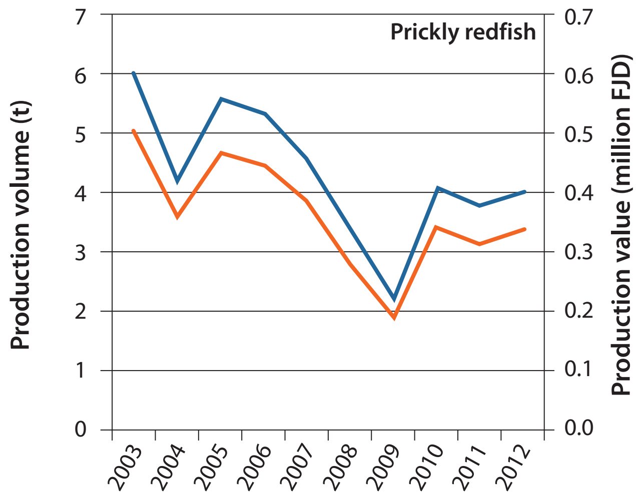


High value



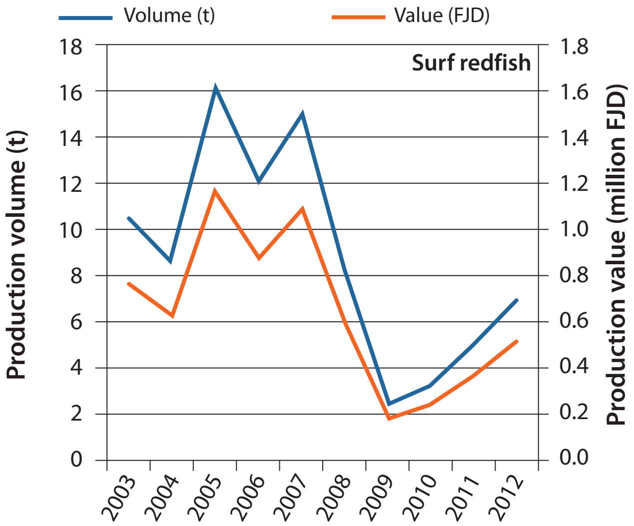




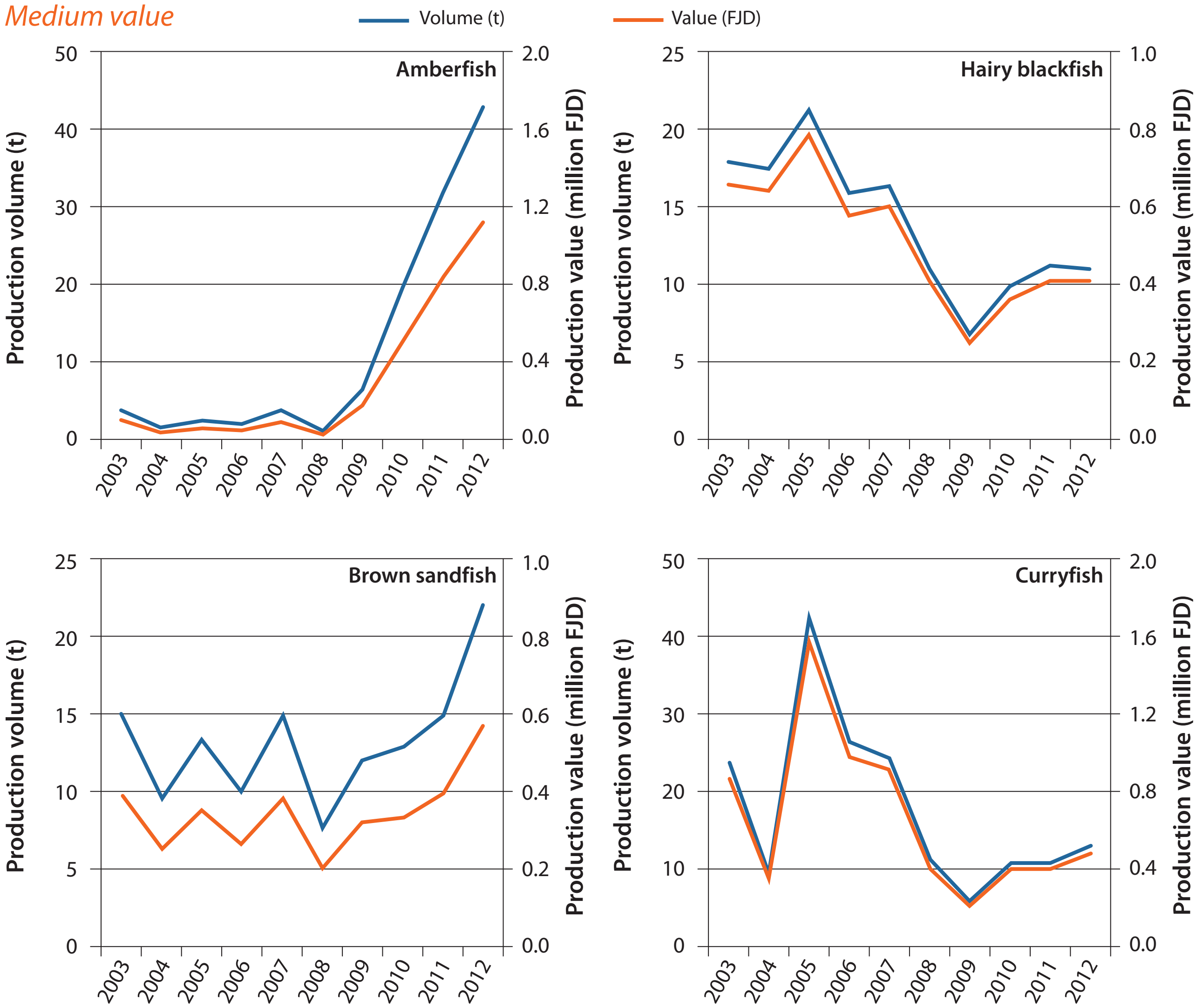


Production volume (dried weight, t) and value (million FJD) of the main traded sea cucumber species (excluding sandfish)

High value (cont.)

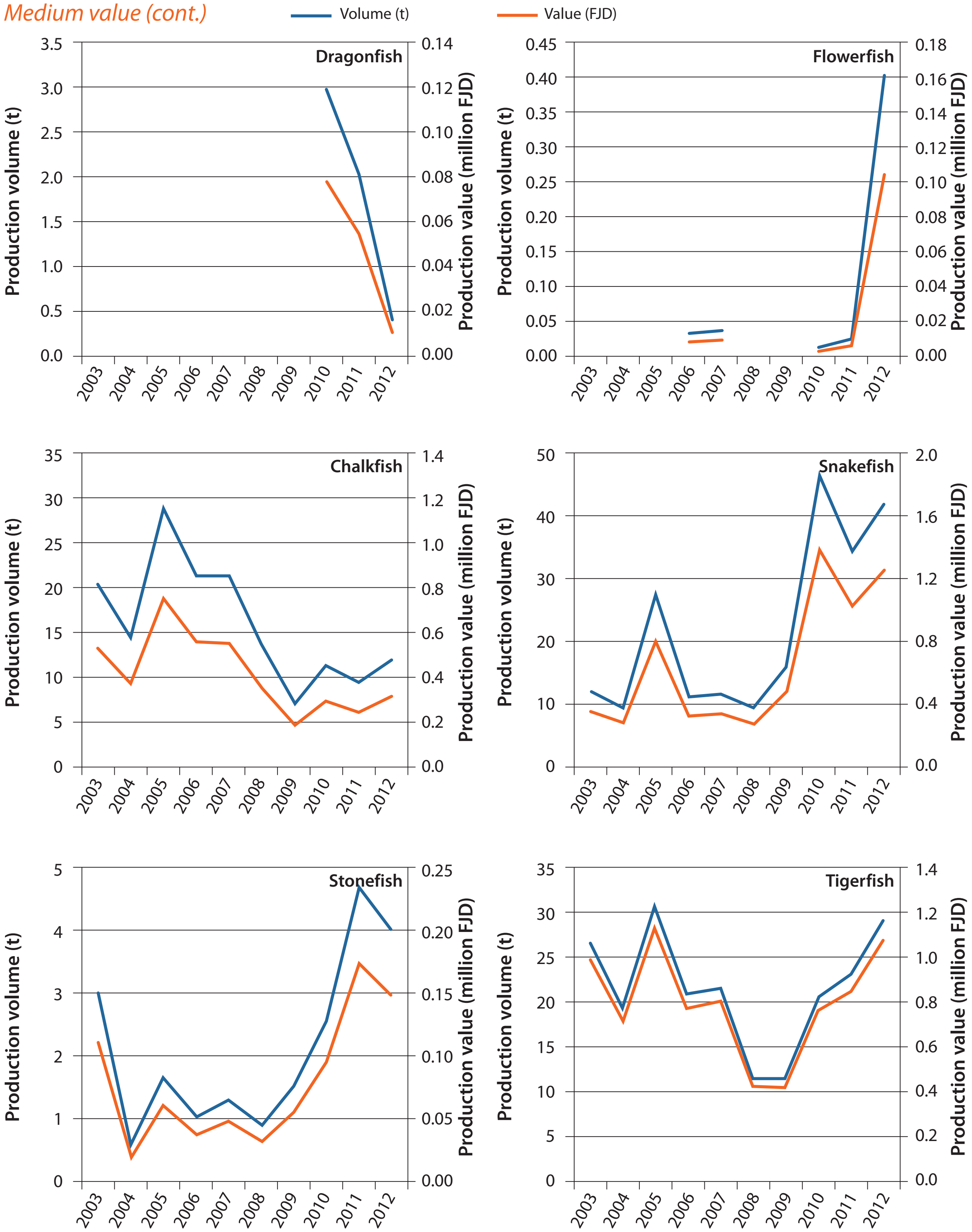


Medium value



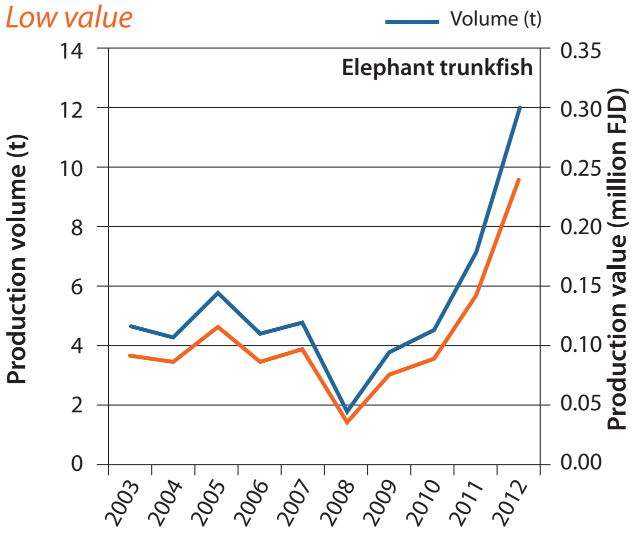
Production volume (dried weight, t) and value (million FJD) of the main traded sea cucumber species (excluding sandfish)

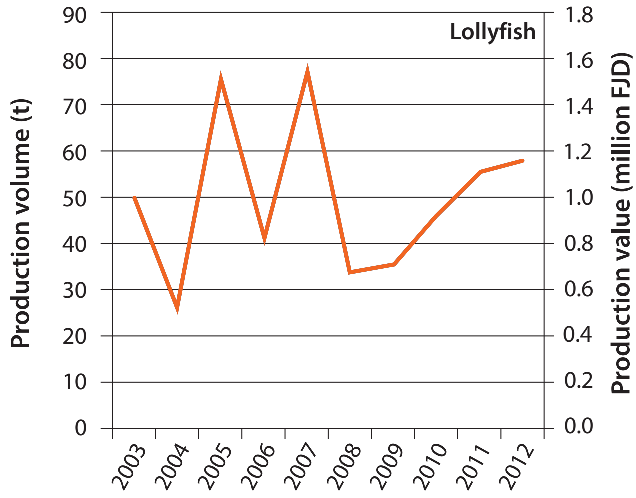
Medium value (cont.)



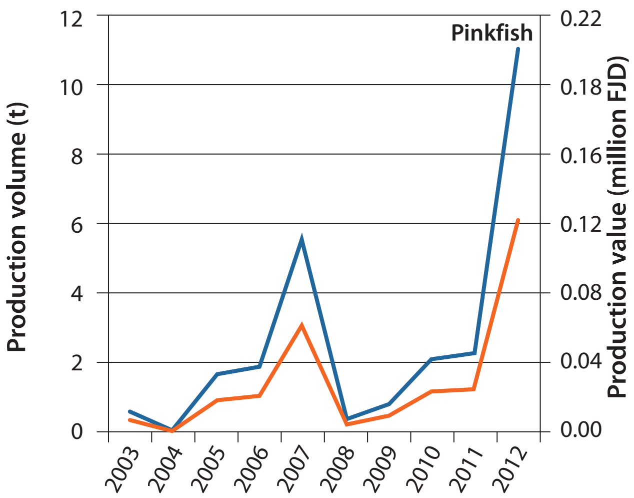
Production volume (dried weight, t) and value (million FJD) of the main traded sea cucumber species (excluding sandfish)

Low value





Note for lollyfish graph: Volume and value curves follow the same pattern.



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