TONGA
NATIONAL SEA CUCUMBER FISHERY MANAGEMENT AND DEVELOPMENT PLAN.

Prepared by: Fisheries Management & Planning Section

Fisheries Division

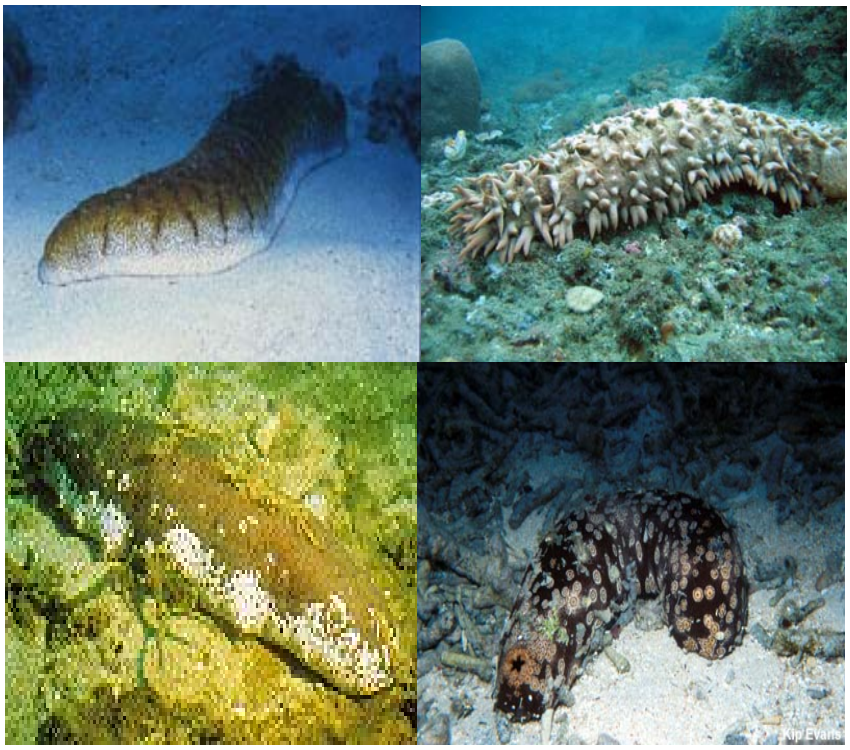

Table of Content

Definitions and Abbreviations

For the purpose of this Sea cucumber management plan, the following terms have the definitions given below.

Abbreviations:

FMA	Fisheries Management Act 2002
GPS	Global Positioning System
K	Growth coefficient
L∞	Mean length of very old fish (strictly: infinitely old)
M	Natural mortality
SCFMC	Sea Cucumber Fishery Management Committee
SMA	Special Management Area
SPC	Secretariat of the Pacific Community
TAC	Total allowable catch

Definitions:

Bech-de-mer	The dried processed body wall of sea cucumbers
Catch per unit effort	Number of sea cucumbers fished per hour or number of sea cucumber fished per person.
Quota	A portion of the total allowable catch allocated to each island group (in kilo of dried bech-de-mer).
Total allowable catch	The total regulated catch from the sea cucumber stock with in the fishery's open season
'Ota	Harvesting of any part of sea cucumber species to be consumed raw
The Fishery	The sea cucumber fishery
The Ministry	Ministry of Agriculture & Food, Forestry and Fisheries.

Part 1: INTRODUCTION

This management plan is about managing of sea cucumber fishery in Tonga. A fishery which is composes of three sectors. They are fishing activities, processing activities and exporting industries. The export product is known as bech-de-mer.

A fishery for sea cucumber was developed in Tonga in1990. The fishery was developed on a commercial purpose through exporting the resources for foreign revenue. The resource was deemed to be overfished by 1996 and the fishery was closed in late 1997 under a ten year moratorium. The re-opening of the fishery to fish for sea cucumber and the export of bech-de-mer species must be carefully managed and monitored.

Developing of a proper management plan has become a major priority for the Fisheries Division and the private sectors. Under the Fisheries Management Act 2002 the Minister for Fisheries; "*be responsible for conservation, management, sustainable utilization and development of fisheries resources in the Kingdom and its fisheries waters*". And the Secretary for Fisheries; "*to progressively develop management and development plans for Tonga fisheries."*

This Sea Cucumber Fishery Management Plan is the public statement and legal basis for management of Tonga's sea cucumber harvesting, processing and export industry. The harvesting of sea cucumbers refers to the fishing activity. To successfully manage the fishery, wider commitment and understanding is required. This plan should be reviewed annually or as maybe required to achieve and maintain its main goals and objectives appropriately.

1.1 The purpose of the Tonga Sea Cucumber Management and Development Plan.

The plan has been develop under the provision of the Fisheries Management Act 2002. It provides clear objectives and strategic directions for –

- the conservation and management of sea cucumber resources
- maximizing of its potential economic yield in a sustainable manner.
- access to the resources
- allocation of processing right and exports licenses
- environment conservation and sustainability.

1.2 Scope of the Plan

- The species covered by this sea cucumber management plan shall include all species of sea cucumber, both target and non-target species as outlined in table 1

- The plan applies to all activities by the way of "fishing" as define by the Fisheries Management Act 2002, which includes but not necessary limited to –
    - commercial fishing
    - artisinal fishing
    - subsistence fishing and
    - marine scientific research fishing

- The area covered by the sea cucumber management plan includes the following island groups –
    - Tongatapu
    - Ha'apai
    - Vava'u
    - 'Eua
    - Niuatoputapu
    - Tele-ki-Tonga and Teleki-ki-Tokelau (are covered under the SMA arrangement)

- This plan covered all methods of fishing for sea cucumbers but not necessary limited to waders or divers who collected sea cucumbers by hand or with drop spears.

- And all related activities included but not necessary limited to –
    - processing
    - all services related for processing
    - and all other provision for processing facilities
    - exporting
    - all services related for exporting
    - and all other provision for exporting facilities.

Table 1. Target and non-target species in this fishery

Scientific name	**Common name**	**Tongan name**
Thelenota anax	Amberfish	Mokohunu saianiti
Actinopyga miliaris	Blackfish	Mokohunu loli
Holothuria nobilis	Black teatfish	Huhuvalu 'uli'uli (m.maka)
Bohadschia vitiensis	Brown sandfish	Mula
Stichopus hermani	Curryfish	Lomu
Actinopyga echinites	Deep-water redfish	Telehea
Holothuria fuscopunctata	Elephant trunkfish	Elefanite
Stichopus chloronotus	Greenfish	Holomumu
Holothuria atra	Lollyfish	Loli
Holothuria edulis	Pinkfish	Loli pingiki

Thelenota ananas	Prickly redfish	Pulukalia
Holothuria scabra	Sand fish	Nga'ito
Holothuria coluber	Snakefish	Te'epupulu
Actinopyga lecanora	Stonefish	Telehea maka
Actinopyga mauritiana	Surf redfish	Telehea kula
Bohadschia argus	Tigerfish	Matamata
Holothuria fuscogilva	White teatfish	Huhuvalu hinehina
Bohadschia similis	Brownspotted sandfish	Finemotu'a

Source: Fisheries Division

Part 2: OBJECTIVES, CHALENGES AND CONSTRAIN

2.1 Management objectives

These objectives have guided by the Fisheries Management Act 2002. It generally refers to the use of precautionary principal[1], ecosystem protection, sustainability, access rights and the need to adhere to international laws and conventions.

These objectives shall be subject for further revision by the stakeholders and the Fisheries Division on an annual basis. The objective for the conservation, sustainable and the development of the sea cucumber fishery in Tonga are to –

- Ensure that a fishery for sea cucumbers must be managed to ensure the sustainability of natural sea cucumber resources

- Develop access right to the resources in a manner that is transparent, fair and creates economic growth and employment opportunities for Tongan nationals, giving particular regard to those living in remote communities.

- Managed flexibly and in the light of the best scientific advice available and in a manner that causes no degradation or damage to the broader marine environment.

- Ensure that the principal of precautionary approach is applied to the fishery when and if considered necessary by the Ministry.

2.2 Specific goals

The following goals are the expected outcomes in pursuing the management objectives:

- Sustainability of the sea cucumber resources.
- Fair share of economic benefit to remote communities
- Create employment opportunities for Tongan nationals and generate revenue to the country.
- Effectively monitoring of the fishery with the best available scientific and economical data.
- Reviewing of the plan with appropriate management measure in a timely manner.

[1] A response to uncertainty where the resources may face potential harm given a lack of best scientific information.

2.3 Major constrains to achievement of goals

- Participation and commitment of fishers and stakeholders to management controls for the sustainability of the resources.
- Commitment of Fisheries Division to established control measures for a sustainable fishery.
- The capacity of the Fisheries Division to ensure the appropriate compliance with the management plan.
- The Fisheries Division's capacities to effectively monitor the fishery through establish and maintain an appropriate and accurate data collection, analysis and reporting system.
- Capacity of the Government of Tonga to mount successful prosecutions will be a constraint to effective compliance and enforcement.

Part 3: MANAGEMENT MEASURES FOR SEA CUCUMBER MANAGEMENT PLAN.

3.1 Sustainability.

- The principle of precautionary approach shall be adopted to ensure the sustainable management of this fishery. A close season management measure shall be use during the spawning season. The fishery shall be closed between 1st of October to 31st of March of every year.

- The fishery shall be managed using a quota management system. Separate quotas are assigned for each species and for each island groups. 'Eua and Tongatapu shall share the same quota. The following quotas (kg of processed beche-de-mer) shall apply;

Table 2: Species by species annual quotas (dry weight in kg).

Species	**Tongatapu grounds**	**Ha'apai grounds**	**Vava'u grounds**
Amberfish	2800	8500	6800
Blackfish	600	800	0
Black teatfish	500	700	100
Brown sandfish	28600	3600	11000
Curryfish	0	1000	0
Deep-water redfish	0	0	0
Elephant trunkfish	1300	3800	1800
Greenfish	500	2500	100
Lollyfish	23300	11900	7100
Pinkfish	No quota limit	No quota limit	No quota limit
Prickly redfish	2300	2700	100
Sandfish (golden sandfish)	0	0	0
Snakefish	21900	2100	700
Stonefish	0	0	0
Surf redfish	200	1000	200
Tigerfish	12600	5500	5100
White teatfish	1000	6500	200

Source: Friedman et al. 2004, Matoto et al. 2004.

- Although sandfish is one of the most valuable species it has a slow growth rate and has yet to reach a sustainable harvesting biomass.

- Other species with zero allocation throughout Tonga means that they have not reach a satisfactory harvesting biomass level.

- The sizes of sea cucumber to be fished are restricted. The following size limits shall apply.

Table 3: Sea cucumber size limits

Species	Minimum length (wet) (mm)	Minimum length (dry) (mm)
Amberfish (*T. anax*)	400	200
Blackfish (*A. miliaris*)	190	90
Black teatfish (*H. nobilis*)	260	130
Brown sandfish (*B. vitiensis*)	240	120
Curryfish (*S.hermani*)	260	130
Elephant trunk fish (*H. fuscopuntata*)	350	150
Greenfish (*S. chloronotus*)	130	60
Lollyfish (*H. atra*)	165	80
Prickly redfish (*T. ananas*)	300	120
Redfish (*A. echinites*)	120	60
Tigerfish (*B.argus*)	270	130
White teatfish (*H. fuscogilva*)	320	160

Source: Fisheries Conservation and Management Regulation 1994.

- Sea cucumbers must be collected only by wading and free diving. The use of artificial breathing apparatus (SCUBA, hookah) to take sea cucumbers is banned. Any person found in possession of sea cucumbers in a boat that carries artificial breathing apparatus will be guilty of an offence.

3.2 Yield Maximization.

- The yield will be optimized through the use of size limits specified by table 3. The price of bigger size product is higher than they are in small sizes. The cost of fishing for small sizes sea cucumber species is higher than bigger sizes.

- Seasonal harvesting procedure allows some time for sea cucumbers to successfully spawn and reproduces. New recruitment to the stock may recover the fished down portion of the population and further enhanced the yield.

3.3 Access to the resources.

- No person shall harvest sea cucumbers during the fishery's closed seasons, except for harvesting of the following species for the purpose of 'ota.

- Curry fish (Lomu)
- Snake fish (Te'epupulu)
- Brownspotted sandfish (Finemotu'a)

- The only persons who may allow to fish for sea cucumbers for commercial gain or sale are those who have registered to fish for sea cucumbers with the Fisheries Division.

- No person shall process sea cucumbers and/or operate a fish processing establishment for sea cucumber without a license issued by the Head of Fisheries.

- No person shall export bech-de-mer (for commercial gain and home consumption) without a license issued by the Head of Fisheries.

- A Bech-de-mer export licence holder who wishes to process sea cucumber may be permitted under these prescribed conditions:
  - only allow to process 50% of its total allocated export quota
  - the remaining 50% shall be bought from other processing licence holders who have no export licence.

- There shall be a maximum of three Bech-de-mer Export Licences for each of the island group (Tongatapu, Ha'apai and Vava'u). Niuatoputapu shall be allocated a special quota by the Fisheries Division given its transportation isolation.

- All beche-de-mer stored or in transit (in Tongatapu or elsewhere in the Kingdom) must be bagged and labeled with the exporter's name and license number clearly visible.

- There shall be no bech-de-mer exported from the Kingdom of Tonga after the 2nd week of the fishery's' seasonal closure.

3.4 Monitoring of the Fishery

Monitoring provides essential information for assessing the performance of the fishery, and the plan in achieving its main objectives. The initial challenges would be the gathering of the data, validity and cross-checking before using it for the sustainable management planning. These major efforts must apply -

- A sea cucumber processor must complete and submit the form of sea cucumber fishing log sheets to the Fisheries Division on a weekly basis. Such form is prescribed in the Sea Cucumber Processing Establishment Specific Licence terms and conditions (Appendix 3).

- Bech-de-mer Export Licence holders must maintain a daily record of all exported bech-de-mer and maintain on the packing list form prescribed in the Bech-de-mer Export Specific Licence terms and conditions (Appendix 2). A copy of additional Custom stamped travel document must be included. These records are to be submitted to the Fisheries Division with in 7 days of the date of export.

- The Fisheries Division should conduct an assessment of sea cucumber resources as it sees necessary. Such surveys are to estimate the densities and population sizes for all commercialize species. Advice on the design of such surveys is given in (Appendix 4).

- The Fisheries Division must review the quotas and size limits from time to time as it deems necessary. The adjustment should be based on catch and effort trends, species composition, trends in density estimates from survey data and any other information that supports alteration of a quota or size limit.

The current status of the fishery will be reported to fisheries stakeholders in a quarterly basis after the analysis of the fishery's data.

3.5 Surveillance and Compliance Issues.

The success of the Sea Cucumber Management Plan is based on the understanding and the acceptance of stakeholders that fishers, processing sectors and export industries should comply with the control measures of the plan.

3.5.1 License terms and conditions

Bech-de-mer Export License and Fish Processing Establishment Licenses for sea cucumber's general terms and condition (Appendix 2 &3) should set out to assist in controlling and monitoring of the fishery from the processing and exporting sector. These licenses conditions shall address issues such as –

- Specific areas in which the license can be used
- Quota assigned for each licence.
- Quality enhancement
- Restricted processing and export practices
- Restricted on fishing gears
- Requirements for submission of log sheets and packing list
- Compliance with the Tonga National Sea Cucumber Management Plan
- Compliance with any special condition or provision of any access agreement that the license was issued under.

3.5.2 Fishers Registration

The Fisheries Division shall register all fishers who fish for sea cucumber species for commercial gain or sale. Only those that have attended the training program hosted by the Fisheries Division can be registered. Such training will cover these aspects –

- species identification
- handling techniques
- processing techniques
- sea cucumbers management issues and
- implications of sea cucumber management plan in Tongan waters.

Persons cannot be registered to take sea cucumbers by the Fisheries Division unless they can produce a certificate of attendance for the training program described above.

3.5.3 Fishing Vessels Registration

Any boat used for harvesting sea cucumbers shall be registered in the Fisheries Division's Fishing Vessels Register. Vessels to be used for harvesting sea cucumber must-

- be less than 25ft in length and must
- comply with Tonga fisheries legislations

3.5.4 Sea Cucumber Compliance Plan

The approved compliance plan will be an implementing tool for the sea cucumber management plan. The plan should address the following issues –

- Total allowable catch and compliance requirements
- Size limits and compliance requirements Licensing
- General terms and Conditions
- Data collection and security
- Fisheries authorized officers
- Fisheries observers
- Surface petrol

3.5.5 Fisheries Legislation

Development of any regulation specifically for sea cucumber fishery should fall under the parameters of the Fisheries Management Act 2002 as Sea Cucumber Fisheries Regulations. Development of such legislative support to stipulate the legal elements of sea cucumber fishery shall address the following –

- The fisheries seasonal closure

- The size restrictions
- Restricted fishing gears
- The Licence terms and conditions
- Fees and its applications
- Penalties and prosecutions

A Cabinet Decision may be in effective to express any decision that may be directed by His Majesty's Royal Cabinet on any matter related to the fishery.

Part 4: OBLIGATION AND RESPONSIBILITIES

4.1 Fishers and Stakeholders

Fishers, Processing sector and the Exports industries are the fisheries' key stakeholders who are liable to harvest, process and selling bech-de-mer. The fisheries stakeholders together with the Fisheries Division should cooperatively through participatory management to face the challenges of managing this fishery.

The sensitive nature of this fishery has urged the active participation and the supportive effort of its stakeholders in sharing of information, input into the development of MCS measures and promotion of voluntary compliance. Promotion of co-management with the fisheries stakeholders can assist in monitoring the fishery and report on non-compliant activities and the development and implementation of this management plan.

Fishers as a major stakeholder of the plan should adhere to management controls specified by the plan. Fishing for sea cucumber should be done in a manner that is sustainable to the resources and does not harm the whole marine ecology. Fishing activities should refrain from using of restricted fishing gears and fishing methods that could deplete the sea cucumber resources. Fishers should also commit more effort in seeking for better fishing methods and fishing gears that would promote the sustainability of the resources and the conservation of the marine environment

Export industries and processors should give an extra effort to sustain the quality of Tonga's exported bech-de-mer product. Processors should process sea cucumbers purchased from fishers to meet all requirements demanded by the exporters in consistence with the criteria demanded by overseas markets. Exporters should assist processors with expertise in sea cucumber processing. Maintaining the country's reputation will secure the standard of the Tonga'n product in the overseas markets.

Determining and reviewing of the appropriate management measures will be base on the fishery's performance. To effectively monitor the fisheries performance, decisions will be base on the data collected from fishers, processing sectors and the exporting industries.

Providing the Department with the most reliable fishing and effort data will surely reflect the appropriate true status of the stock. Data from packing list with any related economic data will use for assessing the economic performance of the fishery. These evidences should be submitted to responsible sections of the Department with in the times specified by the plan.

4.2 The Fisheries Division

The Fisheries Management Act 2002 Section 4 states the responsibilities of the Minister in terms of fisheries conservation, management, sustainable utilization and development. The Minister for Fisheries should manage the fishery with the fisheries stakeholders through participatory management. By doing so, the Minister should still be the overriding decision maker.

The Fisheries Division has the primary responsibility to develop, implement and administer the management strategies under the sea cucumber management plan. Therefore it is essential for the Ministry to provide effective and efficient support to ensure the success of the plan.

The fishery is challenged by controlling the fishing effort to a level that is profitable and sustainable ecologically. The focus should be to manage the access to the resources by registered all fishers to compliance with the existing management measures. The Fisheries Divisions' capacity to enforce and to mount successful prosecutions will potentially hindered the effectiveness of the control.

The Fisheries Division should facilitate consultation with fisheries stakeholders to discuss and developed management measures for further revision of the plan. The challenge will be for the Fisheries Division to implement and enforce these management measures that given by the plan.

The Fisheries Division is also responsible for the on going monitoring of the fisheries performance. A data colleting system should be designated to effectively facilitate the need for colleting of fishing effort and fishery's economic data. Data collected should be analyzed by the Fisheries Division to asses the performance of the fishery.

Stock surveys should be conducted when necessary and further scientific surveys could be arranged if required. Fisheries stakeholders and the Sea Cucumber Fishery Management Committee (SCFMC) should be given further advice with status of the stock if necessary prior to review of the plan.

4.3 Sea Cucumber Fishery Management Committee.

The Sea Cucumber Fishery Management Committee (SCFMC) is established under this plan in consistence with section 7(4) of the Fisheries Management Act 2002. The committee will be primarily responsible for the implementation fisheries plan and take part in monitoring of the fishery. The committee should review the fisheries plan with the information provided by the Fisheries Division and advise the Minister accordingly.

a) Main functions of the SCFMC

- Provide a forum for discussion of issues and strategies that require the input of all stakeholders, non government organizations, other government ministries and the Fisheries Division.
- Implement, monitor and review the management plan
- Advice the Minister and the Fisheries Division with the effective management and administration
- Ensure transparent decision making in regards to the access to the sea cucumber resources and fishery.

b) Memberships

The Sea Cucumber Fishery Management Committee should have the following representatives:

- Director of MAFFF (Chairperson)
- Head of Fisheries Division (Deputy Chairman)
- Head of Custom Department
- Head of Finance Department
- One representative from MLCI or Tonga trade
- One representative each from the bech-de-mer licence holders of Tongatapu, Vava'u (including Niuatoputapu), and Ha'apai (3).
- One Representative each from Tongatapu, Vava'u and Ha'apai representing the bech-de-mer processors (3).

Note: Other representatives from Fisheries can be co-opted from the Planning and Compliance Sections.

c) Frequency of meetings:

The Sea Cucumber Fishery Management Committee should meet at least once a quarter.

Part 5: TRENDS AND STATUS OF THE STOCK

5.1 Research history:

There have been a series of surveys designed to establish the extent of Tonga's sea cucumber resources. None have been fully comprehensive, but they do give valuable data on the nature of the resource over time.

Okamoto (undated, 1984) undertook two basic dive surveys at Vava'u and Ha'apai. Preston and Lokani (1990) use his dive survey data, based upon sightings per unit of time, to extrapolate an overall population density of 89 animals (all species) per hectare in shallow waters of Ha'apai.

Preston and Lokani have estimated the overall density of 38 commercial species per hectare in 1990. Their estimation was based over a wide range of depths and habitat form of 45 sites in Ha'apai. The teatfish species, *H. nobilis* and *H. fuscogilva* are accounted for one-third of the total numbers.

A total of 1,015,000 animals of the major (commercial) species standing stock were estimated based on average density for the Ha'apai waters. An estimated area of 263,050,000 m^2 of sea floor with in the depth of 0 to 3 meters was inhabited by these animals. The precision of these estimates is open to question.

Lokani, Matoto and Ledua (1996) report on the SPC/ICFMaP Ha'apai survey for sea cucumber conducted in 1996. They concluded that approximately 50% of the commercial species had been removed since the 1990 survey (see below, Table 4).

Table 4: Density estimates (nos. per ha)

Species	1990	1996
Black teatfish	4.56 (1.43)	1.33 (0.74)
White teatfish	8.6 (2.21)	2.23 (1.12)
Elephant trunk fish	6.35 (2.59)	8.48 (2.87)
Prickly redfish	2.97 (1.17)	0.44 (0.44)
Amberfish	13.34 (5.66)	3.57 (1.55)

Source: Lokani, Matato & Ledua (1996)

The fishery was closed in late 1997, after its almost total collapse. The 1996 survey was repeated by SPC in 2004 and reported by Friedman et al (2004, in draft). They concluded that there were mixed signals in relation to recovery, with mixed recovery rates (e.g. white teatfish densities approximated at 1990 levels, but black teatfish showed little recovery). The authors suggested some species could be considered for carefully managed harvesting under an individual species quota regime.

Data given in Table 5 looks at species composition and relative abundance (commercial species only) from the four resource surveys conducted in Ha'apai waters between 1990

and 2004 (Preston and Lakoni (1990), Lakoni et al (1996), Friedman et al. (2004) and Matoto et al. (unpublished)).

There is considerable variation in reported species composition. This may reflect different interpretation of what were considered to be commercially significant species. It is much more likely, however, that the variation can be attributed to differences in survey design.

Table 5: Proportions of commercial sea cumber species recorded at Ha'apai during 4 surveys from 1990 to 2004.

Species	Indicative price (INFOFISH 2002) ($US)	Relative abundance 1990 (Preston & Lakoni) (Proportion of 6 commercial species)	Relative abundance 1996 (Lakoni et al.)	Relative abundance 2004 (Friedman et al.)	Relative abundance 2004 (Matoto et al.)
Amberfish		29.4			
Black teatfish	$23	9.2	6.3	10.1	2.4
Blackfish	$18		6.3	8.8	4.3
Curryfish	$14		7.9	5.9	0
Elephant trunkfish	$2	20.2	30.1	14.8	7.0
Greenfish	$13			5.9	12.0
Lollyfish	$1.5		11.1	13.5	51.4
Prickly redfish	$12	6.1	1.5	11.0	2.3
Sandfish	$34-$45			1.2	1.8
Stonefish	$14			8.4	0.6
Surf redfish	$10			2.5	4.6
Tigerfish	$3		30.1	13.5	4.4
White teatfish	$23	28.2	7.9	11.4	8.9

Sources: Preston & Lakoni 1990, Lakoni et al. 1996, Friedman et al. 2004, Matoto et al. 2004.

5.2 State of the stock

Knowledge about the state of sea cucumber resources is largely based upon a series of surveys. These surveys were undertaken by staff from the South Pacific Commission and Ministry of Fisheries (now Fisheries Division). The pre-fishing survey was undertaken in 1990. The next survey was done in 1996, immediately after the heavy fishing period. The latest survey was completed in 2004 after the 7 years of the fishery's closure. These surveys were conducted in the waters of Ha'apai.

The Ministry of Fisheries (now Fisheries Division) also collected other data from a more extensive survey of the Tongatapu, Ha'apai and Vava'u waters in 2004. Differences in survey methods used by each surveys have let to dissimilarities between the data collected. Therefore the Ha'apai population was used as an indicator for the entire country's sea cucumber resource.

All species of commercially valued sea cucumbers showed a significant decline in numbers between 1990 and 1996. The overall population levels being reduced by factors of between 50% and 75% depending on the species involved.

Data from the 2004 surveys have suggested that recovery of sea cucumber numbers from the 1991-1996 fishery has been inconsistent. Species such as black teatfish are still considerably less abundant now than they were in 1990. Black teatfish densities are at about 50% of is population size in 1990. White teatfish densities have recovered to about 80% of its 1990 baseline level. Some species, including prickly redfish, brown sandfish and amberfish are now at densities recorded in the pre-fishery survey in 1990. Greenfish appear to be considerably more abundant in 2004 than they were in 1990.

Sandfish are the most highly valued of the sea cucumbers. Sandfish numbers are uncertain. The original population levels in Ha'apai were never high and a comparison between survey data sets therefore means little. The environment of Tongatapu's Malia Bay is better habitat for sandfish than the oceanic waters around Ha'apai, but the population in this area may have been reduced by poaching even since the 1997 closure.

Part 6: GENERAL BIOLOGY OF THE RESOURCES.

6.1 Taxonomy

The taxonomy of sea cucumbers is not stable. Cannon and Silver (1998) give a detailed taxonomic account of sea cucumbers in northern Australia, but there appears to be some uncertainty about the scientific nomenclature of a number of species. In particular, there is some confusion about the correct scientific names for black teafish (*Holothuria nobilis* vs. *H. whitmaei*) and white teatfish (*H. nobilis* vs. *H. fuscogilva* vs. *H. whitmaei*). This report gives scientific names from the original author, but is worded in terms of common names where possible.

6.2 Reproduction

Most sea cucumbers are of separate sexes and all are broadcast spawners. Spawning is normally seasonal, predominantly in the warmer months of the year. Fecundity is high, with females setting between 1 million and 78 million eggs per female (Conand 1990).

The larvae are plantotrophic as they develop through auricularia and doliolaria phases prior to settlement. On the basis of limited culture work (on sandfish, *Holothuria scabra* and the Galapagos sea cucumber *Isostichopus fuscus* (Mercier et al. (2004)), the larval life is of two to four weeks' duration. This duration may vary in other species.

While Mercier et al. (2004) give a very detailed description of larval physiology, there is virtually nothing published on the ecology of the larval phase. There is suggestion of some population structuring in sandfish, on a spatial scale of 10s to hundreds of km., which suggests that larvae may be behaving in a manner that limits dispersal (Uthicke & Benzie 2001), whereas black teatfish (*Holothuria nobilis*) show no sign of population structuring, suggesting larvae are able to travel considerable distances (Uthicke & Benzie 2000).

The juvenile phase of sea cucumbers is poorly known. Juvenile sea cucumbers appear to be highly cryptic and are rarely encountered in surveys. There is some suggestion that juveniles of some species can be associated with seagrass, possibly using the habitat for shelter. Dance et al. (2003) noted that survival of hatchery-reared sandfish released in seagrass-mangrove trial sites was significantly greater than those released in a coralline sand environment.

6.3 Movement

Sea cucumbers do not apparently move far once they are large enough to be observed. They have some capacity for movement, using their tube feet, but typically move less than 1 m per day. They may be moved about by strong tidal currents.

They can bury, partially or wholly. The purpose of burying behaviour is not well described but is assumed to be a measure against predation. Some species are cryptic during the day, sheltering under boulders and coral heads. Such behaviour has the capacity to impact on accuracy of abundance surveys.

6.4 Growth

Growth rates of sea cucumbers are remarkably poorly understood. Preston (1993) gives growth parameters for 6 species (Table 4, below). All data, however, are from sources that are effectively impossible to access and review for potential accuracy and error.

Hatchery reared sandfish appear to attain marketable size within 18 - 24 months (Purcell 2004), and Long et al. (1996) give equivalent growth rates for this species based on size frequency data. Data given in Chen (2004) and Yaqing et al. (2004) suggests that the prickly sea cucumber *Apostichopus japonicus* reaches marketable size of 150 gm (dry weight) in less than eighteen months in marine ranches. And Mercier et al. (2004) give maximum growth of the Galapagos sea cucumber *Isotichopus fuscus* as being up to 9 cms in 110 days in culture. There appear to be no readily available estimates for growth of any other species.

6.5 Recruitment

There appear to be no published studies or any on-going programmes designed to develop any information on recruitment levels, recruitment variation and parameters affecting recruitment beyond the ongoing resource surveys being conducted by various research groups.

The most comprehensive of these surveys appears to be the Torres Strait monitoring program (Skewes at al. 2004b). These surveys are typically being directed towards heavily exploited and supposedly recovering populations. The information on natural recruitment processes is therefore confounded by changes in brood stock abundance.

Sea cucumber recruitment is low and sporadic, Conand (1990) suggested, although the basis of her statement is not clear. Some species of sea cucumber can reproduce asexually, by fission, and there is some interest in increasing populations through artificially dividing the animals.

The prolonged periods required for recovery from overfishing for some species of sea cucumber are given in the table 1 below. Species with seemingly rapid growth rates and fairly high natural mortality rates suggested that recruitment procedures may not conform to conventional population models for species with high fecundity and rapid generation time. Such animals are typically capable of rapid population regeneration after heavy depletion.

Reduction in density of sea cucumbers may lead to reduced fertilization success known as the Allee effect, Uthicke (2004). Removal of sea cucumbers from a given area may actually alter that area's habitat in such a way as to affect subsequent recruitment levels. However, these suggestions seem to be based upon intuition rather than hard data.

6.6 Natural Mortality

There are limited data on natural mortality rates of sea cucumber species. Preston (1993) gives estimates of M for 5 species (Table 6). All data are again from sources that are effectively impossible to access and review for potential accuracy and error. Skewes et al. (2004b) assume natural mortality rates in the order of 0.6 – 1.0 (annual instantaneous rate), based upon data in Preston (1993) and Conand (1990).

Given the range of species taken in sea cucumber fisheries, it is believed that the growth, survival and mortality rates should not be uniform across all species. Natural mortality rates are key determinants for population assessment, are difficult to estimate and are rarely measured accurately in sessile invertebrates.

Table 6: Estimates of growth and natural mortality parameters

Species	L_∞ (mm)	K (annual)	M (annual)	Equivalent annual survival	Length interval (for estimating growth, mortality)
Holothuria atra	324	0.11	1.02	36%	130-220
Actinopyga echinites	230	3.00			100-300
A. echinites	295	0.09	0.64	53%	90-240
A. mauritana	340	0.12	1.45	23%	70-280
Stichopus chloronotus	342	0.45	1.79	17%	40-300
Thelenota ananas	663	0.20	0.63	53%	160-640

Source: Preston (1993)

6.7 Environmental sustainability

The process of taking sea cucumbers (hand picking, no by-catch) is one of the more environmentally benign forms of fishing. The only direct foreseeable environmental consequence of sea cucumber fisheries is the potential for reduced bio-perturbation of the

upper few millimeters of the sea bottom where sea cucumbers occur. Sea cucumbers are generally a conspicuous and abundant component of shallow water benthic communities in tropical and sub-tropical waters.

They feed on the surface layer of sediments and turn over considerable amounts of the upper sedimentary layer. Sea cucumbers feed on bacteria and, in some species, micro-algae or drift seaweed. Most species ingest large quantities of sand and mud from the sea floor, selecting out food items and passing the remainder. This activity may be an important element in maintaining organic and oxygen stability of the bottom in some areas. Thus sea cucumbers seem to have some capacity and role in environmental stabilisation and equilibrium.

A substantial reduction in numbers of sea cucumbers may have the potential to alter the bio-geography or sediment structure in localised seabed areas. This risk is greatest in areas of high sea cucumber density and where benthic organic loads are highest. Thus seagrass beds that support substantial populations of species such as sandfish, or near-shore flats that support large populations of snakefish (*Holothuria coluber*) might be at greatest risk of environmental change and damage by through excessive harvest of sea cucumbers.

Re-development of a capture and processing industry for beche-de-mer in Tonga will create a substantial demand for timber, particularly mangrove wood, to be used in the drying and smoking phases of processing. There have been estimates that processing one tonne of beche-de-mer can use 10 tonnes of timber. The impact of such timber usage should not be ignored, particularly in remote areas and island communities where timber resources are limited.

Part 7: DEVELOPMENT OF THE FISHERY

The development of the sea cucumber fishery will rely on the commitment of its stakeholders, and actions from other government agencies to the implementation of the strategies and the achievement of the goals outlined in part 2.3. Achievement of these goals will be a major factor in the sea cucumber management plan to meet the overall objective of the fishery.

We should ensure that the utilization of Tonga's sea cucumber resources is compatible with the sustainable harvesting of the sea cucumber stock through out their range. The economic benefit to Tonga can be maximize from utilizing the sea cucumber species through the use of appropriate size limit and quotas allocated.

7.1 Export Quality

Market quality, market reputation and revenue are linked to processor expertise and capacity. Once poor quality product originates from a particular country, that country's reputation is compromised for a long time, and revenue from the resource is reduced as a consequence.

Sea cucumber species are collected only by waders or by divers using dropping spears who have trained and registered by the Fisheries Division. Processing of sea cucumber is done only by those who have licensed to processed bech-de-mer with the Fisheries Division. These are the first steps of ensuring the high quality of the bech-de-mer product is maintained.

However, further development in the quality of the export product is required. This could allow the exporting of low value species which are currently sold locally. And there is a need for more training and better understanding of the stakeholders with regards to post harvest matters such as processing activities and the right handling of sea cucumbers products taking into account the health issues and food safety.

7.2 Infrastructure

The availability and the provision of the supporting adequate infrastructure is required for further development of sea cucumber fishery. Processors and exporters should invest more capital in plant and the general operation.

For processing, onshore processing facilities should develop to accommodate all requirements for processing of sea cucumber products. All necessary items with in a proper processing facility may include a processing plant, proper storage facilities, and processing equipments to be inspected by the Fisheries Division.

Export license holders should also maintain adequate infrastructures that facilitate packing and the storage of the exported bech-de-mer product. All facilities must meet all criteria that are outlined by the bech-de-mer processing and export license terms and conditions.

7.3 Foreign earning

Exporting of Bech-de-mer contribute to the country's foreign exchange earning. On the south-east Asia wholesale markets, bech-de-mer has a current average price of US$20/kg. The average reported annual harvest of about 760 tones between 1991 and 1996 is now worth about ToP$2.5m at the south-east Asian wholesale point of sale. Wharf side value to fishers would be considerable less than this.

Obtainning a reliable estimates of the foreign exchange from the sea cucumber resources will require a follw-up with the industry perhaps through the Customs Department. Foreign exchange earnings value from sea cucumber fisheries will benefit through-

- providing the government with better guide for allocation of sea cucumber resources
- understanding the true value of the sea cucumber resources of the nation

7.4 Culture of sea cucumber

Most sea cucumber species can be cultured in hatcheries. Some species can reproduce asexually, by fission through artificially dividing the animals.

Culturing of sea cucumbers should be prioritized and aimed specifically to enhance the stock from the wild and to replace the portion of the population that has been fished down. Enhancing the natural population will ensure the sustainability of the sea cucumber resources and will maximizing the yield from this fishery.

The Fisheries Division and fisheries stakeholders should together contribute adequate efforts and resources to culture sea cucumbers. Sea cucumber seedling should be distributed to reefs and places that the resources may have depleted. And experts in sea cucumber culture should make available to train local communities and fishers on artificial reproduction of sea cucumbers resources.

Part 8: AMENDMENT AND REVIEW OF THE PLAN

The Fisheries Division in consultation with the Sea Cucumber Fishery Management Committee should be responsible for reviewing of the plan at the end of every fishing year or any other time may required by the Minister for Fisheries.

The Fisheries Division base on the best available information gained from monitoring and researches will review the total allowable catch (TAC) and the level of fishing effort. In revising the plans' management measures, the following issues should be taken into account –

- the best scientific information, including the level of uncertainty in stock assessments;
- the level of catch in adjacent areas
- the economy of the fishery
- fishing efforts in adjacent waters
- development of fishing methods and fishing gears
- the main objectives and goals for the sea cucumber fishery as set out by this plan.
- licence fees and charges
- licence terms and conditions
- the current resources of the Fisheries Division to manage, monitor and control the fishery.

Reviewing of total allowable catch, there needs to be carefully considered species with zero catch quotas. Assessment of the stock will determine the available catch quotas to be harvested. Future effort will be assessed by take into consideration the total allowable catch and annual catch quotas.

Looking ahead, the concept of community management will be introduced as a tool in managing Tonga sea cucumber resources. This involves allowing a local group to arrange management and use of the resources within a relatively small area over which it has some agreed historic access rights. Such form of management should be under a national management framework in order to ensure local areas do not suffer gross overfishing.

There are explicit provisions within the Fisheries Management Act 2002 that provide for coastal communities to organize themselves in such a way as to manage specified fisheries resources within declared Special Management Areas. The Coastal community will be responsible for developing their local management arrangement, allocation of the harvest and allocation of income from the resource.

This process offers advantages of a high degree of local resource ownership, and with it, an increased probability that the sea cucumber resource will be managed sustainably and fairly. And be confident that the wealth is being distributed to outlying and needy communities.

Acknowledgement

The preparation of this Fisheries Management Plan was made possible by efforts of the following:

- Past and current staff of the Fisheries Division
- Fishers and Fisheries stakeholders in Tongatapu, Ha'apai and Vava'u
- Assistant from the Secretariat of the Pacific Community
- Assistant from the Tonga Fisheries Project (AusAID)

Appendix 1: Basic licence criteria and administrative procedure for bech-de-mer export and sea cucumber processing establishment licence.

1. LICENCING CRITERIA:

1.1 General criteria to be met by an export license applicant

a. To specify in the letter

- Past experience in the fishery
- Where it is intended to export from. If export from other island groups, then must give details of the operation, the details and address of transit in Tongatapu.
- Mode of transportation from Tonga.
- Number of people intended to be employed.

b. Additional supporting documents

- Business plan
- Proof of capability to provide export facilities (storage and packing facilities)
- Market verification (Proof of a foreign market, they are to email or fax the Fisheries Division)
    - company registration certificate
- Proof of an importer agreement (included the price list)
- Evidence of financing the purchase and export of bech-de-mer
    - financial evidence eg. Bank statement, etc.
- Police record (past history of compliance with other fisheries operations)
- If a company is applying then should provide a proof of registration, certificate of incorporation and shareholders information.

1.2 General criteria to be met by an applicant for a sea cucumber processing establishment license.

a. To specify in the letter

- Processing experience
- Source of product –
    - own fishing

- price of buying raw sea cucumber (financial evidence e.g bank statement, etc.)
- Location of processing facility.

b. Additional supporting documents for processing establishment

- Proof of processing establishment -
  - processing plant (equipements)
  - land ownership
- Police record of applicant(s)
- If buying, must provide financial evidence e.g bank statement, etc.)
- If a company is applying then should provide a proof of registration, certificate of incorporation and shareholders information.

2. ADMINISTRATIVE PROCEDURE.

2.1 Licencing procedure

1. Applicant must lodge a letter of interest together with a proposal of a business plan which meets all the criteria listed above. Such letter must be directed to the Head of Fisheries.

2. All letters received by the Head of Fisheries to be collected and maintain by the Licence Screening Committee's (LSC) secretariat (Head of Licencing section).

3. The LSC will screen all applications at once base on the listed criteria specified above, after the closing date for application.

4. The chairperson and the secretariat shall submit recommendation to the Head of Fisheries. The Head of Fisheries shall reply in writing to all applicants indicating the status of the application.

5. If application for license is favorable, all administration requirements shall be met.

6. The Head of Fisheries shall direct the appropriate Licensing section to proceed with the processing of the licence upon the receival of the application form.

7. Successful applicant must meet all fees required prior to issuance of an approved licence by the date specified by the Committee.

8. Issuance of approved licence.

2.2 The License Screening Committee (LCS).

The Licence Screening Committee is established under the objective of the Sea Cucumber Management and Development Plan:

"Develop access right to the resources in a manner that is transparent, fair and creates economic growth and employment opportunities for Tongan nationals, giving particular regard to those living in remote communities"

The Committee shall be responsible for:

- setting and reviewing of licencing criteria.
- provide forum for discussion on issues with regards to licencing
- screening of each application with consistent to agreed licencing criteria
- advice the Head of Fisheries with the appropriate licences to be selected.

Appendix 2: Specific Terms and Conditions for Fish Export Licence (Bech-de-mer)

RESTRICTED PRACTICES

1. Must not receive any bech-de-mer from any person unless that person has a fish processing establishment licence (sea cucumber).

2. Must not trade or purchase any bech-de-mer from any area not specified in the licence.

3. Must not export any species of bech-de-mer more than the total allowable catch allocated for in the licence.

4. Must declare all current bech-de-mer to the Fisheries Division with in 1 week before the 31st of September.

Attachment 1:

BECH-DE-MER PACKING LIST

COMPANY NAME: …….....

DATE OF SHIPMENT: ……..

NAME OF INSPECTOR: ……

Species name	Quantity (pieces)	Weight (kilo)
TOTAL		

Appendix 3: Specific Term and Condition for Fish Processing Establishment Licence (Sea Cucumber)

RESTRICTED PRACTICES

1. Must not use any vessel with length of more than 25 ft to conduct any fishing and other related activities under this licence.

2. Must not receive any sea cucumber from any person unless that person is registered by the Fisheries Division to fish for sea cucumber.

3. Must not receive any sea cucumber from any other island group other than the area specified by the license.

4. If the holder of this licence has a Bech de mer export licence, the holder, shall only process 50% to its total export quotas. The other 50% of its total export quota shall be bought from other licence processors.

5. Must declare all current bech-de-mer to the Fisheries Division with in 1 week before the 31st of September.

Attachment 2

SEA CUCUMBER FISHING LOGSHEET.

PROCESSOR'S NAME: ……

Date	Name of Harvesters	Species name (Common name/Tongan name)	Number of pieces	Weight (kg)	Area & Location	Number of hours spend fishing

Processor's Signature……...
Date: ……...

Fisheries Authorized Officer's Signature……..
Date: ……

Appendix 4: Design of stock assessment surveys

Monitoring abundance of sea cucumber population numbers is most effectively done by dive survey. The following guidelines about the conduct of surveys should be used as the basis of repetitive sampling to estimate sea cucumber density.

1) Dive surveys should be undertaken as frequently as possible. Ideally, they would be done annually, but, as a bare minimum, at least every three years while a fishery for sea cucumbers takes place. Should the fishery close there should be pre- and post-fishery surveys. It is advised that future survey shall be conducted by district.

2) Survey sampling strategy must be undertaken and completed well before the commencement of the survey.

3) The survey team, consisting of qualified divers and boatmen used to working with divers, should undertake a training program for recognition of the sea cucumber species identified in this Management Plan.

4) The sampling strategy should be based upon a randomized, stratified survey. The area to be surveyed should be stratified at least on the basis of depth (0-10m, 10-20m, 20-30m) and if possible, by habitat type.

5) Sample locations within each stratum MUST be identified randomly, preferably using the random number generation facility of a computer. The number of sample sites will depend upon resources and time available for the survey. The more sites that can be sampled, the greater will be the value of the survey.

6) The sample design should include a series of reserve sites that can be sampled if there is free time in which to sample, or which can be sampled in the event of bad weather or other obstacles preventing sampling at primary sites.

7) Sampling should be conducted by two divers making independent assessments of sea cucumber species and numbers, along transects of predetermined length. The length of a transect will be set out using a weighted stringline, set out before the transect is swum. The line should, as much as possible, be set out along a single depth contour. The swathe of observations on sea cucumber numbers should be aided with a measuring rod that allows each diver to independently estimate numbers within a given width of the transect line.

8) Upon completion of the transect, the two divers should independently report their data to a recorder or write into a database.

9) Sample location should be recorded using a GPS with known baseline.

10) Upon completion of the day's sampling, all sample data should be recorded into a master database.

11) A representative sample of each species of sea cucumber should be taken in each survey, for measurement of length, wet weight and gonad condition. The sample should include at least 20 animals of each species.

12) Data from the survey should be logged into a database and undergo preliminary analysis, to record density by species by stratum.

13) Further data analysis should be undertaken in consultation with a trained statistician if possible.

14) THE SURVEY MUST USE CONSISTENT METHODOLOGY IN SUCCESSIVE YEARS.

List of References

Anon. (1996) Status and management of inshore fisheries in the Kingdom of Tonga: Beche-de-mer. SPC Beche-de-mer Information Bulletin #8, pp 12-14.

Bell, L.A.J., Fa'anuna, 'U. & Koloa, T. (1994) Fisheries Resource Profiles: Kingdom of Tonga. Forum Fisheries Agency Report No. 95/5, 170 pp.

Cannon, L.R.G. & Silver, H (1988) Sea Cucumbers of Northern Australia. Queensland Museum, Brisbane.

Chen, J. (2004) Present status and prospect of sea cucumber industry in China. In Conand, C., Purcell, S., Uthicke, S., Hamel, J.F., & Mercier, A. (eds) Advances in sea cucumber aquaculture and management. FAO Fisheries Technical Paper #463.

Claereboudt, M. (1999) Fertilisation success in spatially distributed populations of benthic free-spawners: a simulation exercise. Ecological Modelling, 121:221-233.

Conand, C (1990) Fishery resources of the Pacific Islands Part 2. The holothurians. FAO Technical Paper 272.2 FAO, Rome.

Dance, S.K., Lane, I., & Bell, J.D. (2003) Variation in short-term survival of cultured sandfish (*Holothuria scabra*) released in mangrove-seagrass and coral reef flat habitats in Solomon Islands. Aquaculture 220, 495-505.

Friedman, K., Lokania, P., Fale, P., Mailau, S., Ramohio, P & Romofafia, C. (2005, in draft) Survey of the sea cucumber resources of Ha'apai, Tonga. Draft report to the Ministry of Fisheries, Kingdom of Tonga.

Lincoln Smith, M.F., Pitt, K.A., Bell, J.D. & Ramhoia, P. (2000) Testing the use of marine protected areas to restore and manage tropical multi-species invertebrate fisheries at the Arnavon Islands, Solomon Islands. Great Barrier Reef Marine Park Authority Research Report 69.

Lokani, P., Matoto, S.V. & Ledua, E. (1996) Survey of sea cucumber resources at Ha'apai, Tonga, May-Junes 1996. SPC, Noumea.

Lowden, R. (2005) Management of Queensland sea cucumber stocks by rotational zoning. SPC Beche-de-mer Information Bulletin#22, p.47.

Long, B.C., Skewes, T.D., Dennis, D.M., Poiner, I.R., Pitcher, C.R., Taranto, T.J., Manson, F., Polon, P., Karre, B., Evans, C., & Milton, D. (1996) Distribution and abundance of beche-de-mer on Torres Strait reefs. CSIRO Division of Fisheries Final Report, Cleveland, Australia.

McLoughlin, K. & Caton, A.E. (2004) Status reports for Australian fisheries. Bureau of Rural Science, Canberra.

Mercier, A., Hidalgo, R.Y. & Hamel, J-F. (2004) Aquaculture of the Galapagos sea cucumber *Isostichopus fuscus*. In Conand, C., Purcell, S., Uthicke, S., Hamel, J.F., & Mercier, A. (eds) Advances in sea cucumber aquaculture and management. FAO Fisheries Technical Paper #463.

Okamato, K. (undated) Beche-de-mer (sea cucumber) stock survey: Report 1. Tonga Fisheries Division, mimeo.