# The status of sea cucumber resources and recommendations for management

in Samoa

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*by*

*Maria F. Sapatu[1] and Kalo Pakoa[2]*

*[1] Samoa Fisheries Division, Ministry of Agriculture and Fisheries*
*[2] Secretariat of the Pacific Community*

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# Contents

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## Summary

Commercial sea cucumber fishery in Samoa was banned in 1994 after concerns about over-exploitation and to protect sea cucumber species that are important for subsistence use in Samoa. In recent years, however, there has been an upsurge of interest in commercial harvesting of sea cucumber for export. In addition to an interest in harvesting wild stock, there has also been an interest in the development of aquaculture and ranching of sea cucumbers.

This report presents the current state of the sea cucumber fishery in Samoa, with recommendations on measures to control commercial fishing if this is permitted, and measures to control mariculture of sea cucumber to prevent any unnecessary impact on existing wild stock.

Information in this report is based on (a) assessments conducted by the Secretariat of the Pacific Community (SPC) on Savai'i in May 2012 as part of the in-country training of fisheries officers from the Samoa Fisheries Division and (b) the follow-up survey in Upolu by the trained team in July 2012. SPC's involvement was part of the joint country strategy for coastal fishery management technical assistance to the Samoa Fisheries Division in the sustainable management of sea cucumber fisheries.

The three most abundant species found were greenfish (*Stichopus chloronotus*), lollyfish (*Holothuria atra*) and tigerfish (*Bohadschia argus*). Greenfish and lollyfish were present above the regional reference densities for healthy stocks. Species exploited by the subsistence fishery, namely brown sandfish (*Bohadschia marmorata*), dragonfish (*Stichopus horrens*), were not in good stock status and require management intervention. Curryfish (*Stichopus herrmanni*) was last recorded in the 1990s (Mulipola 1994) but was not recorded in this survey, nor in the previous SPC surveys in 2005. Eriksson et al. (2006) suggest the species may have disappeared. The dragonfish is the main source of *sea* production (pickled viscera). Accurate assessment of catch landing data is necessary to understand subsistence fishery trends for these species. In addition, opportunities for the introduction of some of these fragile species seem an option for further discussion if they are to be rehabilitated.

Harvestable quantities for lollyfish and greenfish are provided, based on proposed legal harvest size limits of 160 mm and 200 mm respectively. Stock estimates are provided for the sites assessed, while overall island estimates will have to be done on availability of habitat maps, which SPC does not have at the moment. Unauthorised harvesting and processing have been recorded, indicating the urgency of putting in place Samoa's national sea cucumber fishery management plan. The plan should provide measures to control fishing, in case commercial fishing is allowed, and also control development of aquaculture in terms of broodstock management and protection and procedures for conducting ranching activities in a manner that does not interfere with wild stock sea cucumbers. Regulations on harvest size limits and catch monitoring mechanisms must be put in place to monitor catch, as well as any illegally fished products.

# 1. Introduction

## 1.1 Geography of Samoa

Samoa is located between latitude 13° 25'–14° 05'S and longitude 171° 23'–172° 48' W. The land area is 2,935 km$^2$ which is mainly contributed by the two main islands, Upolu and Savai'i; eight small islets comprise just 1% of this total land area (Vunisea et al. 2008). All the islands are of volcanic origin and are mountainous. The country has the smallest exclusive economic zone (EEZ) in the Pacific region — 120,000 km$^2$ — due to the close proximity of neighbouring countries. The population was estimated to be 187,820 in 2011 (Samoa Bureau of Statistics 2011) with communities mainly settled along the 447 km coastline. Adjacent to these communities are shallow lagoons (2–3 m depth), which are enclosed by fringing coral reefs that can extend up to three kilometres seaward. Traditionally, Samoa's economy was mainly that of agriculture and fisheries but recently tourism has increased, and family remittances from overseas and development aid have become important to the economy. The estimated gross domestic product (GDP) in 2006 was USD 1.218 billion (in purchasing power parity) and agriculture, including fisheries, represented about 11%.

## 1.2 The sea cucumber fishery

Sea cucumbers, also known as beche-der-mer, are slow-moving sedentary marine invertebrates that have been harvested across the Indo-Pacific Ocean either for subsistence or trade. At the moment, many sea cucumber fisheries in the region are considered overfished due to the change of traditional fishing methods to sophisticated diving equipment, bigger boats and the availability of frequent shipping, enabling fishers and sellers of sea cucumbers to fish and export more sea cucumbers to satisfy the increasing demand by consumers in Asia (Friedman et al. 2008).

Samoa's sea cucumber fishery was heavily exploited commercially in the early 1990s, leading to its collapse. This led to the decision to prohibit commercial export fishery in 1994 to allow stocks to recover (Mulipola 1994). Some species, such as dragonfish (*Stichopus horrens*), curryfish (*S. herrmanni*) and brown sandfish (*Bohadschia marmorata*) continue to be harvested for subsistence food security and for sale at domestic markets.

In 2005, as part of the coastal component of the Pacific Regional Oceanic and Coastal Fisheries Development Programme, underwater assessments were conducted of the status of invertebrates. There was good coverage of densities and size information on sea cucumbers. In 2006, a detailed assessment was conducted on sea cucumbers to determine whether stocks in Samoa had recovered from previous fishing pressure. Results obtained from these assessments recommended keeping the fishery closed from commercial exploitation, even though some species showed viable stocks for short-term small-scale commercial exploitation (Eriksson 2006). Recently, many investors have requested the Samoan Government through the Fisheries Division to reopening the fishery for farming and export. This initiated another nation-wide assessment of sea cucumbers by the Fisheries Division with the assistance of SPC to obtain an updated status of stocks to inform recommendations to the Samoan Government regarding whether the fishery should be reopened and on what conditions.

### *1.2.1 Subsistence and artisanal fishery*

Sea cucumbers are food resources in Samoa, supporting household food needs and the surplus sold at domestic markets for an income. Pickled body wall and intestine mixed with seawater and other invertebrates is a delicacy often used as a gift. The two main targeted species are dragonfish (*S. horrens*), valued for its viscera that are regarded as a delicacy, and brown sandfish (*B. marmorata*), valued for its body wall. Other species consumed are summarised in Table 1.

**Table 1.** Sea cucumber species harvested and consumed for subsistence.

| Common name (scientific name) | Samoan name | Part consumed |
|---|---|---|
| Tigerfish (*Bohadschia argus*) | *Ulutunu* | Body wall |
| Brown sandfish (*Bohadschia marmorata*) | *Fugafuga* | Body wall |
| Lollyfish (*Holothuria atra*) | *Loli* | Body wall |
| Curryfish (*Stichopus herrmanni*) | *Sea amu'u* | Viscera |
| Dragonfish (*Stichopus horrens*) | *Sea* | Viscera |

### *1.2.2 Commercial fishery*

Sea cucumber trade started in Samoa in the 1960s–1970s but there is no record available of the amount and value exported (Eriksson 2006). Three tonnes were recorded in 1987 as having been exported to Fiji by one company, but with uncompetitive prices and financial hardship the company closed down (Mulipola 1994). Export was restarted in 1992–1994 by five companies. They mainly exported *B. marmorata*, *B. argus* and *Actinopyga mauritiana* (Table 2). It was noted that *S. chloronotus* was unpopular for export due to its fast degeneration, even though it was accessible to fishing and abundant in the lagoons. The export companies managed to stay economically feasible for only a brief period of time (less than two years) due to the collapse of the fishery (Mulipola 1994). Commercial harvesting of sea cucumbers in Samoa was closed in 1994.

**Table 2.** Average price and catch data obtained from export years (1993–1994) in Samoa (Mulipola 1994).

| Common name (scientific name) | Samoan name | Average price $kg^{-1}$ (USD) | Weight (kg) |
|---|---|---|---|
| Brown sandfish (*Bohadschia marmorata*) | *Fugafuga* | 2.72 | 18,078 |
| Surf redfish (*Actinopyga mauritiana*) | *Mamao* | 6.04 | 12,299 |
| Tigerfish (*Bohadschia argus*) | *Ulutunu* | 3.78 | 7,875 |
| Greenfish (*Stichopus chloronotus*) | *Maisu* | 9.00 | 1,056 |
| Black teatfish (*Holothuria nobilis*) | *Susuvalu uliuli* | 8.00 | 977 |
| Lollyfish (*Holothuria atra*) | *Loli* | 1.75 | 771 |
| White teatfish (*Holothuria fuscogilva*) | *Susuvalu pa'epa'e* | 12.33 | 153 |
| Prickly redfish (*Thelenota ananas*) | *Fugafuga sauai* | 8.90 | 97 |

### *1.2.3 Previous resource surveys*

No independent survey on sea cucumbers was conducted before the export years. However, Mulipola (1994) reports an abundance of lollyfish (*H. atra*) and greenfish (*S. chloronotus*) in the lagoons. In 2005, SPC assessments of Vaisala and Salelavalu at Savai'i, Manono Island and Vailoa on Upolu provided a baseline inventory of invertebrates, including sea cucumbers (Vunisea et al. 2008). Results of this work showed high density of the same two species reported to be abundant in the 1994 surveys by Mulipola (1994). A follow up survey in 2006 in Safaatoa, Saleimoa, Satuimalufilufi, Toamua, Vailele and Vavau documented seven species and again greenfish and lollyfish were the more dominant species (Eriksson 2006). The 2006 assessment results indicate high densities of greenfish for the sites assessed.

### *1.2.4 Sea cucumber fishery management*

Samoa's coastal communities are empowered with the authority to manage adjacent coastal waters and their resources under the Village Fono Act (1990). Since then, such authority has been implemented through various management programmes of the Fisheries Division such as the Community-based Fisheries Management (CBFM) Programme. The aim was to help the villages set up management plans by identifying key problems and possible solutions through regulations, and providing continuous biological assessment (King and Faasili 1999). Sea cucumbers have been one of the priority species identified in such management plans.

The Fisheries Act (1988) and Fisheries regulation (1996) govern marine resources, their conservation and monitoring. They prohibit certain fishing methods, allow for the authorisation of scientific research and provide regulations to regulate and manage fisheries (Skelton et al. 2000). Special terms and conditions were developed under the Fisheries Act to cater for the export of sea cucumber when the fishery was open to commercial harvest. With the closure in 1994, sea cucumbers have been traditionally managed by communities under the CBFM programme, with village by-laws to deal with neighbouring communities who may obstruct implementation of resources management. At the moment, the Fisheries Division is awaiting the finalisation and approval of a new Fisheries Bill.

Apart from the moratorium on commercial exports, there is currently no sea cucumber fishery management plan and therefore no specific measures currently in-place for the management of sea cucumber. The development of a fishery management plan is identified in the Coastal Fisheries Management and Development policy 2013.

## 1.3 Objectives of this study

The main objective of this study is to conduct comprehensive assessment of Samoa's sea cucumber resources to assess densities of shallow-water sea cucumbers from selected sites in Upolu and Savai'i. The results of the survey will assist decision-making on the management of this fishery. At the same time this assessment aims to build the capacity of local officers to conduct similar surveys in future.

# 2. Methodology and design

## 2.1 Underwater resource surveys

The design of the surveys follows standardised regional invertebrate assessments of sea cucumbers which are based on in-water assessment. Sample size varies by site and covers all potential shallow habitats for sea cucumbers. Sites previously assessed — Vaisala and Salelavalu on Savai'i, and Aleipata and Manono on Upolu (Vunisea et al. 2008) were targeted for comparability purposes, and additional sites provided the status of sea cucumber resources for the country. Distribution of station locations was planned on a Google map (Google Earth Map-http/www.google.com). Assessments on Savai'i were completed as part of the in-country training of fisheries officers conducted by SPC in May 2012, and surveys in Upolu were conducted by the trained officers. After the completion of the Upolu surveys, an officer travelled to SPC Noumea to undergo further training on data processing and reporting.

Two main survey protocols — manta tow and reef benthos transect — were adopted to assess the resources in shallow waters (Fig. 1). Manta tow surveys involve towing a surveyor over shallow lagoons, back reef and lagoon slopes at a speed of around 3–4 km hour$^{-1}$. The surveyor observes from the manta board and records the number of sea cucumbers observed along an observation belt 300 m by 2 m at a depth from 1 to 7 m (Vunisea et al. 2008). Hand tally counters mounted on the manta board are used to enumerate common species observed along a run. The transect length is calibrated using the odometer function of a Garmin 76Map and Garmin eTrex GPS.

A reef benthos transect employs two snorkelers equipped in shallow waters and measuring and recording counts and length of sea cucumber species (Vunisea et al. 2008). A transect is 40 m long by 1 m wide and six replicate transects constitute one survey station.

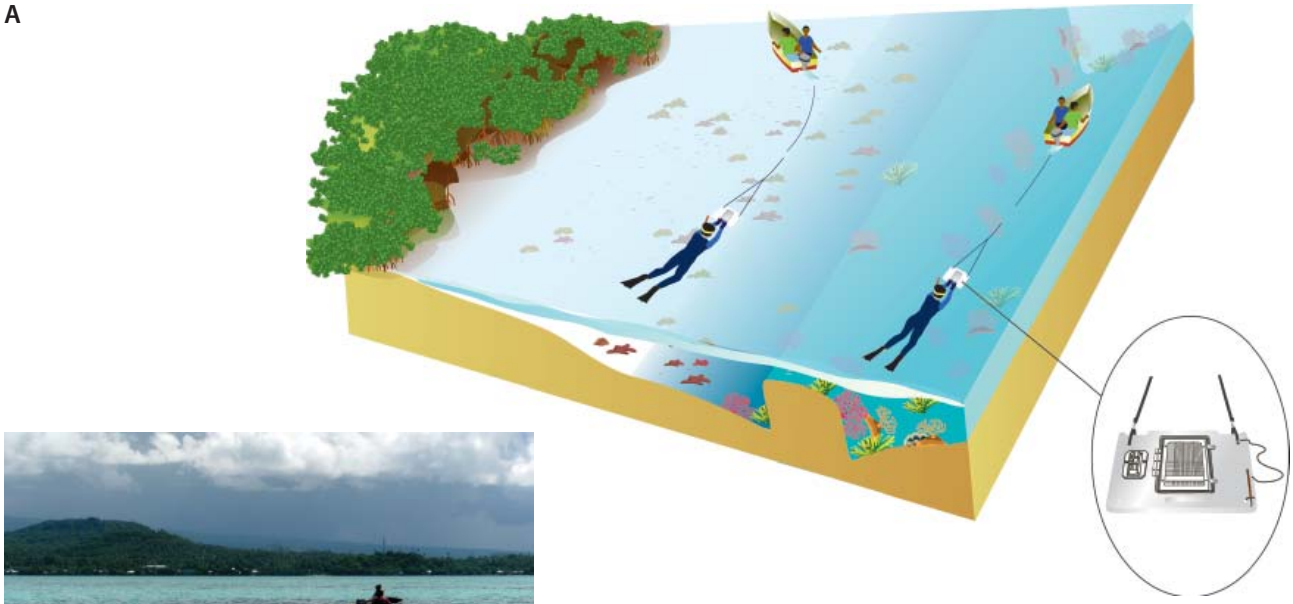
## 2.2 Fishery landing surveys

In addition to underwater resource data, the Samoa Fisheries Division collected landing data on a weekly basis. Sea cucumber products on sale at local markets are in the form of bottled sea cucumber viscera and body wall mixed with seawater, other invertebrates and seaweed. The units of measure are number, volume of bottle and type of mix in the content. This information is used to assess domestic production trends over past years and cross check with the resource information.

## 2.3 Data analysis and reporting

Data were entered into the Reef Fisheries Integrated Database (RFID) at the Samoa Fisheries Office and at SPC Noumea during the training attachment in July 2012. The analysis of stock status follows sea cucumber fishery status indicators provided in *Sea cucumber fisheries: A manager's toolbox* (Friedman et al 2008), regional coastal fisheries status reports (Pinca et al. 2010; Vunisea et al. 2008; Friedman et al. 2010) and the invertebrate resource survey manual (SPC in press). A preliminary report was released to Samoa Fisheries at the end of 2012 on the results while this report was being finalised. Fishery landing data were assessed using an Excel spreadsheet.

A



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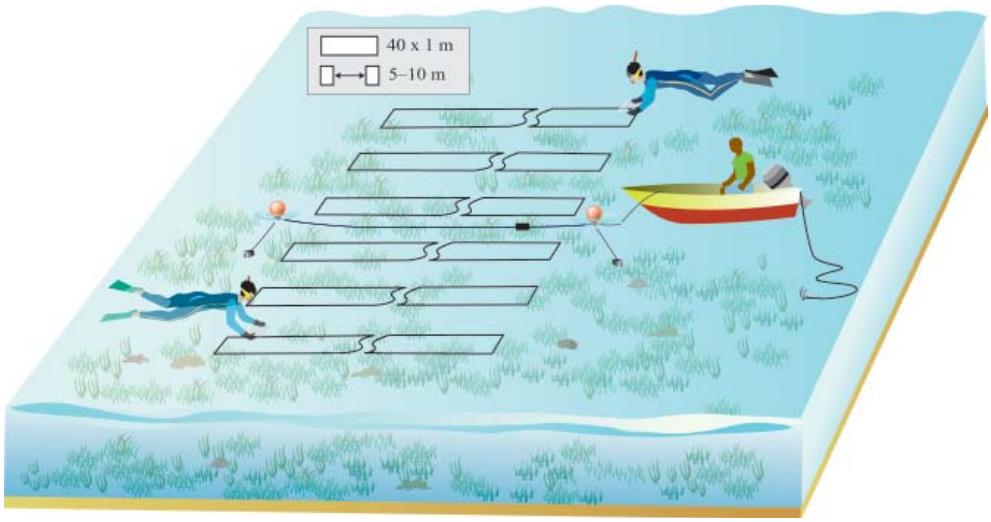


**Figure 1.** Assessment methods adopted for sea cucumber surveys at sites in Samoa. A: manta tow; B: reef benthos transects (Illustration by Youngmi Choi, SPC).

# 3. Results

## 3.1 Coverage area

The sea cucumber surveys were located mainly within the back reef, lagoon and coastal reef habitats of Samoa's two main islands, Savai'i (three sites) and Upolu (four sites) (Fig. 2). A total of 121 survey stations were completed, 41 in Savai'i and 80 in Upolu (Table 3). Sites previously assessed in the 2005 surveys; are Vaisala, Salelavalu, Manono and Aleipata (Vailoa).

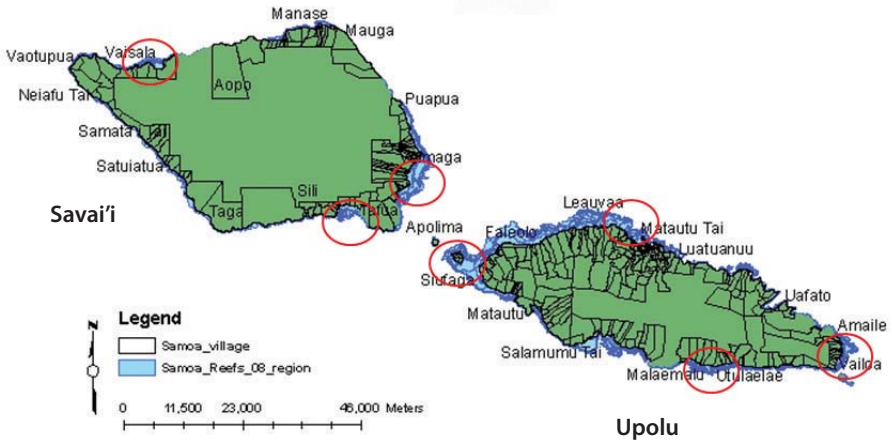


**Figure 2.** Map of Samoa indicating sea cucumber survey sites.

The total area surveyed by Manta at each station was 3,600 m² (300 m x 2 m x 6 replicates) and 240 m² (40 m x 1 m x 6 replicates) for RBt, equating to a total area of 166,800 m² (16.7 ha) for the 121 stations.

**Table 3.** Details on number of stations conducted for each survey site.

| Island | Site | Manta | RBt | Total stations | Total area (m²) | Total area (ha) |
|---|---|---|---|---|---|---|
| Savai'i | Vaisala | 3 | 12 | 15 | 13,680 | 1.37 |
| | Salelavalu | 6 | 16 | 22 | 25,440 | 2.54 |
| | Faala | 1 | 4 | 5 | 4,560 | 0.46 |
| Upolu | Manono | 9 | 12 | 21 | 35,280 | 3.53 |
| | Faleula | 8 | 12 | 20 | 31,680 | 3.17 |
| | Aleipata | 6 | 12 | 18 | 24,480 | 2.45 |
| | Falealili | 8 | 12 | 20 | 31,680 | 3.17 |
| | **Total** | **41** | **80** | **121** | **166,800** | **16.7** |

## 3.2 Species presence and occurance

A total of 3,395 individual sea cucumbers belonging to ten species was recorded (Table 4) in these assessments. The most recorded species was lollyfish (*H. atra*) with 1,700 records, followed by greenfish (*S. chloronotus*) with 1,205 records, and the non-commercial tigertail fish (*Holothuria hilla*) with 208 records. Tigerfish (*B. argus*) was the fourth most recorded species (Fig. 3). Overall 54% of the total recorded was from the Upolu sites and 46% from the Savai'i sites. This reflects the coverage area in the two islands, Upolu having more reefs assessed than Savai'i. Lollyfish was more abundant in Upolu sites, while in Savai'i sites greenfish was more abundant. Upolu Island shows dominance in the number of species recorded compared to Savai'i due to the higher coverage in Upolu (79 stations) compared to Savai'i (42 stations) and the larger and more complex reef habitat areas in Upolu sites. Important subsistence species brown sandfish (*B. marmorata*) and dragonfish (*S. horrens*) densities are highlighted (Table 5) and pictured with the unrecorded curryfish (*S. herrmanni*) (Fig. 4).

**Table 4.** Count of sea cucumber species recorded by sites.

| Species | Site | | | | | | | Total count |
|---|---|---|---|---|---|---|---|---|
| | Vaisala | Salelavalu | Faala | Manono | Faleula | Aleipata | Falealili | |
| *Holothuria atra* | 315 | 191 | 1 | 358 | 652 | 84 | 99 | 1,700 |
| *Stichopus chloronotus* | 438 | 437 | 52 | 67 | 85 | 105 | 21 | 1,205 |
| *Holothuria hilla* | 9 | 2 | | 2 | 151 | 44 | | 208 |
| *Bohadschia argus* | 48 | 20 | | 65 | 12 | | 18 | 163 |
| *Holothuria whitmaei* | | 1 | | 14 | | 12 | 3 | 30 |
| *Synapta maculata* | 1 | 25 | | 4 | 20 | 3 | | 53 |
| *Bohadschia marmorata* | 1 | | | 12 | 10 | | | 23 |
| *Holothuria coluber* | | | | | 4 | | | 4 |
| *Stichopus horrens* | | 6 | | | 1 | | | 7 |
| *Thelenota ananas* | 1 | | | | | 1 | | 1 |
| **Total** | | | | | | | | **3,395** |


**Figure 3.** Main sea cucumber species in Samoa.
A: Large or reef lollyfish (*Holothuria atra*); B: Greenfish (*Stichopus chloronotus*);
C: Common or small lollyfish (*Holothuria atra*); D: Tigerfish (*Bohadschia argus*).


**Figure 4.** Important subsistence species that are now rare.
A: Brown sandfish (*Bohadschia marmorata*); B: Curryfish (*Stichopus herrmanni*); C: Dragonfish (*Stichopus horrens*).

## 3.3 Densities and abundance of species

### *3.3.1 Mean species densities*

The most frequently encountered species from the two assessments are lollyfish (*H. atra*) and greenfish (*S. chloronotus*) (Tables 4 and 5). Tigerfish was the next important species although its density is much lower. Densities of brown sandfish (*B. marmorata*) and dragonfish (*S. horrens*), two important subsistence species, were low. High densities recorded for reef benthos transects for greenfish and lollyfish reflect their patchiness and high densities in shallow water habitats which were accessible by reef benthos transect assessment.

**Table 5.** Mean densities for all sites together for reef benthos transects (RBt) and manta tows (Manta).

| Survey | Species | Mean_O | SE_O | N_O | Mean_P | SE_P | n | % |
|---|---|---|---|---|---|---|---|---|
| RBt | *Stichopus chloronotus* | 6,906.8 | 2,490.2 | 80 | 12,278.7 | 4,277.2 | 45 | 56 |
| | *Holothuria atra* | 5,392.2 | 2,028.1 | 80 | 8,987.0 | 3,291.7 | 48 | 60 |
| | *Holothuria atra* (big) | 266.7 | 163.7 | 80 | 1,254.9 | 738.1 | 17 | 21 |
| | *Bohadschia argus* | 72.4 | 17.2 | 80 | 214.5 | 38.8 | 27 | 34 |
| | *Holothuria whitmaei* | 12.0 | 3.9 | 80 | 79.9 | 14.9 | 12 | 15 |
| | *Stichopus horrens* | 3.6 | 2.2 | 80 | 97.2 | 27.8 | 3 | 4 |
| | *Bohadschia marmorata* | 2.6 | 2.1 | 80 | 104.2 | 62.5 | 2 | 3 |
| | *Holothuria coluber* | 6.8 | 6.3 | 80 | 270.8 | 229.2 | 2 | 3 |
| | *Thelenota ananas* | 0.5 | 0.5 | 80 | 41.7 | | 1 | 1 |
| Manta | *Holothuria atra* | 1,176.3 | 541.0 | 41 | 1,663.0 | 749.8 | 29 | 71 |
| | *Stichopus chloronotus* | 707.2 | 290.7 | 41 | 805.5 | 328.2 | 36 | 88 |
| | *Bohadschia argus* | 11.3 | 4.6 | 41 | 29.0 | 10.6 | 16 | 39 |
| | *Holothuria atra* (big) | 3.3 | 1.7 | 41 | 12.4 | 5.6 | 11 | 27 |
| | *Bohadschia marmorata* | 7.5 | 4.4 | 41 | 44.0 | 22.3 | 7 | 17 |
| | *Holothuria whitmaei* | 1.1 | 0.5 | 41 | 6.3 | 2.0 | 7 | 17 |
| | *Thelenota ananas* | 0.1 | 0.1 | 41 | 2.8 | | 1 | 2 |

Mean_O = Overall mean density (numbers $ha^{-1}$); Mean_P = mean densities of transect where species is present; n = number of transects and stations; SE = Standard error; n = number of transects or stations where a species is present; % = percentage of transects and stations where a species is present.

Table 6 shows mean densities by sites. Lollyfish is widely distributed in all sites and habitats as indicated by low variation between overall and present mean densities (Fig. 5), which is usual. Small or common lollyfish and large or reef lollyfish are different products and command different values by traders; reef lollyfish is normally higher in value than common lollyfish due to its larger size. Reef lollyfish inhabit narrow habitat along the outer reef flat, just behind the reef crest, with high energy influence. Common lollyfish is widely distributed over much of the reef. The two strains of lollyfish are present in five sites, with greatest densities at Vaisala (*H. atra*) and Aleipata (*H. atra*, big). Greenfish density was highest in Vaisala and high in Aleipata and Salelavalu (Fig. 6).

**Table 6.** Mean densities (individuals $ha^{-1}$) by sites and assessment types.

| Survey | Species | Site | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Vaisala | Salelavalu | Faala | Manono | Faleula | Aleipata | Falealili |
| RBt | *Stichopus chloronotus* | 34,152.8 | 4,210.9 | 489.6 | 166.7 | 204.9 | 5,743.1 | |
| | *Holothuria atra* | 4,371.5 | 682.3 | 10.4 | 1,754.0 | 28,292.0 | 31.3 | 569.4 |
| | *Holothuria atra* (big) | 326.4 | 78.1 | | 27.8 | | 1,292.0 | 45.1 |
| | *Bohadschia argus* | 173.6 | 39.1 | | 180.6 | 45.1 | | 31.3 |
| | *Bohadschia marmorata* | 3.5 | | | | 13.9 | | |
| | *Thelenota ananas* | 3.5 | | | | | | |
| | *Holothuria coluber* | | | | | 45.1 | | |
| | *Holothuria whitmaei* | | 2.6 | | 41.7 | | 31.3 | 3.5 |
| | *Stichopus horrens* | | 15.6 | | | 3.5 | | |
| Manta | *Stichopus chloronotus* | 5,665.7 | 835.2 | | 93.8 | 47.6 | 519.4 | 205.9 |
| | *Holothuria atra* | 550 | 652.8 | | 840.7 | 4,349.0 | 25.5 | 18.8 |
| | *Bohadschia argus* | 79.6 | 2.8 | | 17.9 | 0.7 | | 5.2 |
| | *Holothuria atra* (big) | 2.8 | 2.8 | | | | 11.6 | 5.2 |
| | *Bohadschia marmorata* | | | | 31.2 | 3.5 | | |
| | *Holothuria whitmaei* | | | | 2.5 | | 2.8 | 0.7 |
| | *Thelenota ananas* | | | | | | 0.5 | |

Note: *Holothuria atra* and *Holothuria atra* (big) are the same species however two variations of this species were common in Samoa.

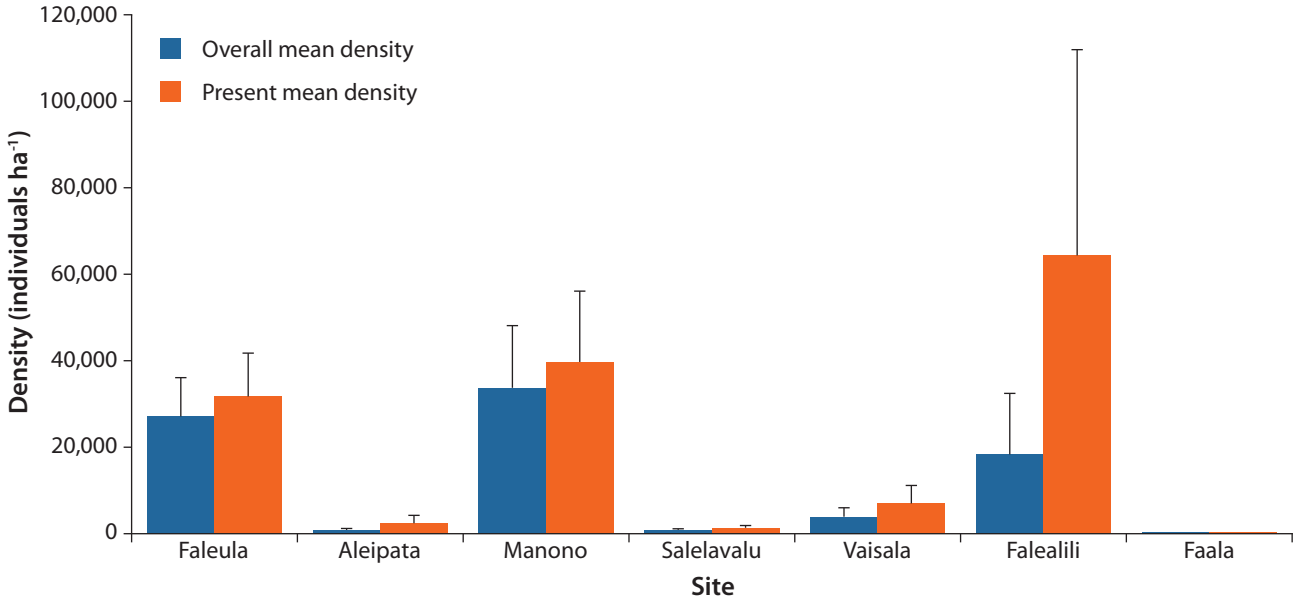


**Figure 5.** Overall mean density (left bar) and present mean density (right bar) for lollyfish (*Holothuria atra*).

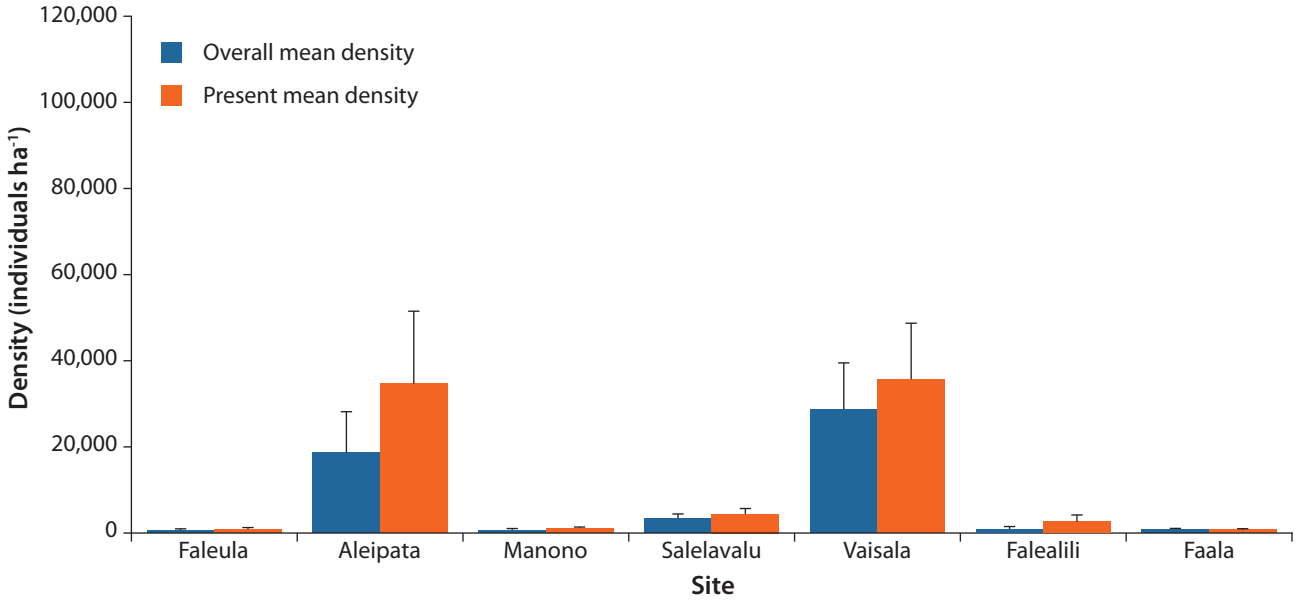


**Figure 6.** Overall mean density (left bar) and present mean density (right bar) for greenfish (*Stichopus chloronotus*).

### 3.3.2 Determining healthy mean densities

The Pacific regional average densities for sea cucumbers for manta tow and reef benthos transect surveys (Table 7) are used as guide to assist managers determine the state of their resources. These regional reference densities were derived as the mean of the upper 25% of site densities across the Pacific. Overall reef benthos transect densities for greenfish and lollyfish for Samoa were above regional reference densities for healthy stocks. Manta tow densities for both species were below regional reference densities. Habitat coverage of manta tow is along the lagoon slope and over shallow lagoon habitats, which hold fewer aggregations of both species. Lollyfish and greenfish densities were in healthy condition. However, site specific reference densities need to be developed, which are bound to be more accurate.

**Table 7.** Comparison of overall mean density for all sites by species and method of survey, with regional reference density.

| Survey | Species | Mean density (ind. ha$^{-1}$) | Regional reference density (ind. ha$^{-1}$) |
|---|---|---|---|
| RBt | *Stichopus chloronotus* | 6,906.8 | 3,500 |
| | *Holothuria atra* | 5,658.9 | 5,600 |
| | *Bohadschia argus* | 72.4 | 120 |
| | *Holothuria whitmaei* | 12.0 | 50 |
| | *Stichopus horrens* | 3.6 | |
| | *Bohadschia marmorata* | 2.6 | 100 |
| | *Holothuria coluber* | 6.8 | 1,100 |
| | *Thelenota ananas* | 0.5 | 30 |
| Manta | *Holothuria atra* | 1,179.6 | 2,400 |
| | *Stichopus chloronotus* | 707.2 | 1,000 |
| | *Bohadschia argus* | 11.3 | 50 |
| | *Bohadschia marmorata* | 7.5 | 160 |
| | *Holothuria whitmaei* | 1.1 | |
| | *Thelenota ananas* | 0.1 | |

Note: The regional references are as of March 2013, based on updated information from recent surveys.

### 3.3.3 Sea cucumber references densities for Samoa

Development of more accurate site specific density reference points is encouraged. Data generated from this study provide an opportunity to develop reference densities for three commercially important species, greenfish, lollyfish and tigerfish with the following considerations:

- a long period of resting of the stocks, as commercial fishing of sea cucumbers in Samoa has not been active for many years, which allowed the stocks to grow to the present status — close to or near natural densities of these species;
- the presence of high densities of greenfish and lollyfish in the sites assessed, which are among the highest recorded in the Pacific sites;
- the larger survey coverage in this assessment compared to past assessments;
- re-assessment of sites assessed in the past with other surveys by the Samoa Fisheries Division provides sufficient information to determine reference densities.

These seven sites can become long-term monitoring sites for sea cucumbers and the new reference densities (Table 8) can be used to assess the relative health of abundance at these sites. Regional reference mean densities are based on the mean density of the upper 25% of the overall mean densities for sites across the Pacific region. These reference densities are useful assessment tools for future resources assessment to determine healthy stock status for fishing or biodiversity monitoring purposes.

**Table 8.** New sea cucumber reference densities for Savai'i and Upolu.

| Survey | Species | Savai'i (ind. ha$^{-1}$) | Upolu (ind. ha$^{-1}$) |
|---|---|---|---|
| RBt | *Holothuria atra* | 1,600 | 6,000 |
| | *Stichopus chloronotus* | 11,200 | 1,100 |
| | *Bohadschia argus* | 60 | 50 |
| Manta | *Holothuria atra* | 400 | 1,000 |
| | *Stichopus chloronotus* | 1,700 | 140 |
| | *Bohadschia argus* | 20 | 5 |

## 3.4 Species mean size and distribution

Size distribution presents an understanding of stock responses to certain management measures or fishing pressure. Mean size for sea cucumber species are displayed in Table 9. The size structure of lollyfish (Fig. 7) and greenfish (Fig. 8) follows a pyramidal shape, indicating limited disturbance of the stock during the closure period. The lollyfish size structure is skewed towards the right with maximum size at 435 mm while the mean size is 122 mm, and this is contributed by the larger strain of lollyfish, the reef lollyfish. The two strains are indicated (Fig. 7), sizes from 200 mm to 425 mm is the reef lollyfish while the common lollyfish dominates. Common lollyfish size in the Pacific is 230 mm and maximum length is 650 mm (Purcell et al. 2008).

Greenfish (Fig. 8) is a non-subsistence species so the population structure depicts an unfished stock.

Tigerfish (Fig. 9), a subsistence species in Samoa, is less abundant and the stock structure is non-uniform; the lower mean size is 233 mm and the common size recorded in the Pacific is 370 mm (Purcell et al. 2008). The disturbed structure could be caused by fishing by the subsistence fishery.

**Table 9.** Mean sizes (mm) of sea cucumbers in Samoa.

| Common name (Scientific name) | Mean size (mm) | SE | n |
|---|---|---|---|
| Lollyfish (*Holothuria atra*) | 122.09 | 0.86 | 1,965 |
| Greenfish (*Stichopus chloronotus*) | 121.90 | 1.11 | 1,875 |
| Tigertail fish (*Holothuria hilla*) | 112.37 | 2.08 | 208 |
| Lollyfish (big) (*Holothuria atra*) | 285.36 | 3.87 | 203 |
| Tigerfish (*Bohadschia argus*) | 242.47 | 5.68 | 139 |
| Brown sandfish (*Bohadschia marmorata*) | 148.00 | 19.60 | 5 |
| White teatfish (*Holothuria whitmaei*) | 213.05 | 16.92 | 22 |
| Dragonfish (*Stichopus horrens*) | 97.14 | 9.93 | 7 |
| Prickly redfish (*Thelenota ananas*) | 310.00 | 0.00 | 2 |

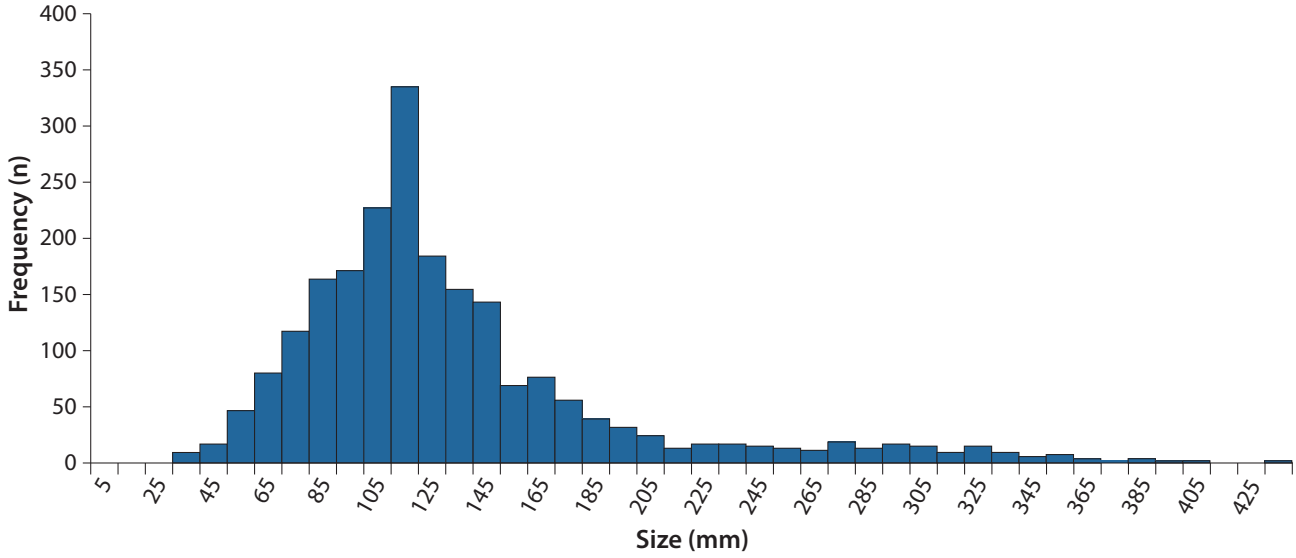


**Figure 7.** Size distribution for lollyfish (*Holothuria atra*).

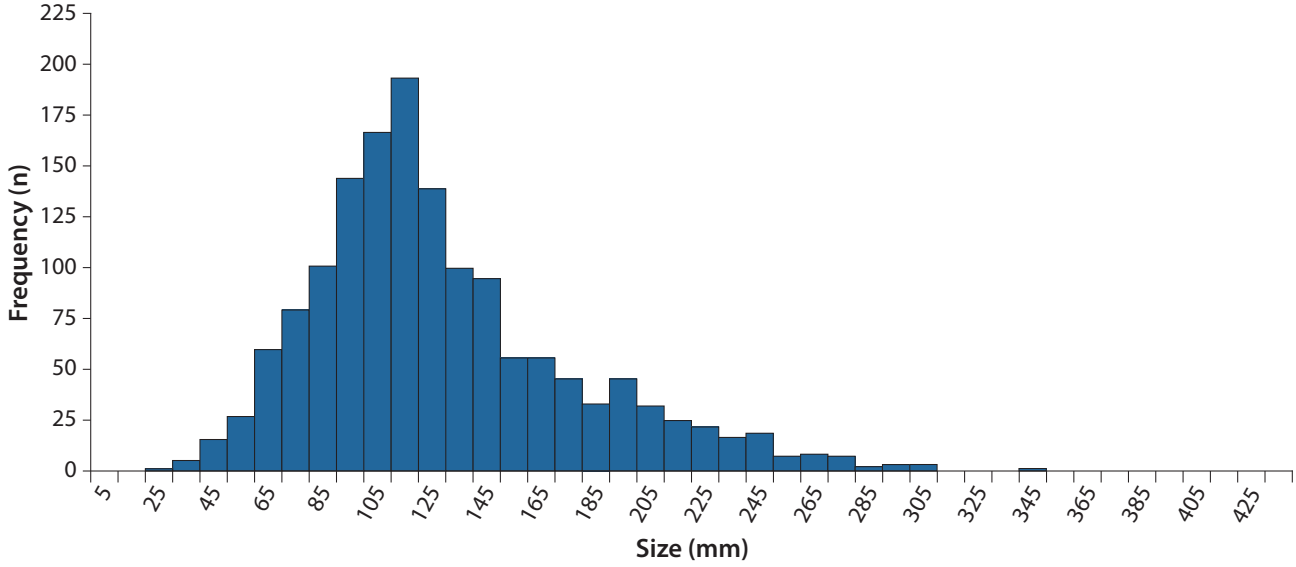


**Figure 8.** Size distribution for greenfish (*Stichopus chloronotus*).

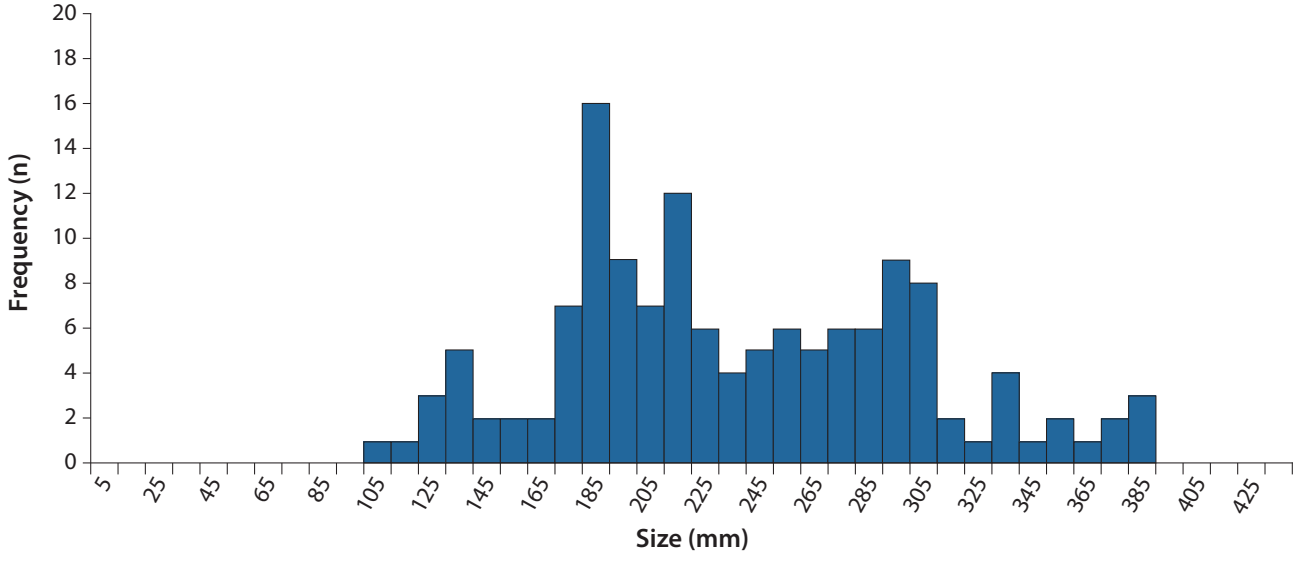


**Figure 9.** Size distribution for tigerfish (*Bohadschia argus*).

## 3.5 Fishery information

### *3.5.1 Catch landing*

Sea cucumber is consumed and marketed locally as a mixture of intestine (or viscera) and body wall (the main ingredients) mixed with seawater. The sea cucumber viscera and body wall is occasionally mixed with other invertebrate products and seaweed. Annual landings are assessed by bottled units, which can be converted to tonnes. Total landings of bottled sea cucumber at the local markets (roadside and municipal markets) increased from 2000, peaked in 2003 at over 8,000 bottles (4,298 kg) and have gradually declined reaching 3,164 bottles (1,637 kg) in 2012 (Fig. 10). Conversion of the number of bottles to quantity (kg) is based on the average weight of bottles — large bottles: 750 ml; small bottles: 285 ml. These are the main bottle sizes used in marketing the product.

Of the five species consumed in Samoa, three species — brown sandfish, dragonfish and lollyfish comprise close to 90% of landings (Eriksson 2006). The falling trend in total landings (Fig. 10) provides an indication of resource availability of the three species, and further analysis of landing data will help identify trends by species. Of these species, lollyfish stock is in good condition from the in-water assessment; the other two most preferred species are rare. Dragonfish is known to regenerate when the carcass is returned to the sea after removal of the viscera. However, studies of the recovery rate in Samoa show the survival rate to be very low (Eriksson 2006). Brown sandfish on the other hand is valued for its body wall.

An increasing number of other sea cucumber products is being sold; as mixtures of sea cucumber with sea grape (*Caulerpa racemosa*) or sea hare eggs (*Dolabella auricularia*). Adding a small amount of dragonfish viscera to the mix increases its value (Eriksson 2006). These mixed products have become more diverse in type as well as in bottle volumes, as indicated in Table 10. The falling trend in landings and the increasing use of alternative products and bottle volumes points to a behaviour change in fisheries, which could be attributed to changes in resource condition. The rarity of both brown sandfish and dragonfish revealed in this survey provides an explanation.

**Table 10.** Number of different sea cucumber products and bottled types.

| Year | Number of product types | Number of bottle sizes |
|---|---|---|
| 2005 | 7 | 6 |
| 2006 | 9 | 6 |
| 2007 | 7 | 5 |
| 2008 | 7 | 6 |
| 2009 | 16 | 7 |
| 2010 | 22 | 14 |
| 2011 | 12 | 13 |

Bottled dragonfish (*sea*) is the most sought-after product, commanding a price that ranges from ST 25–50 for a 750 ml bottle and ST 10–15 for a 285 ml bottle. *Sea* made from other sea cucumbers is sold at prices ranging from ST 15–25 per bottle. An average price of ST 25 per bottle is used to produce the annual average landing value (Fig. 11). The local sea cucumber industry has contributed on average over ST 126,000 annually to the local economy over the last 13 years: a significant contribution.

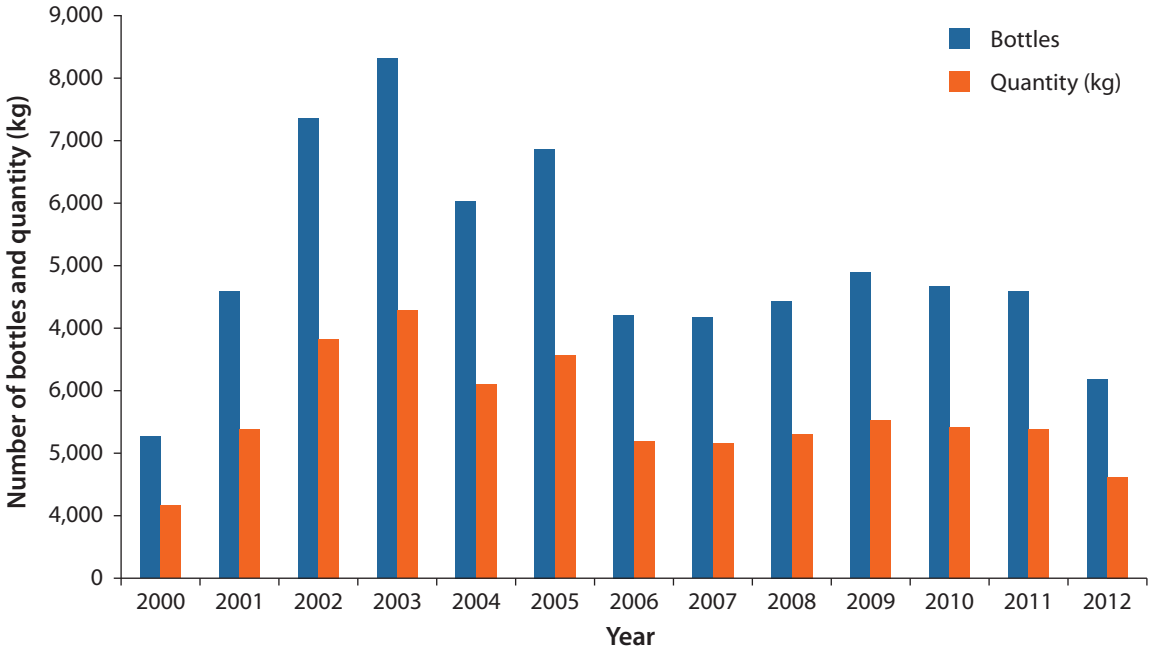


**Figure 10.** Landing of pickled sea cucumber or *sea* in Samoa.

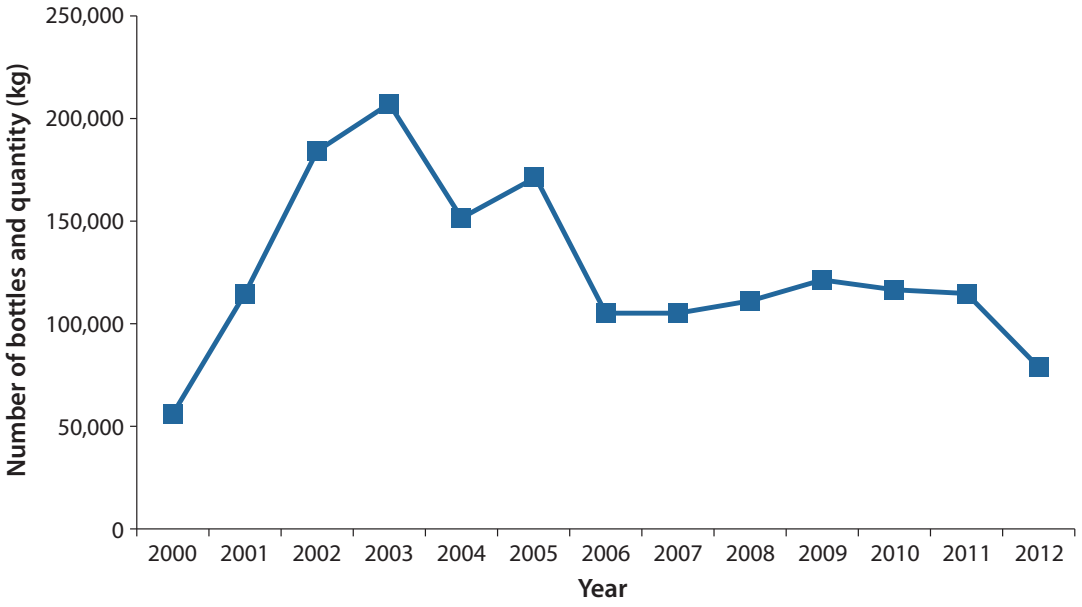


**Figure 11.** Annual landed value of pickled sea cucumber or *sea* in Samoa .

### 3.5.2 Unauthorised commercial harvesting of greenfish

Some illegal sea cucumber harvesting has occurred; in 2010, a shipment of some 40–60 bags was intercepted at the airport by fisheries enforcement personnel. Not much information was gathered and released but the bags were known to contain dried greenfish. It is not known whether the product was destroyed or re-sold. During the field training in Savai'i, the survey team witnessed greenfish being processed without proper authorisation from the Fisheries Division (Fig. 12). The catch of 139 pieces of greenfish weighing 7.3 kg was purchased from local fishers and confiscated by the Fisheries Officers. Another consignment was intercepted in 2013, but there is no detailed information available on species and quantity of the product.

**Figure 12.** Dried greenfish (*Stichopus chloronotus*) encountered in Savai'i, April 2012.

### 3.5.3 Stock estimation

Stock estimation is the ultimate goal of resources assessment: to advise fishers on stocks available for fishing in an area. Total stock above a certain size (e.g. legal size limit or minimum harvest size limit) can be estimated. Where there is no minimum size, size limits used in other countries can be used as a reference for determining harvestable quotas or total allowable catch. In Samoa there is much interest in the commercial harvest of sea cucumber, so there is a need for stock estimation of species with healthy densities. Stock estimation is an extrapolation of species density for the total habitat area. Initially, reef habitat area is identified and total area calculated using GIS. Estimated areas of suitable habitats on the two main islands are provided in Table 11, based on habitat classification by Andréfouët et al. (2005). Potential reef habitat class of importance for lollyfish, greenfish, based on the above classification, are diffuse fringing, reef flat, shallow terrace, linear reef flat, intermediate reef flat, reticulated fringing, intermediate reef flat and shallow terrace. (The estimated area of each site is provided in detail in the appendix.)

Based on the classification, the total estimated reef habitat areas for the islands of Savai'i and Upolu are derived (Table 12) which is used for stock extrapolation.

**Table 11.** Total estimated reef habitat area for Savai'i and Upolu, Samoa.

| Island | Habitat type | Area (ha) |
|---|---|---|
| Savai'i | Shallow terrace | 2,299 |
| | Reef flat | 1,446 |
| | Reticulated fringing | 769 |
| | Diffuse fringing | 437 |
| | Linear reef flat | 146 |
| Upolu | Shallow terrace | 7,963 |
| | Reef flat | 5,030 |
| | Diffuse fringing | 2,473 |
| | Enclosed lagoon | 763 |
| | Intermediate reef flat | 689 |
| | Deep terrace | 401 |
| | Subtidal reef flat | 49 |

For site specific stock estimates, a breakdown of total reef habitat area can be done as in Table 12 for survey sites.

**Table 12.** Reef habitat area for sites assessed.

| Island | Sites | Total area (ha) |
|---|---|---|
| Savai'i | Faala | 37.90 |
| | Salelavalu | 960.10 |
| | Vaisala-Asau | 41.92 |
| Upolu | Aleipata | 9.17 |
| | Falealili | 53.16 |
| | Manono | 32.62 |
| | Faleula | 301.46 |

### *3.5.4 Stock extrapolation for all sites combined and by sites*

From density analysis, two species (lollyfish and greenfish) have relatively healthy stock abundance. Tigerfish density is low or impacted, even though the fishery was closed for many years. Table 13 presents estimated population (number) by sites and table 14 shows total estimates for all sites with lower and upper 95% confidence and the proportion above the proposed legal size. Estimation of the harvest proportion is normally based on stock above legal harvest size or stocks above size at maturity, which is currently not available in Samoa. The recommended minimum harvest size limit or wet minimum size limits are 160 mm, 200 mm for lollyfish and greenfish respectively, based on biological studies in New Caledonia (Conand 1993). From these recommended size limits, stock estimates (Table 13) provide the number of pieces from which a proportion can be recommended for harvest if fishing is going to be permitted.

**Table 13.** Population estimate for harvestable sea cucumbers by site.

| Species | Site | | | | | | |
|---|---|---|---|---|---|---|---|
| | Aleipata | Faala | Falealili | Faleula | Manono | Salelavalu | Vaisala |
| Lollyfish | 285 | 395 | 19,170 | 7,630,794 | 55,625 | 632,379 | 41,355 |
| Greenfish | 51,254 | 18,555 | 4,151 | 55,858 | 5,311 | 1,447,513 | 373,910 |
| Reef lollyfish | 11,499 | - | 1,595 | - | 858 | 17,078 | 1,666 |

In the case of greenfish — a non-subsistence species that has not been harvested for 18 years apart from occasional unauthorised harvests, and despite the possible variation of size of greenfish in different geographical locations in the Pacific, the current stock in Samoa is likely to be at natural density and size or relatively close to natural population status. The recommended size limit based on stocks in other areas therefore might not be accurate for Samoa's stock in this case. Further estimate is made by sites (Table 14) for understanding site specific stock abundance. Extrapolation of stock for the whole island is important for management decision making that affect the whole island. Based on estimated reef areas for the whole islands of Savai'i and Upolu (Table 11), stock extrapolation by total estimated potential habitat area can be been undertaken.

**Table 14.** Total estimate stock of sea cucumbers based on recommended minimum size limit (RMSL).

| Species | Total pop | Lower (95%) | Upper (95%) | % pop > RMSL | Pop > RMSL | Harvest pop (20%) | Harvest pop (30%) |
|---|---|---|---|---|---|---|---|
| Lollyfish | 8,379,608 | 4,882,872 | 11,941,736 | 21 | 1,759,718 | 351,944 | 527,915 |
| Greenfish | 1,937,997 | 1,101,751 | 2,774,243 | 9 | 174,420 | 34,884 | 52,326 |

## 4. Discussion

The 18 years moratorium on the fishery has been effective in resting the resources to allow recovery, as noted in the abundance of lollyfish and greenfish. While there are several local factors that could dictate the current resource status (Eriksson 2006), fishing tends to be the main human impact on reef resources. Of the ten sea cucumber species presented, five are exploited in the subsistence fishery and three — lollyfish, dragonfish and brown sandfish form major part of the catch in the subsistence fishery. While densities of lollyfish and greenfish are healthy, consideration of commercial fishing for lollyfish is important, as the species could become a significant food security resource in future. Greenfish is not a subsistence species and the presence of it in abundance in some sites explains the lack of fishing pressure on the resource. Both lollyfish and greenfish have high rates of recovery and growth, owing to the asexual and sexual reproductive strategies both species are known to adopt. Lollyfish is the most common species, with wide distribution in all sites, while greenfish is present in a few sites only. Density from this assessment was higher than the 2005 record (Vunisea et al. 2008) due to high sample size covered. Lollyfish of both variations — the common lollyfish and reef lollyfish — were important in Faleula, Manono, Salelavalu and Vaisala, with Faleula having the highest density. The lollyfish variations were recorded separately because they command different prices because of their size and weight differences. Their separate treatment in this survey provides useful information about the presence and density of both variations.

Tigerfish, a targeted species for local consumption, depicts abnormal or disturbed population structure which relates to either natural low occurrences or the impact of continuous fishing pressure by the subsistence sector. This could be due to fishers shifting to tigerfish to replace brown sandfish, as collecting sufficient quantities of brown sandfish is now difficult. Curryfish was not recorded this time or in 2005 (Vunisea et al. 2008); the use of a local name indicates it has been present, but the lack of any recent record suggests it may have disappeared or be limited due to existing habitat limitation.

Sea cucumber is a source of food security in Samoa and the moratorium on commercial fishing established in 1994 is working to protect sea cucumber stocks. Long periods of resting have allowed stocks of lollyfish and greenfish to grow to their maximum size ranges. In the case of lollyfish, the skewed population reaching 430 mm is contributed by the larger strain of lollyfish, known by traders as reef lollyfish, which are found in high energy areas just behind the reef crest. This assessment found very low numbers of the important subsistence species dragonfish or *sea*. The species was recorded in the 2005 assessments in Vaisala and Salelavalu where fishers were observed fishing for it. This survey was unable to record it, although a group of fishers managed to find three specimens at Salelavalu during a daytime low-tide period, indicating its rarity and possible local extinction. The falling total landing of *sea* products since 2004 and the increased variation in *sea* products are in line with the low densities found in this survey. A further look at the landing data may provide useful trends on the fishery status by species.

## 5. Recommendations

1. Lollyfish and greenfish are present in healthy densities to recommend commercial fishing. However, lollyfish is also an important subsistence species and likely to become more important as other traditional species are overfished.
2. The stock of tigerfish is relatively low and seems impacted, possibly from subsistence fishing. Tigerfish is likely to be targeted more as brown sandfish is depleted. Allowing commercial fishing would put existing stock in danger of further depletion, so it is not recommended for tigerfish.
3. Brown sandfish and dragonfish are at critically low density levels. Low densities of both species indicate they are likely to be overfished by the subsistence fishery sector. Further assessment of brown sandfish and dragonfish is needed in areas not assessed in this study and urgent control measures on subsistence fishing are needed if existing stocks are to be protected.
4. Curryfish or *sea amu'u* was reported in the early 1990s (Mulipola 1994) but was absent in the 2005 assessment (Vunisea et al. 2008) and again in this survey. Considering its habitat limitation in Samoa, the species could have disappeared; further assessments are needed to confirm its existence.
5. A management plan should be developed and actions implemented as a matter of priority. The plan should clearly outline the national policy on sea cucumber fishery with clear objectives on subsistence fishery, domestic sale and commercial exports, with respective control measures. Measures on commercial fishing that can be incorporated include limiting the number of exporters and processors, quota allocation by species, harvest size limits, establishment of open season periods, pricing control of products, and license conditions for mariculture and ranching of sea cucumbers. Measures that can be proposed for community management can include closed areas for certain species, monitoring of local catches, and protection of certain species for subsistence harvest.
6. Given the critically low levels of brown sandfish and dragonfish, management intervention is required to re-build the stocks. Assuming agreement by communities, remaining stocks of mature animals of these species could be collected and relocated in suitable habitats at densities greater than 100 per hectare to increase the chances of spawning success and recruitment. This will require careful management and monitoring to be effective.
7. Regulations on minimum harvest size must be established prior to opening the fishery, and a monitoring mechanism set up to monitor the size limit regulation.
8. Species recommended for aquaculture development are brown sandfish, curryfish, and dragonfish. However limited stocks of these species are available locally, translocation from other sites within Samoa or outside Samoa can be assessed. Any aquaculture venture of any of these local sea cucumber species must be carried out under strict conditions to facilitate genuine research and to prevent commercial harvesting of wild stocks by interested aquaculture developers.
9. Future assessments should follow the same methodologies of estimating densities, species presence and size distributions for stronger comparability and understanding of changes from fishing and other environmental induced impacts.

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# Appendix

## Reef habitat classification and area for sites assessed in Samoa

| Sites | Habitat classifications | Area (km²) | Total area (km²) | Total area (ha) |
|---|---|---|---|---|
| Aleipata | Diffuse fringing | 0.0018 | 0.092 | 9.2 |
| | Reef flat | 0.0889 | | |
| | Shallow terrace | 0.0009 | | |
| Faala | | | | 37.9 |
| Falealili | Diffuse fringing | 0.2007 | 0.532 | 53.2 |
| | Reef flat | 0.3299 | | |
| | Shallow terrace | 0.0009 | | |
| Manono | Diffuse fringing | 0.0154 | 0.326 | 32.6 |
| | Reef flat | 0.3091 | | |
| | Shallow terrace | 0.0018 | | |
| Salelavalu | Linear reef flat | 0.0353 | 9.601 | 960.1 |
| | Reef flat | 1.8774 | | |
| | Reticulated fringing | 7.6875 | | |
| | Shallow terrace with constructions | 0.0009 | | |
| Vaisala -Asau | Reef flat | 0.0479 | 0.420 | 42.0 |
| | Shallow terrace | 0.3713 | | |
| Faleula | Diffuse fringing | 0.0009 | 3.015 | 301.5 |
| | Intermediate reef flat | 2.6323 | | |
| | Reef flat | 0.0072 | | |
| | Shallow terrace | 0.0009 | | |
| | Subtidal reef flat | 0.3733 | | |

**Secretariat of the Pacific Community (SPC)**

BP D5 • 98848 Noumea Cedex • New Caledonia

Phone: +687 26 20 00 • Fax: +687 26 38 18

www.spc.int/fame • cfpinfo@spc.int