TONGA DEEPWATER FISHERIES MANAGEMENT PLAN 2014 – 2016

Prepared by Fisheries Division, Ministry of Agriculture and Food, Forests and Fisheries and European Union ACP Fish II Project

FOREWORD

The Tonga Deepwater Fisheries Management Plan is one of the series of national fisheries management plan being developed. This is an effort to establish responsible and adaptable fisheries management for sustainable utilization of the fisheries resources in the Kingdom of Tonga. It is a product of analysis of past data, consultation and effort between the Fisheries Division of the Ministry of Agriculture and Food, Forests and Fisheries (MAFFF), Secretariat of the Pacific Community, European Union "ACP Fish II Project and the consultant and fishing industry in Tonga. Fisheries Division of MAFFF acknowledges past and present license holders who gave their view freely to the formulation of this plan.

The deepwater fisheries are viewed as a one of the key factor in the future economic prosperity of the fishing industry for the country. To this end the plan provides further opportunity for stakeholder involvement through committees and National Fisheries Council. Fundamentally, the deepwater fisheries are critically for the sustainability of the fishing industry and also for food security in Tonga.

I thank all who contributed to bringing this plan to fruition. It will need updating to meet new situations and requirements of the fishery to ensure responsible and adaptable management in the future.

It is with pleasure that I present this guide to the Government, the stakeholders in the deepwater fisheries and the people of Tonga for their future.

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Honourable Sangster Saulala
Minister of Agriculture and Food, Forest and Fisheries

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ABBREVIATIONS:

ARGOS VMS:	ARGOS VESSEL MONITORING SYSTEM
CPUE	CATCH PER UNIT EFFORT
FD	FISHERIES DIVISION
FMAC	FISHERIES MANAGEMENT ADVISORY COMMITTEE
FAO	FOOD AGRICULTURE ORGANISATION OF THE UNITED NATIONS
FFA	FORUM FISHERIES AGENCY
FMA 2002	FISHERIES MANAGEMENT ACT 2002
MAFFF	MINISTRY OF AGRICULTURE AND FOOD, FORESTRY AND FISHERIES
MSY	MAXIMUM SUSTAINABLE YIELD
MEY	MAXIMUM ECONOMIC YIELD
MCS	MONITORING, CONTROL AND SURVEILLANCE
SPC	SECRETARIAT OF THE PACIFIC COMMUNITY
SFMC	SNAPPER FISHERIES MANAGEMENT COMMITTEE
SFMP 2007	SNAPPER FISHERY MANAGEMENT PLAN 2007
TAC	TOTAL ALLOWABLE CATCH
TDFMP	TONGA DEEPWATER FISHERIES MANAGEMENT PLAN

TONGA DEEPWATER FISHERIES MANAGEMENT PLAN

PART 1: INTRODUCTION

The Government of Tonga began promoting exploitation of deep slope resources of snapper, grouper and emperors in Tonga in 1980. The fishery was originally intended to relieve fishing pressure on inshore resources but developed into an export fishery that generated greater economic benefits from foreign revenue. Tonga was a net importer of fish products at the end of the 1970's. However, since then, the nature of several fisheries has changed, and in recent years, the majority of the target species of the deepwater snapper fisher are exported, while the by-catch and shallow water species are sold locally.

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*". This includes control of the use of local Tongan fishing vessels for fishing or any related activity on the high seas. The Minister (under the new Government structure, the Minister of Agriculture & Food, Forests and Fisheries (MAFFF)), in exercising his powers, must consider, "the need to ensure the long term *conservation and sustainable use of fishery resources, and to this end adopt management measures to promote the objective of optimum utilization and to achieve economic growth, human resource development, employment creation and sound ecological balance" (Sect 4.(a)).* These are enacted through having an agreed Fisheries Management Plan enabled by the Ministry of Agriculture & Food, Forests and Fisheries, Division of Fisheries (DOF).

The current Snapper & Grouper Fisheries Management Plan (SFMP 2007) was adopted in 2007 after an extensive consultative period. This document is an amendeaid plan based on an analysis of recent trends in the fishery and consultation with stakeholders.

1.1 Policy Statement

The policy guidance for the Tonga Deepwater Fisheries is to ensure responsible fishing, participation by stakeholders, sustainable utilization and an economically viable fishing sector for Tonga. If managed responsibly, the fishery has the potential to provide sustainable economic benefits for Tonga. The plan is based on the FMA 2002: Section 4(g):.." *the need to take measures to prevent or eliminate over-fishing and excess fishing capacity and to ensure that levels of fishing effort do not exceed those commensurate with sustainable use of fishery resources*" (FMA 2002; Section 4(g)).

This Revised Tonga Deepwater Fisheries Management Plan (TDFMP) will be a document that will require ongoing input and scrutiny. Once adopted, it should be reviewed every three years and amended as needed.

1.2 Purpose of the Tonga Deepwater Fisheries Management Plan:

This plan's purpose under the Fisheries Management Act 2002 (Section 4&7) is to promote the conservation, management, sustainable utilization of Tonga fisheries resources, and to exercise control of any Tongan fishing vessels of this fleet fishing on the high seas. It also supports and ensures that the working policies, Terms and Conditions of licenses provided by the Secretary for Fisheries are adhered to by those which have been given the limited rights to fish. The Plan is a *framework* to guide those licensed fishers and the enactment of specific and future measures. The accompanying regulation and licence conditions contain details of the measures to implement this plan.

The plan encourages co-managing of the resources to foster an active partnership with fishers and other stakeholders and the government.

That plan *aimed* that through participatory mechanisms:

- provide the direction to fishers;
- foster fisheries cooperation and co-management of the fish resources;
- ensure harvesting is maintained at a sustainable level given the unpredictable nature of the resources ant its environment;
- provide food security for domestic market;
- maximize the benefits to the economy through export;
- preserve the environment;
- provide measures to control fishing effort, fishing capacity; and
- provide precautionary measures in the absence of best scientific assessment.

This plan has the same overall *aims* with the addition of:

- provide a viable and profitable business for both the harvest and post-harvest sector.

1.3 Preparation of the Tonga Deepwater Fisheries Management Plan

The management plan that was adopted in 2007 was developed with stakeholder input in conjunction with the Fisheries Management Act 2002. The process was started in 1990, and the draft plan went through many iterations. A summary of the different drafts can be found in (Wilson, 2007).

This revised draft plan is based on a review of the 2007 Plan, a completion of past information, an analysis of recent trends in the fishery and stakeholder consultations carried out under an EU funded ACP-FISH II project entitled "Support for the sustainable exploitation of deepwater snapper fisheries in Samoa and Tonga". The technical report on which this plan is based is available from the Tonga DOF and on the ACP-FISH II website (Staples, 2013).

1.4 Background information on the deepwater fishery;

The drop line fishery exploits a multi-species assemblage of members of the family *Lutjanidae* (snappers), *Lethrinidae* (emperors) and *Serranidae* (groupers). Drop line bottom fishing occurs to depths ranging from 50 to 450 m (Bell et al, 1995) in which catches are derived from both banks and seamounts.

The fishery for export species is based principally on seamounts. Historically 6 target species (Crimson jobfish, *Pristipomoides filamentosus,* Golden eye jobfish, *Pristipomoides flavipinnins,* long-tail snapper, *Etelis coruscans,* Short-tail red snapper. *Etelis carbunculus,* comet grouper, *Epinephelus morhua* and convict grouper, *Epinephelus septemfasciatus*) constituted around 80% of the catch. The species composition has changed over time in association with changes in targeting and depth of fishing. A shallower bank fishery also operates providing fish for the domestic market (MRAG, 1994). The long-tail snapper, *Etelis coruscans,* is now the dominant species, comprising more than 50% of the catch (Staples, 2013).

Species of these families are bottom dwelling carnivores that feed on benthic fishes and crustaceans. The life history characteristics of these species make them vulnerable to over-fishing and exploitation - long longevity, slow-growing, low rates of natural mortality, large size at sexual maturity and spawning aggregations. Although there is uncertainty about the degree of migration between seamounts, limited data does suggest that seamounts support relatively isolated meta-populations (MRAG, 1994).

Both the former and this plan is based on research and data carried out by a number of agencies and individuals. The South Pacific Commission (SPC - now the Secretariat for Pacific Communities) Deep Sea Fisheries Development Project ran between 1974 and 1988 with the collaboration of the Fisheries Division to assess the deepwater drop line resources and develop economic fisheries. The Overseas Development Administration (ODA) Fish Management Science Program (FMSP) started a comprehensive research and data gathering project in the second half of 1986. The main objective of this project was to get the biological data necessary for the effective management of the deepwater snapper and grouper fishery. By 1991, after five years of data gathering, the Tonga snapper fisheries became one of the most researched small-scale fisheries in the Pacific Islands. The studies continued with the added collaboration of MRAG from 1993 until 1998. Others that provided scientific advice included Viliami Langi and Sarah Langi, Saia Tulua and Tevita Latu and Dr. Michael King in 1992, and Marc Wilson from the AusAID funded Tonga Fisheries Project that carried out a 4-year project in 2002-2006 with the aim of further developing and refining management plans and enforcement procedures for key fisheries.

Collection of catch, effort and size frequency data began in the 1986. Unfortunately it has not been collected consistently, often due to limited staff and funds. This has resulted in data deficiencies at certain times, especially in the 2000s. The establishment of the Fuel Concession in 2000 provided a mechanism for encouraging supply of quality log-sheet and offloading data from licensed fishers. Data collection systems were reviewed in 2004

and since then checking and validation mechanisms have been in place to ensure data quality and completeness. Data collected from 2007 to 2012 are of a high quality.

Research has been conducted in Tonga and in other areas of the Pacific to obtain life history parameters to aid in management. Annex 1 provides a summary of the known biology of the main species.

1.5 Scope of the Plan

The plan, for ease of understanding, covers what is commonly known to fishers as the Tongan Drop Line Bottom Fishery, Deepwater Drop Line Fishery and Deepwater Snapper Fishery. It includes;

a) Fishing for deep bottom fish (demersal) species (as defined in Table 1 below), by fishing gear that includes, but not limited to;

   Drop lining (a weighted line with baited hooks attached);

b) The target and non-target, associated or dependent species taken in the course of fishing for the following species (Table 1):

c) And other reef or slope fish species not specifically listed in Table 1 such as reef groupers, wrasses and parrotfish (that may occur from change of market preferences).

d) Vessels licensed to fish these species in the deepwater regions of the banks and seamounts in the Tongan EEZ and the high seas.

e) All "related activities", as per the FMA 2002, including, but not necessarily limited to:
   a) Transhipping;
   b) Bait fishing;
   c) Provisioning and all other services relating to the snapper & grouper fisheries, including;
   d) On-shore processing; and
   e) Provision of port facilities.

f) The plan does not cover the following:
   a) Subsistence fishing
   b) Recreational fishing

e) Secretary shall consider this plan when exploratory or test fishing authorisations are granted to any applicant for any kind of deepwater fishing activity, which will affect this fisheries, including marine scientific research fishing

Table 1: Table of species that may be targeted and non-targeted in this fishery.

Scientific Name	Common Name	Tongan Name
Aphareus rutilans	Rusty jobfish	palu polosi
Aprion virescens	Green jobfish	utu
Carangidae	Trevallies and jacks	lupo
Etilis carbunculus	Short-tailed red snapper	palu malau
Etilis coruscans	Long-tail snapper	palu tavake
Epinethelus morrhua	Comet grouper	ngatala pusi
Epinethelus octofasciatus/ *Septemfasciatus*	Eight bar/ convict grouper	mohuafi mohuafi
Pristipomoides filamentosus	Crimson jobfish	paluhina
Pristipomoides flavipinnis	Golden eye jobfish	palu sio'ata
Pristipomoides argyrogrammicus	Ornate jobfish	
Lethrinus chrysostomus	Sweetlip emperor	manga
Paracaesio kusakarii	Saddleback snapper	palu mutumutu
Gymnocranius radiosus	Silver snapper	palu hina

The Plan also supports the Port State control principles whereby any fishing vessel that enters any port of Tonga, can be subjected to a full inspection for compliance of Tongan, regional, or international agreements or third party fisheries laws.

The plan endorses national legal stances on pollution of any kind in the fisheries waters of the Kingdom of Tonga.

PART II: ISSUES IN THE FISHERY: TRENDS AND RESOURCE STATUS

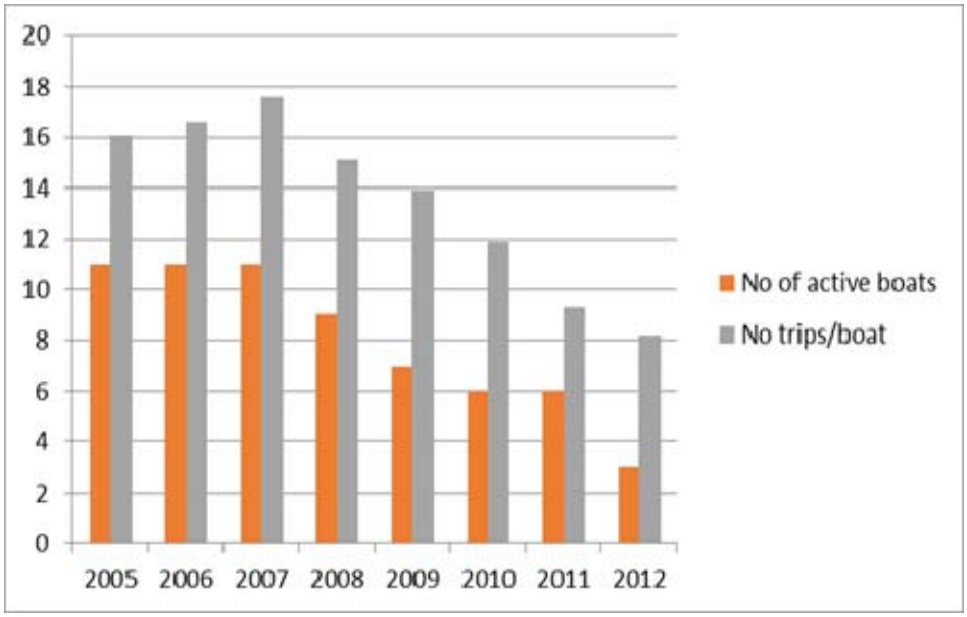
Based on the review of past information, analyses of recent trends and stakeholder input, four major issues and two other lower risk issues have been identified.

2.1 Overcapacity of the fishing fleet, latent effort and 'boom and bust'

Overcapacity

Fishing fleet

In 1988, the FAO/UNDP boat-building scheme completed a fleet of 40 vessels designed for snapper fishing. These vessels were 28ft long and equipped with four Samoan style hand-reels. At that time there were very optimistic forecasts for the future of deepwater line fishing. A few privately built fishing vessels also participated in the fishery, and by the end of 1988, the fleet size was 44 vessels (Bell et al, 1995). However due to declining catch rates and the lack of consistent maintenance and attention to safety, the number of fishing boats constantly decreased so that in 1992 only 19 boats were licensed. Since 1992 an average of 20 boats have been licensed each year, but there is considerable latent effort[1] with many boats not choosing to purchase a licence in some years. The average number of fishing trips since 1994 has been around 200 trips/year.



Number of active boats and trips per boat from 2005 - 2012

The number of licensed vessels fell to only 14 in 2012. Of these, only 3 boats completed greater than 15 fishing trips in the year (active boats). The number of active boats and the number of fishing trips per boat have decreased markedly over the past five years

[1] Latent effort refers to boats that are not actively fishing but could fish if conditions changed.

(Data of MAFFF, DOF), but the other boats still remain tied up to the wharf and could re-enter the fishery if prices and costs change or if they are refurbished.

Maximum sustainable yield (MSY)
There have been a number of attempts to estimate the maximum sustainable yield (MSY) of the Tongan deepwater snapper fishery (Table 2). These are all based on data collected during the fish-down period of the fishery (from 1987 to 1993). All authors caution that many of the assumptions built into stock assessments were not met with this data set, but it does give an indication of the magnitude of expected yields from the fishery and the number of boats that it could support.

MSY estimates range from 64-225 tonnes for the sea mounts with a median value of around 200 tonnes and from 113-350 tonnes for both banks and seamounts with a median of around 250 tonnes. Given the uncertainty in these estimates, a working MSY would be 250 tonnes (200 tonnes for seamounts and 50 tonnes for the banks). Recent catches are below this level.

Table 2: Previous estimates of the maximum sustainable yield (MSY) for Tonga

Author	**Species/depth**	**Method**	**MSY estimate (tonne/year)**
(Latu & Tulua, 1990)	All spp; seamounts	Depletion model	64-198
(Latu & Tulua, 1991)	All	Depletion model	71-222
(Dalzell & Preston, 1992)	All spp; banks and seamounts	Depletion model	113-338
(Latu & Tulua, 1992)	5 main species; seamounts	Surplus production (x2)	356/412
(Langi, et al 1992)	6 major spp; seamounts	Depletion model	217
(King, 1992)	All; depth>200m	Surplus production	200-300
(King, 1992)	All; depth>200m	Length-based	255 maximum
(MRAG, 1994)	Seamounts	Surplus production	64-225

In most fisheries, the maximum economic yield (MEY) is less than the MSY. This is the catch that maximises the economic benefits, measured as the sum of net benefits to producers and consumers, and resource rent. (Wilson, 2007) showed that the effort required to meet the maximum economic yield (MEY) was about 50% of that required to catch the MSY. (Langi & King, 1994) in discussing management options, also stated that the number of boats needed to take the MEY would be half that needed to take the MSY in the Tongan deepwater fishery.

King (1992) estimated that 7 - 13 deepwater snapper fishing boats of the type operating

in 1991 would be the best number to maximize profit-per-vessel (based on a surplus yield assessment of the fishery). However, 20 or so such vessels could possibly operate without exceeding the biological sustainability of the stock. Latu and Tulua (1992) calculated that maximum profit occurs at a fleet size of 16 - 17 vessels noting fish prices at the time. However, their estimate of the MSY and MEY is considerably higher than those of others and probably over optimistic (this has been shown to be the case when we examine the historical trends in the fishery).

Until more stock assessment results come to hand, a working MEY would be 200 tonnes (170 tonnes for the seamounts and 30 tonnes for the banks). The average catch per trip for 2012 was just in excess 1000 kg (Staples, 2013).

The most recent stock assessment for snapper has been carried out by (Williams, et al., 2013) for fish sampled in New Caledonia. The maximum observed age, based on increment counts from sectioned othliths, was 21 years for long-tail snapper, *E. carbunculus,* and 18 years for short-tail red snapper, *E. coruscans.* The fish apparently live longer than originally thought. A spawner biomass-per-recruit analysis demonstrated that *E. coruscans* would need to be fished at lower rates of fishing mortality for than for *E. carbunculus*. These estimates were more sensitive to variation in natural mortality than in the age at first capture, suggesting that regulating fishing mortality rather than gear selectivity would be a more effective management measure for both species. Maintaining fishing mortality at a relatively low value ($F<0.1$) for both species was recommended as a cautious approach to management, given the uncertainty in estimates of natural mortality and mixed fishery considerations.

'Boom and bust'

The following account of the fishery is based on a reconstruction of catches, fishing trips and boats 1986-2012 (Staples, 2013). The reconstructed data and sources are in Appendix 1.

Early development 1980 – 1993

In the early years of the fishery, there was a lot of fishing activity, with an average of over 1000 trips carried out by the fleet in 1987 and 1988. As expected in the early phases of the fishery, catch per trip was high but rapidly declined, as the fish-down of the stocks occurred. This was associated with a shift from targeting shallower water spp (*Pristipomoides* spp) to the deeper spp (*Etelis* spp). (Bell et al, 1995) shows that the percentage of long-tail snapper increased from 8.6% in 1986 to 54.1% in 1990, but it also declined again in 1992, presumably as fishers adjusted their fishing patterns.

Recovery 1994 to 2002

The catch rate increased from the low in 1993 to a second peak in 2002 as fishers focused in the now dominantly export-orientated fishery and the number of trips per year declined after the first few heady years of the fishery. The number of trips started to increase again towards the end of this period and the catch also started to increase again. And the catch per trip peaked in 2002.

Decline 2003-2006
After the peak 2002, a period of decline again occurred. This was also detected by the analysis of (Wilson, 2007) who showed a decline in catch per litre fuel used (a proxy for fishing effort) from 2002 to 2006.

Reconstructed trips (blue line), catch (orange line) and catch per trip (green line) for the Tongan deep water snapper fishery (data are at Appendix 1)

Recent increase 2007-2012
In recent years, both the number of trips and the catch have been declining, but the catch per trip has been increasing steadily. This is because the efficiency of the smaller number of boats has been increasing, with changes such as an increase in the number of hooks occurring.

Most Tongan boats are either dedicated tuna longliners or snapper dropliners but a few boats have chosen to change their licenses from the deepwater snapper fishery to the tuna fishery and vice versa, especially in the early 2000s. However, these are the exception rather than the rule.

It is interesting to note that both times when the fishery increases to over 200 trips per year (for the whole fleet), a decline in the catch per trip followed. This is more evidence that a MEY of 200 tonnes (200 trips per year at 1 tonne per trip) is a good working target.

2.2 Ageing fleet and inefficient fishing technologies

Most of the vessels operating in the fishery still use the Samoan hand reel designed back in the late 1980s. Of the original fleet of FAO 28ft vessels only three are still operating, but many of the boats introduced in the 1990s are still operating. There are some larger vessels entering the fishery, albeit on a part-time basis. One vessel has mechanised hauling gear that should lead to increased catch rates.

The average vessel size of licensed vessels has been between 35-40 ft from 2001 to 2012, with no discernable trend. The average size of licensed vessels increased slightly in 2012 when a 61ft vessel became licensed and carried out a few fishing trips.

Apparently, the Government of Tonga is considering funding a boat refurbishment scheme (Fakalolo, pers comm, 2013) that would presumably increase the number of boats fishing and convert some of the now latent effort into active fishing effort. This is a major concern given the overcapacity of the fleet and 'boom and bust' issues, and is counter to the vision, goals and objectives of this plan.

2.3 Marginal profits and returns to fishers, processors and the Tongan economy

Three early studies analysed the economic viability of the fishery. Latu and Tulua (1992); Fakalolo (1992); King (1992) agreed that the fishery at this time was likely to be running close to its maximum economic yield, and suggested enforcement of the moratorium on the number of boats participating in this fishery. All these studies showed that profit levels in the fishery were low, even in the early days of the fishery and that a typical 28ft vessel operates either very close to, or below, the break-even point where income from fish sales balances costs.

(Wilson, 2007) compared costs in 1991, 2001 and 2006. In general, all costs except wages had risen as a proportion of the total costs. Most notable was the rise in fuel price and he concluded that, in general, economics had declined over the period 1994 to 2006, despite the DOF introducing a fuel rebate scheme in June 2000.

This fishery has produced over TOP$2-3million of export revenue, and has employed up to 200 people in fishing, marketing and other ancillary services ('Alatini and Maritime pers comm., 2004). The highest earning for the fishery was in 2002 at approximately TOP$1.1 million (FOB). Over 62% of the total landings have been exported since 2006. The export value in 2012 was TOP$567,675 based on a FOB value of $6.91.

Those fish not exported are sold on the domestic market. These include other species, damaged lower quality fish and juveniles of the target species. Reducing the number of juveniles taken (for example protecting seamount known to have a higher proportion of juvenile fish), would increase the proportion of fish suitable for export.

There were a number of earlier reviews on the quality of deepwater snapper (and tuna) exported from Tonga to overseas markets ((Elsey, 1983), (Crossland, 1985), (Roberts, 1991) and (Bartram, 1993)). These reviews all identified earlier major problems as:

1. Poor handling at sea;
2. Lack of adequate ice carried on board vessels; and
3. Poorly designed ice boxes

and all recommended that a system of quality control be introduced to maximize returns on overseas markets.

Since that time, quality has improved, and companies are now HACCP certified, but there is always room for further improvements. Many similar fisheries in the world have also adopted spiking (ike jimi) on board the vessel as way of improving quality. (MAFFF, 2012) identified that the constraints for getting exported marine products to market include (i) increasing transportation costs, (ii) lack of available cargo space inside the commercial planes, (iii) lack of storage space and capacity at the airport where marine cargo may be held or stored when flights are delayed. Long delays and poor cargo handling contributed to damaged and poor quality of exported marine products. The market is very conservative and relies heavily on the Hawaiin market. Markets, on the other hand, are dynamic and with the changes in the balance of trade in fish, alternative markets should eventuate.

2.4 Poor governance

Governance issues include:

Lack of effective co-management arrangements

The 2007 management plan set out very comprehensive terms of reference for a consultative framework and participatory co-management approach through the establishment of a Deepwater Fisheries Management Committee (DFMC). This did not really eventuate, although stakeholders do meet with government official on an ad hoc basis. The ongoing port sampling scheme also means that some DOF staff meet and interact with skippers and crews.

Lack of regulations to support the management plan

Although drafted, the regulations to support the implementation of the management plan were never gazetted. The management plan did contain a number of specific management measures regarding gear and boat specifications that, in hindsight, should have been in regulations. This will be fixed in this revised draft management plan.

Monitoring and evaluation (M&E) of management

This important aspect of fisheries management was emphasized in the 2007 plan, but never implemented. The data collection and database management of landings has improved but no attempt has been made to analyse these data and provide reports to stakeholders. The necessary economic data was also never collected, although it could be obtained through a 5-yearly survey. Each objective of this plan has indicator(s) that form the minimum data and information required for effective M&E.

MCS

In one of the many revisions made to the draft first management plan, it was stated that the lack of commitment to MCS controls, specifically limits to vessels licensed and regulation of unlicensed vessels have resulted in effort creep far above recommended economic and biological levels of effort. There are reports of vessels <6m that do not need to be licensed also fishing on seamounts. This is illegal under the SFMP 2007.

Through the intervention of a Fuel Concession (first introduced in in 2000) and the introduction of VMS, there is now tighter control of the fishery, but MCS plans and reports are needed to support the implementation of this plan.

2.5 Other issues

These issues do not pose as great a risk to the fishery as those listed above, but management measures that help to address them, as well as the major issues, can be considered as a bonus

Safety at sea

In the earlier days of the fishery, lack of attention to safety and the low maintenance of engines and gear, led to vessels becoming unseaworthy (Gillett, 2003). According to DOF records up to 2002, six boats were lost at sea, one was destroyed by fire and six were repossessed. In Vava'u, many of the remaining vessels are reluctant to venture far offshore because of the likelihood of breakdown (mainly engine failure). (Gillett, 2003) reported that the most serious sea safety incident up to that time occurred in February 2002 when a snapper vessel belonging to Maritime Projects Tonga was lost with six men aboard. The vessel was fishing offshore and equipped with EPIRB, SSB radio and life raft. The other major snapper fishing company, 'Alatini Fisheries, has lost three snapper boats but no lives: a 1994 grounding due to crew error, in 1996 a vessel caught in cyclone, and in 1999 another vessel caught in cyclone.

Safety at sea has improved with the entry of newer vessels into the fishery. However, there are still many old boats either still fishing or potentially could fish if conditions change.

Catch of juvenile fish

There are anecdotal reports that some catches contain a number of juvenile fish that are either exported when the demand is high, or sold on the domestic market. Fishers also report that they can target larger fish by moving to different areas and depths. It is also though that some seamounts have a higher proportion of juvenile fish. Large quantities of juvenile fish can have serious impact on the resources and also lowers the economic efficiency.

By-catch and environmental concerns

Because the principal gear used in the fishery is hook-and-line, which does not damage the seafloor and results in moderate levels of by-catch, there are few environmental concerns, other than changes to the food web. However, noting the growing international concern regarding the by-catch of sharks, turtles and sea birds, data on any interaction with these should have been collected. There is no recent information on by-catch from the Tongan fishery.

In Hawaii, there are some species within the bottomfish management unit that are frequently discarded due to low commercial importance. The two primary discarded

species were the greater amberjack (*Seriola dumertili*) and white trevally (*Pseudocaranx dentex*)(WPFMC, 2009a). Sharks, oilfish, snake mackerel, pufferfish and moray eels are not kept by vessels because they are unpalatable. Other reported by-catch include dogtooth tuna, blueline snapper, blackjack, blacksaddle grouper, and honeycomb grouper. Target species are also sometimes discarded due to predator damage. Logbook data for the northwestern Hawaiian Islands indicates an overall discard rate for all species of 13%, while data from observer coverage indicates a higher rate of 25% (WPFMC 2009a). For the main Hawaiian Islands fishery, it is thought that the majority of species caught are retained, so discards may be fewer in this fishery (WPFMC, 2009a).

For Guam and the Northern Mariana Islands by-catch data is collected through interviews with fishermen. Discards in these regions are considered to be low, but information is limited (WPFMC, 2009c). With regards to endangered and vulnerable species, the National Marine Fisheries Service (NMFS) have concluded that bottomfish fisheries in Hawaii and the other regions will not negatively affect any species listed under the Endangered Species Act (ESA) or any marine mammals protected by the Marine Mammal Protection Act (MMPA) (WPFMC 2009abc).

(Dalzell & Preston, 1992) report that during the early trial fisheries in Tonga unidentified sharks were caught in cruises conducted in 1979, 1981 and 1986, 7.3% , 5.1% 1.8% by numbers of the total catch by numbers, and considerably more by weight.

PART III: VISION, GOALS AND OBJECTIVES

In this section, the plan explains its desired objectives and acknowledges that there will be challenges to overcome.

3.1 Management Challenges

Catches have exceeded MSY and MEY in early years (Latu and Tulua (1992); Fakalolo (1992); King (1992)) and warnings were made that this level of catch was unsustainable. There were several requests to limit the fishing effort in the fishery (mainly through limiting access to a smaller number of boats) in the various drafts of SFMP 2007. However, despite the overwhelming evidence that stricter management is needed, the fishery has been left to struggle on, with the unfavourable economics of fishing the only protection given to the resource - thus the "boom and bust".

The challenge in this fishery is to reduce effective effort to a level that the fishery can operate profitably and sustain ecologically in the long term. In this process, there will be winners and losers, but it must be carried out. The status quo will be an unprofitable fishery, possible with a further "bust" in the future with severe socio-economic impacts.

The use of new technology such as the ARGOS VMS allows validation of fishing locations. Future challenges for the Ministry are (i) to use the VMS to document fishing on seamounts, (ii) maintain the data collection regime, (iii) carry out analyses that will allow for the status of the fishery, especially status of populations on individual seamounts to be assessed, and (iv) assessing the fisheries economic performance and viability of the fishery.

A major challenge is to carry out economic analyses. A clear and reliable economic assessment prior to any review of the DFMP (recommended every five years). Data on fish prices are available, but data need to be collected on costs. Other challenges include:

- Agreeing on an equitable system to reduce the number of licensed boats (see options below)
- Concurrence and commitment of stakeholders to conserve their deep water fisheries resources;
- Commitment of DOF to establish controls for a sustainable fishery, including regulations, and consistency in their application;
- Capacity of the fishers and Ministry to establish and maintain an appropriate and accurate data collection, analysis and reporting system;
- Capacity of fishers and the DOF to collectively ensure appropriate monitoring and compliance with the management plan; and
- Capacity of the Government of Tonga to mount successful prosecutions to promote effective compliance and enforcement.

3.2 Vision

"A well-managed deep water multispecies fishery providing export revenue to improve the standard of living and food security of all Tongans"

3.3 Goals and objectives

The broad objectives of the SFMP 2007 were developed in line with the Fisheries Management Act 2002 and tailored for the Fishery. These objectives were:

Objective 1: To ensure that utilization of the deep bottom fish resources are for long term conservation and sustainable benefit;

Objective 2: To maximize economic welfare to Tonga from utilization of its deep bottom fish resources including harvesting, processing and exporting;

Objective 3: To contribute to the food security and livelihoods of Tongan subjects through sustainable utilization and employment.

For this Revised Draft DFMP, the amended objectives should be change to reflect the changes in the fishery that have occurred since 2007. The year 2007 coincided with a five-year decline in the fishery and there were concerns of biological overexploitation (Adams, 2007). However, because of economic conditions, the fishing effort has declined and the efficiency of the remaining boats has increased.

In line with generally accepted practices, in this the Revised Draft DFMP, there overarching objectives are called goals. Thus, the goals for 2013 are:

Goal 1: To achieve the economic yield (MEY) and improve/ increase the return of the fishery to fishers, processors and exporters.

Goal 2: Implement good governance to ensure that all the requirements of the DFMP are met.

Note: The new goal 1 incorporates objectives 1 and 2 of the 2007 plan. Because the MEY is a more conservative target (in terms of both the fishing effort needed and the catch) than that of MSY, this should ensure that the utilization of the deep bottom fish resources are for long term conservation and sustainable benefit; and it will also maximize economic welfare to Tonga from utilization of its deep bottom fish resources including harvesting, processing and exporting.

Underpinning these goals are several objectives, each addressing the major issues described in Chapter 2. To monitor and evaluate (M&E) whether future management is meeting the objectives, a number of indicators are described that, when compared against the benchmark, can be used to assess management performance. This is part of the

improved governance for this fishery.

Goal 1: To achieve the economic yield (MEY) by improve/increase the return of the fishery to fishers, processors and exporters.

Objective 1: Conserve the fish resources by limiting the amount of fishing
Indicator 1: Number of licensed boats (assuming that no unlicensed boat is fishing)
Bench mark: Number of boats set as the limit in the regulations (to be reviewed as more biological and financial information is provided).[2]

Indicator 2: Total annual catch
Bench mark: MEY and/or total allowable catch (TAC) as set in the regulations

Indicator 3: Total annual effort (both as number of trips and number of hooks/hours).
Bench mark: Effort required catching the MEY as specified in the regulations.

Indicator 4: Catch rate (catch per trip) and catch per unit effort (CPUE as catch per hook/hour)
Bench mark: CPUE trend over past 5 years.

Objective 2: Encourage economic efficiency of vessels and maximize the export revenue in the fishery
NOTE: This objective cannot be addressed until objective 1 has been achieved

Indicator 1: Average age of vessels operating in the fishery
Bench mark: Average age of vessels in 2013

Indicator 2: Number of reels and hooks used
Bench mark: Number of reels and hooks used in 2013

Indicator 3: Technological aids used for both navigation, safety and harvesting
Bench mark: Technology used in 2013

Indicator 4: Return on investment
Bench mark: Trend over past 5 years

Indicator 5: Export volume and value to different international destinations
Bench mark: Export volume and value in 2013

Indicator 6: Percentage of total catch exported.
Bench mark: Percentage exported in 2013.

Objective 3: Protect a number of seamounts (and banks) as a safety valve for stock

[2] A member of MAFFF DOF is currently studying in New Zealand and should be able to provide better information in a few years' time.

sustainability and for protecting juvenile fish.
Indicator 1: Percent of area of seamounts (and banks) protected (no-take zones)
Bench mark: Initially 10% but this would need to be refined as data analyses continue[3].

Goal 2: Implement good governance to ensure that all the requirements of the DFMP are met.

Objective 4: Develop effective co-management arrangements,
Indicator 1: Number of formal meetings and minutes of the Deepwater Fisheries Management Committee (DFMC) (see below for functions and process)
Bench mark: Two meetings per year

Objective 5: Provide stakeholders with formalized the regulations
Indicator 1: Regulations pertaining to this Revised Draft DFMP are gazetted and reviewed regularly.
Bench mark: Regulations are gazetted with six months of the adoption of this DFMP

Objective 6: Develop effective M&E to track the performance of management
Indicator 1: Indicators listed in this Second Draft of the DFMP are monitored and an evaluation of trends against the stated bench marks made regularly
Bench mark: The performance of management is reviewed at least every three year.
Indicator 2: Document the environmental impact of the fishery, especially by-catch and discards.
Benchmark: A report on the by-catch and discards in the fishery is published.

Objective 7: Develop effective MCS
Indicator 1: MCS reports on compliance with regulation and rules presented to the DFMC.
Bench mark: MCS reports presented at the 6-monthly meeting of the DFMC

Based on these objectives, the following are expected to be the main outcomes in pursuing the objectives of the conservations and long term management of the deepwater fishery.

- A well managed but viable fishing fleet;
- Increase revenue generated to fishers and processors through export earnings;
- An ongoing arrangement for co-management that maintain an effective consultative process to support implementation and review of this management plan with DOF;
- Improved safety at sea;
- Minimized environmental impact;
- Effective MCS using the Vessel Monitoring System (VMS); and
- A process of monitoring and evaluation (M&E) in place to analyse and report on the performance of management

[3] As above

PART IV: MANAGEMENT MEASURES

The following sections describe the management measures to meet the two goals described, including moving to a limited access fishery and improving governance.

These measures are based on the concept of ***adaptive management*** that does not wait until all the data and information is collected and analysed before putting in management measures. Then, through monitoring the responses to the measures learn what is working and what is not. For example, although the 'optimal' number of boats is not known precisely, it is obvious from previous work that the number of licensed boats needs to be reduced. To achieve this we set a working target (for example 10 boats) and then as better data are collected the number is fine-tuned so that the MEY is achieved. Adaptive management is closely linked to the precautionary approach that states "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation".

Goal 1: To achieve the economic yield (MEY) and improve/increase the return of the fishery to fishers, processors and exporters.

4.1 Total allowable catch (TAC)

To address objective 1, and 2 the total catch needs to be limited. This would be achieved through setting an annual TAC, based on the best information of the MEY. The Deepwater Management Committee agrees to a TAC of 200 tonnes annually.

4.2 Gear and boat restrictions

All vessels are to be licensed as a 'Drop line (Deep Bottom Fishing) Fisheries vessels to fish from slopes and seamounts in depth deeper than 50m.

All vessels shall have all the "Vessel Identification Markings as prescribed in Schedule 3 of the Fisheries (Local Fishing) Regulations 1995; Sect 9(c), 17 (c).

To prevent very large vessels entering the fishery, the maximum LOA should be imposed.

If the boat or catch limitation has been successfully implemented, there should be no need for gear restrictions or further boat restriction. Boats should be encouraged to use mechanical reels, fish finding technology etc.

All vessels fishing in the fishery are to be fitted with VMS.

The boat limit to 23 meter in size

License suspended for breaking laws and rules and penalties set out in FMA2002 applied.

The fuel concession that provides incentives for fishers to provide the necessary data and information required to manage the fishery should stay in place.

4.3 Export, markets and fish quality

As part of addressing objective 2, diversification of markets into developing overseas marketing should be encourage. Continuing training of best practice handling of fish and icing is an ongoing need.

Summary of measures to meet the objectives under Goal 1 are:

- ***Limit the catch through TAC OF 200 tonnes annually***
- ***No limit on gear***
- ***Impose a maximum LOA, 23 meter***
- ***All vessels registered & licensed***
- ***Vessels fitted with VMS***
- ***Fuel concession to continue to encourage data collection & monitoring***
- ***Promote market diversity and modern handling techniques***

Goal 2: Implement good governance to ensure that all the requirements of the DFMP are met.

4.5 Consultative co-management framework

The Minister responsible for fisheries will manage the fishery in cooperation with stakeholders through participatory (co-management approach) management. The DOF will still be the overriding decision makers. Participatory management facilitates the sharing of information, input into the development of MCS measures and promotion of voluntary compliance, fostering of co-management with the industry so they can assist in monitoring their fishery and report on non-compliant activity. The Fisheries Management Act 2002 states that there may be established a committee for each major fishery in Tonga. The following sections describe the formation of Deepwater Fisheries Management Committee (SFMC), which was also agreed to in the SFMP 2007.

Snapper & Grouper Fishery Management Committee

Consistent with the Section 7(4) of the Fisheries Management Act 2002, a Deepwater Fishery Management Committee (SFMC) is established under this Plan. The Committee "shall be primarily responsible for the implementation and review of the fishery plan or otherwise monitor the performance of the fishery subject of the fishery plan or perform such other duties and responsibilities as are given it under the fishery plan consistent with this Act".

The Ministry shall provide the DFMC with sufficient information to review the fishery and advise the Minister on any appropriate action.

The detailed terms of reference for the DFMC are at Annex 2.

4.6 Fishery regulations

It is essential that all the regulations to implement this plan, including General Terms be submitted to the Government for the consent of Cabinet. It is recommended that any detailed management measures be implemented separately, by notice (under section 19 of FM Act 2002), and appended to the plan as they occur. These measures should not be *prescribed* in the Plan itself, but be consistent with the objectives and management measures described under the Plan.

Any resolutions agreed by the Management Committee would also be appended to the plan. Monitoring of the fisheries will be set according to the authorization as stipulated by Section 19 of the Fisheries management Act 2002 as required from time to time to implement necessary management measures or when precautionary approached is necessary.

4.7 Monitoring and evaluation (M&E) of management performance

The main indicators that require ongoing monitoring were under each of the DFMP objectives (see above) but repeated here for clarity:
Objective 1: No limit the number of boats licensed to access the fishery
Indicators:

- Number of licensed boats (assuming that no unlicensed boat is fishing)
- Total annual catch
- Total annual effort (both as number of trips and number of hook/hours).
- Catch rate (catch per trip)
- Catch per unit effort (CPUE as catch per hook/hour)

Objective 2: Encourage economic efficiency of remaining vessels and maximize the export revenue in the fishery
Indicators:

- Average age of vessels operating in the fishery
- Number of reels and hooks used
- Technological aids used for both navigation, safety and harvesting
- Return on investment
- Percentage of total catch exported.
- Export volume and value to different international destinations

Objective 3: Develop effective co-management arrangements,
Indicator:

- Number of formal meetings and minutes of the Deepwater Fisheries Management Committee (DFMC)

Objective 4: Provide stakeholders with formalized the regulations

- Regulations pertaining to this Revised Draft DFMP are gazetted and reviewed regularly.

Objective 5: Develop effective M&E to track the performance of management

Indicator:

- This list of indicators are monitored and an evaluation of trends against the stated bench marks made regularly
- Document the environmental impact of the fishery, especially by-catch and discards.

Currently in Tonga there are a number of sources of data for the deepwater snapper fishery:

1. *Log sheets:* All requirements of the log sheets are detailed in the Terms and Conditions of licenses.
2. *Port Sampling:* All requirements of the port sampling are detailed in the Terms and Conditions of licenses.
3. *Packing Sheets:* Export data are submitted (pre-export) to the DOF in a (DOF) prescribed Packing List. A fully detailed packing list is submitted to Customs and stamped when approved. This copy is submitted (post export) to the DOF. These data include destination, weight, species, local price and in some cases a value for export price.
4. *Local Market Records:* Ministry staff at the Tuimatamoana Market currently record catch landed from both licensed and unlicensed vessels by species, weight, boat owner, trip departure and arrival dates and times.
5. *Vessel Monitoring System:* All licensed drop line (deep bottom fishing) fishing vessels are required to operate with VMS. The DOF receives location, speed and bearing information with a vessel signature every four hours.

For economic analyses, additional data will be required. This could be obtained from a sample of companies and boats and include major costs of fishing (i) fuel, (ii) fishing gear, (iii) bait, (iv) Food and supplies, (v) ice, (vi) crew wages, (vii) depreciation, and (viii) miscellaneous.[4]

In the preparation of this plan, the data from the packing sheets was in a digital form that could be used to analyse recent trends in species, volume and value of exports, which would have greatly assisted in the understanding of recent fishery trends.

The collation, analysis and presentation of these data are required for evaluating the fishery performance and the responsibility of the DOF. This should take the form of reporting the indicator against its agreed benchmark. This M&E of fisheries performance should be incorporated into the consultative process and reported to the 6-monthly meetings of the DFMC.

Regular stock assessments (every 5 years) to review the MEY figure with respect to

[4] Financial analyses are excellent research topics for students, as shown by the example of (Fakalolo, 1992).

stocks and fishing pressures is required[5]. The SPC is planning to develop a fairly simple Management Procedures framework, where we determine stakeholder objectives and assist them with developing indicators, reference points and harvest strategies. The plan is to keep it simple, and use indicators such as catch rates and size of fish which can be easily monitored, yet still provide an indication of the biological and economic sustainability (Williams, pers comm). The collection and analysis of economic information, relating to this fishery, sufficient for a comprehensive economic analysis, is also required at least every five years.

As a one-off exercise, a report detailing the amount and nature of the by-catch should be written based on a sample of observer trips and interviews with fishers.

4.8 MCS Issues

The monitoring, control and surveillance (MCS) issues for this fishery will depend on the management objectives and measures finally agreed. Vessels licensed for snapper & grouper fishing are fitted with VMS and adhere to the VMS regulations and other legal VMS requirements as set by DOF, special condition may apply as may be deem fit by the Secretary for Fisheries in relation to availability of VMS equipment.
Regardless of the measures, MCS of licenses need to be strictly enforced. Boats <6m that presently do not need to be licensed will need to be brought into the scheme. If boats want to fish both tuna and snapper, a dual license will be required.

If TAC management is decided, a real-time catch monitoring system will be needed. A Quota register will also be required and catches monitored against quota holding for all boats. This will be linked to port sampling. Fishing is to stop fishing once quota reached. Only licensed vessels are allowed to fish for quota and again a link to port sampling will be needed.

The fines and prosecution procedures are detailed in Section 19 of the FM 2002, and need to be strictly enforced to meet the objectives of this plan.

Summary of measures to meet the objectives under Goal 2 are:

- ***Form and maintain the Deepwater Fishery Management committee (DFMC) chaired by Secretary of Tonga Fish (DOF)***
- ***Gazette regulations***
- ***Set up a monitoring & evaluation system based on indicators***
- ***Promote effective MCS surveillances of management measures***

[5] Stock assessments could be facilitated by the SPC

PART V: FINANCING, COMMUNICATIONS AND REVIEW OF MANAGEMENT PLANS

5.1 Sustainable financing and human capacity

Any form of fisheries management requires on-going financing and support from staff in the Fishery Agency. Lack of funding and capacity in Tonga in the past has resulted in many lost opportunities, including incomplete data sets for assessing the fishery and a laissez faire management system.

Obviously, the main source of funding will be from budget allocations to the DOF. The DOF should actively campaign (through the Minister and through other opportunities) for sufficient funds to implement and monitor this plan. The small annual investment will pay large dividends in terms of increased export earnings that will increase the standard of living and food security for all Tongans.

Relevant questions that need to be asked include:

- Where from: existing budget or from new sources?
- What is the existing budget and budget cycles?
- How can you influence the budget allocation?
- What are equity issues and the impacts on stakeholders?

Depending upon the situation, and the support from government, several sources may be available:

Government revenue allocations	• Direct allocations from government budget; • Government bonds and taxes earmarked for conservation; • Debt relief
Grant and donations	• Bilateral and multilateral donors grants; • Foundations; • Non-government organizations; • Private sector; • Trust funds
Fishing industry revenues	• Fish catch and services levies/cost recovery mechanisms; • Eco-labeling and product certification; • Fishing license fees and excise taxes; • Fines for illegal fishing
For-profit investments linked to marine conservation	• Private sector investments promoting conservation; • Biodiversity prospecting
Other sources	• Loans;

5.2 Communication strategy

Once the plan is adopted, a well-designed communication strategy will encourage take up and compliance. Communication includes sharing the results of plan with the identified target audiences and identifying ways to adapt management practices to improve adoption. The strategy will provide a clear process of how results will be shared and logically and strategically organized.

Some relevant questions are:

- Who needs to know about the fishery and why? Are they interested in all aspects or just some aspects of the fishery?
- What are the formats needed for each type of audience: formal report, newsletter, website, etc.
- What should the frequency of the communication products be for each audience?
- What should the report contain: information on successes and failures; progress and blockages; problems and solutions; present state as well as future perspectives?
- What action is expected from the audience in return?
- What impact is the reporting looking for: awareness raising? Institutional response?
- How to get feed-back to the reports?

The communication strategy will include:

1. An audience analysis matrix identifying the range of possible internal and external audiences, their characteristics, and a set of priority target audiences.
2. A plan for how and where results will be delivered by identifying which media and formats will be used with each audience group, and the approach and style of delivery to be taken.
3. A set of key messages which illustrate examples and stories that explain the results and that help to focus the attention of particular target audiences.
4. The timeline of when messages and presentation formats are to be released and delivered to target audiences.

Possible headings for communication strategy:

- Communication objectives
- Stakeholder audience
- Messages
- Media and format
- Personnel/human resources
- Relationship strategy

Media and format could include: meetings, workshops, new articles, web pages, emails, newsletters, status reports, social media and PR materials.

5.3 Review of management plans

The DFMP should be adapted based on regular reviews through the M&E system.

Short-term reviews, carried out as part of the –monthly DFMC meetings, should report on the indicators agreed in this plan. The results should be summarized in an annual report that is easy to read and digest. In general the report will contain:

- Issue
- Objectives
- Status of the indicator
- Bench mark and performance assessment
- Fishery management response

The DFMC should determine which aspects of the plan are working or not. If some aspects are not, the plan may need to be adapted, specifically looking at:

- management measures
- MCS
- governance arrangements

It may be found that activities are going as planned and little change is needed. However, it may also be found that things are not going as expected and big changes need to be made. This will require going back over the plan and its components to make modifications and move forward. Regular reviews are an important element of the adaptive management cycle; they support the flexible and iterative approach by formalizing continuous assessment.

All stakeholders need to understand what actions will be taken if the management is not meeting its objectives. In future, it will be desirable to set up formal "decision rules" based how well an indicator is doing against its bench marks e.g. if the level of a target stock falls below a reference limit point, fishing will be stopped until the stock has recovered.

Longer-term reviews should also be conducted on a regular basis (three to five years), preferably involving a third party audit. These reviews should include consideration of the full management arrangements including data collection/resource monitoring, comprehensive re-assessment, reappraisal of progress towards meeting longer-term goals and objectives. Longer-term reviews may provide evidence that an objective set earlier (e.g. meeting the MEY) is no longer appropriate.

Acknowledgement:

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- Other members of the project team;
- The past and current license holders;
- Past and current staff of the DOF, especially the Secretary of Fisheries, members of the Project Technical Team and the IT Manager who provided the data and information; and
- The Secretariat of the Pacific Community who provided comments on the reports and this DFMP.

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APPENDICES

Appendix 1a: Best reconstructed summary of the number of licensed drop line (deep bottom) fishing vessels, total catch and trips 1986 – 2012: Original data

Year	Number of licensed vessels	No. of fishing trips	Total Catch (tonnes)
1986	32	214	210.6
1987	37	1409	633.0
1988	44	1091	484.7
1989	36	885	450.1
1990	30	491	281.6
1991	27	608	323.5
1992	19	569	115.3
1993	17	35*	45.7*
1994	24	249	110.6
1995	23	175	92.8
1996	19	149	88.0
1997	22	172	126.0
1998	14	161	106.2
1999	12	135	94.3
2000	13	244	189.3
2001	13	285	230.8
2002	15	75*	56.2*
2003	17	98*	132.8*
2004	16	89*	227.0
2005	23	303	191.5
2006	22	348	228.4
2007	14	334	179.8
2008	17	272	164.7
2009	21	237	170.4
2010	21	202	181.7
2011	21	158	133.6
2012	14	115	124.3

Sources: 1986-1992 data: (Bell et al, 1995); 1993-2003 data: Snapper spreadsheet (contains missing data) (Wilson, 2007); 2004 & 2005 data: Snapper database (2004 weight known for only the 10 known species mentioned in Table 1): 1999-2012 boat data from License Unit DOF; 2005-2012 catch and trip data: Snapper database port sampling & log books. Not all vessels were licensed or active for the full calendar year.

Appendix 1b: Best corrected reconstruction summary of the number of licensed drop line (deep bottom) fishing vessels, total catch and trips 1986 – 2012

Year	Number of licensed vessels	No. of fishing trips	Total Catch (tonnes)
1986	32	214	210.6
1987	37	1409	633
1988	44	1091	484.7
1989	36	885	450.1
1990	30	491	281.6
1991	27	608	323.5
1992	19	569	115.3
1993	17	409	113.0
1994	24	249	110.6
1995	23	175	92.8
1996	19	149	88
1997	22	172	126
1998	14	161	106.2
1999	12	135	94.3
2000	10	244	189.3
2001	18	285	230.8
2002	25	290	229
2003	23	295	228
2004	25	300	227
2005	23	303	191.5
2006	23	348	228.4
2007	22	334	179.8
2008	20	272	164.7
2009	17	237	170.4
2010	20	202	181.7
2011	20	158	133.6
2012	14	115	124.3

Four year's data were "corrected" by interpolation with adjacent years. These were the number of trips and catch for 1993; number of trips for 2002-2004; and total catch for 2002-2003 (highlighted in green). Not all vessels were licensed or active for the full calendar year.

ANNEXES

Annex 1: Biological characteristics of target and non-target species

TL – total length; SL – standard length; K – growth rate; tm – age at first maturity; tmax – life span;
target species ****** (major export species (Langi et al, 1992)).

1. ***Aphareus rutilans***	
Family	Lutjanidae (Snappers)
Common name	Rusty jobfish (palu polosi)
Max. size	110 cm TL (male/unsexed); max. published weight: 11.3 kg Spawning months are from September through to February
Environment	Reef-associated; marine; depth range 100 – 330 m
Resilience	Medium, minimum population doubling time 1.4 - 4.4 years (K=0.16)
Biology	Inhabits reefs and rocky bottom areas to depths of at least 100 m. Feeds on fishes, squids and crustaceans.
2. ***Aprion virescens***	
Family	Lutianidae (Snappers)
Common name	Green jobfish (‘utu)
Max. size	112 cm TL (male/unsexed); max. published weight: 15.4 kg
Sexual maturity	Both males and females generally reach spawning condition between 24 to 30 inches (over 2.6 years but under 5years)
Environment	reef-associated; marine ; depth range 0 - 180 m
Resilience	Medium, minimum population doubling time 1.4 - 4.4 years (K=0.29; tm=4-5)
Biology	Inhabits open waters of deep lagoons, channels, or seaward reefs. Usually seen singly, but also in groups. Feeds mainly on fishes, but also on shrimps, crabs, cephalopods and planktonic organisms. Large individuals may be ciguatoxic. Reports of ciguatera poisoning

Caranx melampygus	
Family	Carangidae (Jacks and pompanos)
Common name	Bluefin trevally (lupo)
Max. size	117 cm FL (male/unsexed); max. published weight: 43.5 kg
Environment	reef-associated; brackish; marine; depth range 0 – 190 m
Resilience	Medium, minimum population doubling time 1.4 - 4.4 years (K=0.23; tm=2; Fec=49,700)
Biology	A coastal and oceanic species, associated with reefs. Juveniles occur seasonally in shallow sandy inshore waters. Found in rivers. Occasionally in schools. Feed mainly on other fishes, also crustaceans. Often toxic when it reaches a length of more than 50 cm. Reports of ciguatera poisoning.

Epinephelus morio	
Family	Serranidae (Sea basses: groupers and fairy basslets), subfamily: Epinephelinae
Common name	Red grouper (ngatala kula)
Max. size	125 cm TL (male/unsexed); max. published weight: 23.0 kg; max. reported age: 25 years
Environment	reef-associated; non-migratory; marine; depth range 5 – 300 m
Resilience	Low, minimum population doubling time 4.5 - 14 years (K=0.1-0.18; tm=4-6; tmax=25; Fec=1.4 million)
Biology	Occurs mainly over rocky and muddy bottoms. Uncommon around coral reefs. Usually rests on the bottom. Juveniles may be found in shallow water, but adults are usually taken from depths of 70-330 m. Feeds on a wide variety of fishes and invertebrates. A protogynous hermaphrodite. Most females transform to males between ages 7 to 14. Susceptible to red tide toxin (*Ptychodiscus brevi*).

3. ***Epinephelus morrhua***	
Family	Serranidae (Sea basses: groupers and fairy basslets) , subfamily: Epinephelinae
Common name	Comet grouper (ngatala pusi)
Max. size	90.0 cm TL (male/unsexed); max published weight: 6,700 g
Environment	reef-associated; non-migratory; marine ; depth range 80 - 370 m
Resilience	Low, minimum population doubling time 4.5 - 14 years (Preliminary K or Fecundity.)
Biology	Deep-water habitat. Considered rare in Tahiti but quite common in atolls. The species is easily confused with *E. poecilonotus*, *E. radiatus*, or *E. tuamotuensis*, three closely related deep-water groupers. Known to be ciguatoxic at Mauritius. Reports of ciguatera poisoning.

4. *Epinephelus octofasciatus*	
Family	Serranidae (Sea basses: groupers and fairy basslets) , subfamily: Epinephelinae
Common name	Eightbar grouper (mohuafi)
Max. size	130 cm TL (male/unsexed); max. published weight: 80.0 kg
Environment	bathydemersal; marine; depth range 150 – 300 m
Resilience	Very low, minimum population doubling time more than 14 years (Preliminary K or Fecundity.)
Biology	Probably occurs in rocky reefs. Its apparent rarity may be due to its preference for relatively deep water. Reports of ciguatera poisoning

5. *Etelis coruscans***	
Family	Lutjanidae (Snappers) , subfamily: Etelinae
Common name	Flame snapper / longtail snapper (palu tavake)
Max. size	120 cm TL (male/unsexed)
Sexual maturity	One fish reported to reach sexual maturity at about 20.6 inches; 55-80 cm FL (5 years) and spawning season from May to October similar to Etelis carbunculus
Environment	reef-associated; marine ; depth range 90 - 400 m
Resilience	Low, minimum population doubling time 4.5 - 14 years (k=0.12)
Biology	Inhabits rocky bottoms. Feeds on small fishes, squids and crustaceans.

Lethrinus miniatus	
Family	Lethrinidae (Emperors or scavengers), subfamily: Lethrininae
Common name	Longnose emperor (ngutukao)
Max. size	90.0 cm TL (male/unsexed); max. published weight: 9,600 g; max. reported age: 22 years
Environment	reef-associated; non-migratory; brackish; marine; depth range 5 – 30 m

Resilience	Medium, minimum population doubling time 1.4 - 4.4 years (K=0.06-0.17; tm=2-3; tmax=22)
Biology	Inhabit coral reefs during daytime where they feed occasionally in sand and rubble areas between coral heads. At night, they move out over the sandy sea floor and forage actively. Usually occur in small schools. Feed mainly on crustaceans, echinoderms, mollusks and fish, with crabs and sea urchins predominating.
6. *Lethrinus chrysostomus*	
Family	Lethrinidae (Emperors or scavengers) , subfamily: Lethrininae
Common name	Sweetlip emperor (manga)
Max. size	
Sexual maturity	
Environment	
Resilience	
Biology	Feeds on crustaceans, echinoderms and molluscs, crabs and sea urchins. Carnivorous bottom feeders quite selective and individualistic in their diet.
7. *Paracaesio kusakarii*	
Family	Lutjanidae (Snappers) , subfamily: Apsilinae
Common name	Saddle-back snapper / sea bream (palu mutumutu)
Max. size	60.0 cm SL (male/unsexed)
Environment	reef-associated; marine ; depth range 100 - 310 m
Resilience	Medium, minimum population doubling time 1.4 - 4.4 years (Preliminary K or Fecundity.)
Biology	Occurs over rocky bottoms.

Pristipomoides argyrogrammicus	
Family	Lutjanidae (Snappers), subfamily: Etelinae
Common name	Ornate jobfish (‘utu)
Max. size	40.0 cm SL (male/unsexed)
Environment	reef-associated; marine; depth range 70 – 350 m
Resilience	Medium, minimum population doubling time 1.4 - 4.4 years (Preliminary K or Fecundity.)
Biology	Occurs over rocky bottoms. Feeds on small fishes, crustaceans and squids.

8. *Pristipomoides filamentosus* **	
Family	Lutjanidae (Snappers) , subfamily: Etelinae
Common name	Crimson jobfish (palu hina)
Max. size	100.0 cm TL (male/unsexed); max. published weight: 8,154 g; max reported age: 18 years
Sexual maturity	Females generally reach spawning condition at a fork length of 19.2 inches. Reach sexual maturity at about 1.8 years and generally at about 2.2 years.
Environment	benthopelagic; marine ; depth range 40 - 400 m
Resilience	Medium, minimum population doubling time 1.4 - 4.4 years (K=0.16-0.31; tmax=18)
Biology	Occurs over rocky bottoms; off Guam, caught most abundantly between 180 and 270 m. At night, it migrates vertically to the upper part of its habitat to feed. Feeds on small fishes, shrimps, crabs, amphipods, ascidians and salps.

9. *Pristipomoides flavipinnis*	
Family	Lutjanidae (Snappers) , subfamily: Etelinae
Common name	Golden eye jobfish (palu sio’ata)
Max. size	50.0 cm SL (male/unsexed)
Environment	reef-associated; marine ; depth range 90 - 360 m
Resilience	Medium, minimum population doubling time 1.4 - 4.4 years (K=0.27-0.36)
Biology	Occurs over rocky bottoms; off Guam, caught most abundantly between 180-270 m. Feeds primarily on benthic fishes and to a lesser extent on crustaceans, squids, and pelagic tunicates.

10. *Hyperoglyphe antarctica*	
Family	Centrolophidae (Medusafishes)
Common name	Antarctic butterfish (sifisifi)
Max. size	140 cm TL (male/unsexed; Ref. 9563); max. published weight: 60.0 kg; max. reported age: 15 years
Environment	benthopelagic; marine; depth range 40 – 1500 m
Resilience	Low, minimum population doubling time 4.5 - 14 years (K=0.03-0.3; tm=5-7; tmax=15)
Biology	Most common over or near rocky areas at 100-300 m. Generally, blue eye remain close to the sea bed during the day and move up in the water column at night, following concentrations of food. The fish are found over rough ground and at the edges of canyons and steep drop-offs. Blue eye appear to prefer cold water as part of their general behavior. Juveniles inhabit surface waters, sometimes in association with floating debris. Feed primarily on the pelagic tunicate *Pyrosoma atlantica* which is found near the sea bed during the day but dispersed throughout the water column at night. They also feed on squid, mollusks and crustaceans and fish ranging from small lanternfish (Myctophidae) to large fish such as gemfish (*Rexea solandri*). Juveniles consume small planktonic and sedentary organisms.

11. *Etelis carbunculus*	
Family	Lutjanidae (Snappers) , subfamily: Etelinae
Common name	Ruby snapper / red snapper / short-tailed red snapper (palu malau)
Max. size	127 cm FL (male/unsexed)
Sexual maturity	Reach this at about 11.7 inches fork length (2.8years). A fish 20 inches in fork length can release over 1.3 million eggs per spawn and may release 2 or more batches during a spawning season. Spawn in May to October
Environment	reef-associated; marine ; depth range 90 - 400 m
Resilience	Medium, minimum population doubling time 1.4 - 4.4 years (K=0.13-0.31)
Biology	Inhabits rocky bottoms. Feeds on fishes and larger invertebrates such as squids, shrimps and crabs; also takes planktonic organisms, including pelagic urochordates.

Epinephelus septemfasciatus	
Family	Serranidae (Sea basses: groupers and fairy basslets) , subfamily: Epinephelinae
Common name	Convict grouper (mohuafi)
Max. size	155 cm TL (male/unsexed); max. published weight: 62.8 kg
Environment	reef-associated; non-migratory; marine; depth range 5 – 30 m
Resilience	Very low, minimum population doubling time more than 14 years (Preliminary K or Fecundity.)
Biology	Occurs near shore, including semi-enclosed sea areas in rocky reefs in shallow waters.

(Sources: FishBase, Current Line Fish Facts for Bottom Fishes of Hawaii)

Annex 2: Options for selecting the limited number of boats licensed to fish

Options for selecting the limited number of boats include.

1. *Recognising past commitment and performance: 3 years*

Over the past three years, nine boats have carried out more than an average of 15 trips per year. These could be awarded licenses.

Pros: Recognises commitment

Cons: Excludes boats that have a long history of fishing, but recently not active.

2. *Recognising past commitment and performance: 8 years*

Since 2012, twelve boats have carried out more than an average of 12 trips per year. These could be awarded licenses.

Pros: Includes a longer past history

Cons: Some of these boats now active and may need upgrading

3. *Find out who really wants a license : an auction*

An auction could be implemented that sells the limited number of licenses to the highest bidders

Pros: The real value of the license and genuine stakeholders would become known

Cons: This might prove to be too expensive for some operators

4. *Vessel buyback scheme*

If funding is available, the redundant vessels can be bought out (usually by government).
Pros: People are compensated for leaving the fishery.
Cons: Open to litigation on the criteria of the buyback.

5. *Freeze the license to license holders in 2012 (14 boats) and wait for natural attrition to reduce further*

Pros: A gradual process that allows people to adjust
Cons: Those not licensed in 2013, but licensed in the previous years could object

NOTE: The 2002 Fisheries Management Act Section 19 states “The Minister may, the consent of Cabinet, by Notice in the Gazette -

(a) prohibit fishing or related activity in relation to -
(i) any species, subspecies, class or type of fish;
(ii) any size, weight or dimension of fish or parts of fish;
(iii) age, growth stage or state of fish;
(iv) limits set on catches, fishing effort, the number of persons who may engage in the fishing or related activity;
(v) any specified area of water or specified place;
(vi) any class or type of vessel;
(vii) any fishing method;

(viii) the use, carrying on board a vessel or possession of a class, type, size or quantity of fishing gear, navigational or safety equipment used in connection with fishing or related activity;

Annex 3: Terms of Reference of the Deepwater Fishery Management Committee

a) Functions

The functions of the Deepwater Fishery Management Committee (DFMC) will be to:

- Advise the Minister and Secretary for Fisheries through the requirements of the FMA 2002 and on the effective management and administration of the Snapper Fisheries;
- Provide a forum for discussion of issues and strategies that require the input of all stakeholders, industry, other government ministries and the DOF;
- Implement, monitor and review the management plan;
- Provide recommendations and advice to the Head of DOF relating to the snapper & grouper fisheries operations on a regular basis for management and operational purposes; and
- Ensure transparent decision making in regards to the snapper & grouper fishery.

b) Membership

The DFMC will have representation from all major stakeholders and should include the following representatives:

- Fisheries Management representative from the DOF;
- Compliance representative from the DOF;
- Representatives from such other government ministries/departments as selected by the Head of the DOF;
- A representative from the Vava'u snapper & grouper fisheries license holders;
- Three representatives of the Tongatapu snapper & grouper fisheries license holders;
- A representative of the small-scale fisheries sub-sector;
- A representative from the Tongan Fish Processing Private Sector;
- *ad hoc* advisors and members as determined by the Committee Chair.

c) Chairmanship

Meetings of the DFMC will be chaired by the Secretary for Fisheries.

d. Frequency of Meetings

The DFMC shall meet at least twice annually, and further as required by the Chair to address specific matters.