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Palau's sea cucumber fisheries: the economic rationale for sustainable management

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Palau's sea cucumber fisheries: the economic rationale for sustainable management

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ACRONYMS

BAU: Business as usual

BdM: Beche-de-mer

BMR: Bureau of Marine Resources

CBA: Cost benefit analysis

CITES: Convention on International Trade in Endangered Species of Wild Fauna and Flora

FIB: Foreign Investment Board

FOB: Free on board

HK: Hong Kong

LPG: Low pressure gas

MPA: Marine protected area

NPV: Net present value

PICs: Pacific Island countries

PICRC: Palau International Coral Reef Center

OSCA: Ngardmau Conservation Organization for the Ongedechuul System of Conservation Areas

SPC: Secretariate of the Pacific Community

SSM: Sustainable sea cucumber management

VC: Value chain

VCA: Value chain analysis

Executive Summary

In 2011, Palau amended its 1994 memorandum on the commercial export of sea cucumbers, lifting the ban on the medium-value *Actinopyga spp.*, and opening the door to foreign beche-de-mer (BdM) traders.

Revenues from sea cucumber fisheries can easily be captured at the village-level due to their low input costs, making them an important fishery for coastal communities. In the 48 days its fishery was open, Palau's fishers captured a direct revenue totaling some $1.3 USD million (BMR 2011; Pakoa et al., 2014a). The state of Ngardmau, which provided approximately half the total harvest, secured just over $600,000 USD (BMR 2011).

Palau's harvest was one of the most lucrative in the Pacific (Pakoa et al., 2014b). However, income retained in Palau was a small percentage of the final wholesale value of its BdM products, and resulted in the collapse of Ngardmau's sea cucumber fishery. Ease of collection, density-dependent reproductive biology and high commercial value mean that sea cucumber fisheries are highly susceptible to overfishing; successful management remains elusive and these fisheries continue to fail to yield their full economic and social potential.

The results of Ngardmau's story serve as an example of the boom-bust exploitation cycles that are all too common in sea cucumber fisheries. Using this as a case study, the analysis provides information on the economics of boom-bust exploitation (business as usual – BAU) vs. potential sustainable sea cucumber management (SSM). A cost benefit analysis was used to compare the net economic returns from these different harvest regimes over a 20-year period. Two SSM scenarios were constructed based on limited biological data: a 5% per annum harvest rate and a 20% harvest every three years. Price data was taken from literature on the sea cucumber trade in other Pacific Island countries and Hong Kong. A value chain analysis was also conducted in order to fully describe the BAU situation as well as to identify and discuss what possibilities exist for local stakeholders to capture more value from this fishery by making improvements in the context of SSM scenarios.

Palau's BdM value chain proved to be extremely simple. Unlike in many established BdM exporting countries, the vast majority of links were conducted by the foreign exporting enterprises. Inputs, including processors, were brought in from off-island. Palauan participation was primarily limited to the collection stage in the value chain.

Harvest volumes for the SSM scenarios are larger than under BAU over the 20-year analysis period. Under a 20% take every 3 years, harvest could be 1.5 times as large. Even at the more conservative take value of 5% per annum, the sea cucumber harvest could have been 13.6% higher. Moreover, SSM guarantees a continued revenue flow and a healthy fishery. Indeed it is not known if the BAU experienced in Ngardmau has resulted in the localized extinction of its resident sea cucumber population.

It was found that by participating in the classic boom-bust transaction instead of developing a sustainable approach, Ngardmau sacrificed long-term revenue in the millions. Over the course of 20 years, Ngardmau fishers could have secured income in the range of 3.3 to 10.1 million USD from collection alone (in present value terms–NPV), depending on the SSM strategy and their ability to negotiate sales price. BAU revenues could have matched in between one to 3.5 years. If Ngardmau had upgraded into processing and export, revenues could have been as high as 11.9 million USD NPV.

The results of this study also indicate that the majority of the value from Palau's BdM trade was captured by off-island importers-exporters. The average wholesale value of Ngardmau's harvest at Hong Kong export prices was approximately 7.4 million USD in 2011, of which Ngardmau received only 0.6 million USD: 8.3% of wholesale value. Foreign parties secured some 87 – 97% of the product's wholesale value. Examples from Fiji and Tonga show that this value can be redistributed across the value chain allowing a larger percent to be captured by on-island players; Fijian fishers capture as much as 50% of wholesale value.

Sustainable sea cucumber fisheries management proves to be the ecological and economical choice. If Ngardmau is to commercially benefit from its sea cucumber fishery in the future it will first need to close this fishery to on-going exploitation in order to allow stock recovery. In order for Palau, and in future years Ngardmau, to support the sustainable management of its sea cucumber fisheries the following recommendations should be considered:

1. Improve local knowledge on market prices and price determinants;
2. Invest in product upgrading;
3. Develop novel products and trade routes;
4. Invest in improving biological understanding;
5. Improve monitoring and regulation;
6. Promote regeneration of degraded sea cucumber stocks.

Subsequent policy recommendations detailed by Ngardmau conservation organization for the Ongedechuul System of Conservation Areas (OSCA) and agreed upon by Ngardmau's leadership are available in Annex 1.

Introduction

In 2011, Palau amended its 1994 memorandum on the commercial export of sea cucumbers, lifting the ban on the medium-value *Actinopyga spp*. During the following 7-months, the country experienced its largest ever sea cucumber harvest. In only 48 fishing days, 1,160 metric tons (t) of raw sea cucumbers were gleaned, generating direct revenue to local fishers of 1.3 million USD (BMR 2011; Pakoa et al., 2014a). One of Palau's 16 states, Ngardmau, accounted for almost half of the country's supply (BMR, 2011).

This was perhaps one of the most lucrative sea cucumbers harvests in the Pacific (Pakoa et al., 2014b) and secured just over $600,000 USD for the state of Ngardmau (BMR 2011). However, the total revenues realized were small relative to the commodity's final retail price and left Ngardmau's sea cucumber fishery in collapse.

Palau is not alone; successful management of sea cucumbers remains elusive. As a high-value commodity with slow and density-dependent repopulation rates, these fisheries are highly susceptible to overexploitation and local extinction (Anderson et al., 2011; Friedman et al., 2011; Perez and Brown, 2012; Uthicke and Conand, 2005). Unlike many other high-value fisheries, sea cucumber fisheries have low initial capital costs and, as sedentary animals, sea cucumbers can be easily harvested from shallow coastal waters even at extremely low population densities. Income can therefore be captured at the village level, and these fisheries can provide an important income source for coastal communities across the Pacific and worldwide, including a high proportion of women (Anderson et al., 2011; Bell et al., 2006; Clarke, 2004; Kinch et al., 2008; Purcell, 2013; Purcell et al., 2014b).

With growing demand and rising global prices, increasing pressure has been placed on sea cucumber fisheries in the past few years (Perez and Brown, 2012). Biological and ecological attributes which previously secured benefits at the community level are now the same ones which drive their systematic depletion and collapse (Anderson et al., 2011; Bell et al., 2006; Conand and Byrne, 1993; Eriksson and Byrne, 2015). Boom-bust cycles define these fisheries, a cycle which, when bust, can leave communities without income in the order of decades (Carleton et al., 2013; Friedman et al., 2011; Toral-Granda et al., 2008). As a result such fisheries are failing to yield their full economic and social potential (Battaglene and Bell, 2004).

Demonstrating, and ultimately securing, long-term benefits at the village-level will depend on improving local and national understanding of the costs and benefits of potential management strategies.

Rationale for study

The Republic of Palau, the westernmost nation of Micronesia, comprises 586 islands spread across 629,000 square kilometers (km^2) of ocean. Palau's reef systems show the highest diversity of reef fauna throughout Micronesia and support a number of commercially valuable marine species, including sea cucumbers. Ngardmau is one of Palau's 16 states, and is famed locally for its sea cucumber population, which holds significant cultural value.

Using Ngardmau's sea cucumber fishery as a case study, this report will provide information on the economics of current sea cucumber fishing practices (the so called boom-bust cycles) versus potential sustainable management.

Ngardmau's story repeats itself across the Pacific Islands. This case study therefore represents not only one unfortunate story; it is also an opportunity to better understand the economics of the available management options for other island nations in similar situations. Given the past failures of Palau's national and state governments to adequately manage their resources, there is a bottom up desire to seek out new and more appropriate policies. Ngardmau's state government, along with the state's conservation organization for the Ongedechuul System of Conservation Areas (OSCA), are looking to develop a comprehensive state sea cucumber management plan. In addition, Palau is in the process of drafting a national sea cucumber management plan, which is currently under development by the Bureau of Marine Resources (BMR) and the Secretariat of the Pacific Community (SPC) (Pakoa and Bertram, 2013). If this proves successful, Palau could be the first country in the region to sustainably harvest sea cucumbers while optimizing economic benefits to local communities.

In this context, the present study aims to provide both policy makers and local stakeholders with a rigorous and accurate case study of the benefits of sustainable management. The analysis considers the net present value (NPV) of lower, sustainable harvest rates versus short-term liquidation followed by forgone revenues due to fishery collapse. It also assesses where value can be added across the value chain, including consideration of how a greater share of value generated can be retained locally. These results are used to make recommendations as to how Ngardmau state can maximize local benefits from sea cucumber fisheries; the recommendations are in turn expected to feed into Ngardmau's sustainable sea cucumber management plan. The final policy recommendations, as incorporated by Ngardmau state into its management plan can be seen in Annex 1. It is further hoped that findings and recommendations prove transferrable across other sea cucumber and marine species, terrains and states, and are therefore relevant for multiple Palauan (and indeed other island nation) governing bodies and fishery policies.

Background

Sea cucumber trade

At least 60 species of sea cucumbers are commercially harvested across 70 countries. Although the commercial value of this harvest differs from species to species, sea cucumber fisheries represent an integral part of coastal livelihoods and provide employment to some three million fishers worldwide (Feary et al., 2015; Purcell et al., 2014b).

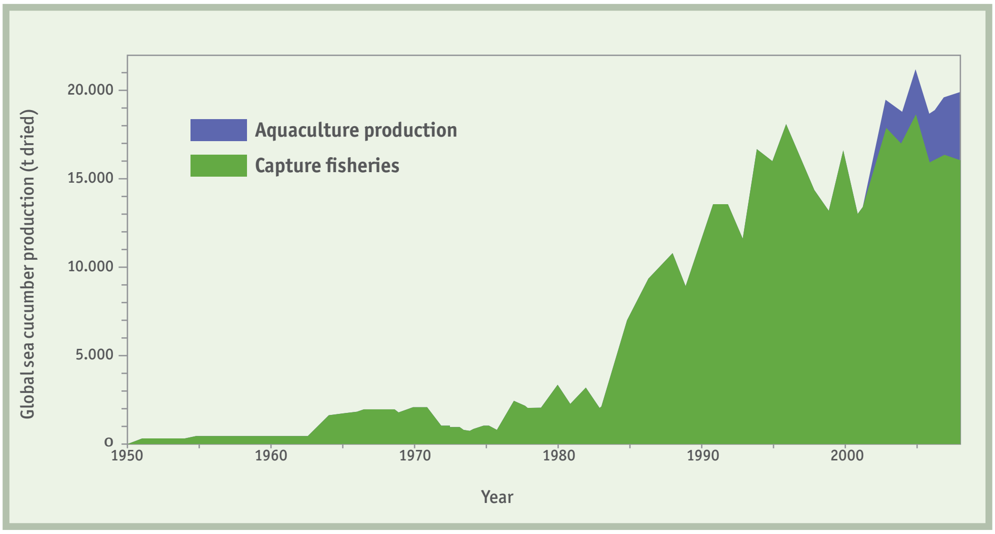
The Indo-Pacific region is an important producer of sea cucumbers. Between 1996 and 2011, the region accounted for all but one of the top five sea cucumber producing countries (based on import data to Hong Kong). In decreasing order of volume these were: Indonesia, Philippines, Papua New Guinea Fiji and Japan. Across the Pacific, sea cucumber fisheries represent the third-most economically valuable marine export commodity, after only tuna and pearls, with an annual worth in the region of 20-50 million USD (Purcell et al., 2014b; Purcell et al., 2013).

The trade in sea cucumber is driven by the Chinese market for luxury seafood commodities. The tissue of sea cucumber is predominantly traded in its dried form, beche-de-mer (BdM), which comprises 99% of all global sea cucumber trade (Anderson et al., 2011). Once rehydrated, this product is avidly consumed for its medicinal benefits and comprises one of five essential luxury items in traditional Chinese festive dinners. In the past, this high-end good was reserved for wealthy Asian consumers or as a delicacy to be served during festive periods such as the Chinese New Year (Purcell et al., 2014a; Purcell, 2014a).

However, the global trade in sea cucumber production increased rapidly starting in the mid-1980s, as can be seen in Figure 3.1. The recent liberalization of Chinese markets and the country's growing middle-class has caused a significant expansion of these fisheries (Anderson et al., 2011; Eriksson et al., 2012; Eriksson and Clarke, 2015; FAO, 2008, 2004; Ferdouse, 2004; Purcell, 2014a; Purcell et al., 2013); indeed, data points to a 13 to 16-fold increase in catch (Anderson et al., 2011).

Hong Kong (HK) has long been the main hub of BdM imports and remains so; however, in the past ten years the emergence of other relevant trading hubs has caused a decline in its relative market share. These include Singapore, Taiwan, Japan and Korea (Anderson et al., 2011; Clarke, 2004; Eriksson and Clarke, 2015; Ferdouse, 2004; Ngoc and Wyatt, 2013; Purcell, 2014a). Approximately 80% of BdM from HK is re-exported, 90% of which is destined for China (often first passing through Vietnam to circumvent existing tariffs) (Anderson et al., 2011; Clarke, 2004; Eriksson and Clarke, 2015; Ferdouse, 2004; Purcell, 2014a). In 2007, HK import statistics reported 5,296 t of dried sea cucumbers imported from 58 countries and territories. These sea cucumbers were then re-exported to 13 countries, including China (Akamine, 2012, 2009).

FIGURE 1. GLOBAL PRODUCTION OF SEA CUCUMBERS SINCE THE 1950S (METRIC TONS DRIED WEIGHT)



Source: adapted from Purcell et al., 2013

As of 2010, there were some 635 firms from about 38 countries supplying sea cucumber products globally, representing trading companies, distributors, wholesalers and processors. However this figure does not include many known exporters present within Pacific Island countries (PICs). It is therefore likely that the actual number of firms is larger (Brown et al., 2010). In contrast, it is believed that only five key import cartels control the majority of the Asian market for sea cucumbers. These five companies stockpile in order to ride out lean periods and ultimately control market prices (Purcell et al., 2012a).

Absolute imports into HK have remained stable since 1986 and have not mirrored the increase in global production. In 1988, HK accounted for 64% of global sea cucumber imports by volume, 58% in 2006, and fell to a third of total imports in 2011 (Anderson et al., 2011; Eriksson and Clarke, 2015). The reported decline can be attributed a number of factors. These include changes in reporting codes that have resulted in under-reporting, the opening of new trade routes to Chinese populations living outside of mainland China, as well as altered trade routes developed to circumvent new trade tariffs (Eriksson and Clarke, 2015; Simos 2015).

Growing demand and the associated rapid decline in global stock has led to the development of many new and lower value sea cucumber fisheries (Carleton et al., 2013; To and Shea, 2012). Combined imports from the four top-producing Indo-Pacific countries (as previously listed) declined by 56% from an annual average of 3400 to 1500 t between 1996 and 2011, although in absolute terms these countries remain top producers (Eriksson and Clarke, 2015). Strong market signals, combined with declining stocks from established trade routes, have tasked new buyers to search more globally for sea cucumber stock, including the procurement of new species through what amount in many cases to abusive or unfair practices (Carleton et al., 2013; To and Shea, 2012; Simos 2105). Based on HK trade statistics, between 1996 and 2011, 48 new countries began importing the species (Eriksson and Clarke, 2015).

It is also important to note that over the period between 1996 and 2011 there has been rapid inflation in market prices (typically shown as a four to five-fold increase in the case of higher value species), which has encouraged further exploitation (Carleton et al., 2013).

Socio-economic importance of sea cucumbers

Sea cucumber fisheries also hold particular socio-economic importance within the Indo-Pacific. They are fished in every PIC for either export or local subsistence (Feary et al., 2015; Purcell et al., 2014b). As noted, unlike many high-value fisheries that require large upfront investments, the economic benefits of sea cucumber fisheries can be secured immediately and at a village level; harvests provide income to over 500,000 small-scale Pacific fishers, including a high proportion of women (Anderson et al., 2011; Bell et al., 2006; Feary et al., 2015; Kinch et al., 2008; Purcell, 2013; Purcell et al., 2014b).

Biological importance of sea cucumbers

Sea cucumbers are sedentary marine invertebrates that can be found across the world's sea floor. As their name suggests, these organisms have soft, cylindrical bodies typically between 10 to 30 centimeters (cm) in length. Most reproduce sexually, relying on appropriate population densities and reaching sexual maturity only after two or three years (Friedman et al., 2008).

Beyond their socioeconomic value, sea cucumbers also hold significant ecological value for reef ecosystems. As suspension feeders, sea cucumbers regulate water quality by affecting carbonate content and acidity, and also play an important role in the nutrient cycle important for coral reef formation (Anderson et al., 2011; Schneider et al., 2013). Also deposit feeders, they change the size of ingested particles and turn over sediment via bioturbation. Sea cucumbers further alter the stratification and stability of muddy and sandy bottoms, significantly reducing micro algal biomass and algal blooms, recycling nutrients which would otherwise remain trapped in the substrate, and opening up potential habitat for other species (Anderson et al., 2011). As prey, they represent an important food source for fish, sea stars and crustaceans in both shallow and deep waters (Anderson et al., 2011; Francour, 1997).

At present the ecological impact of removing high levels of sea cucumbers on marine ecosystems is poorly understood due to difficulty in monitoring and gaps in research; however, its implications for the sustainability of reef ecosystems is considered to be significant (Eriksson and Byrne, 2015).

Susceptibility of sea cucumber fisheries to boom-bust cycles

Sea cucumber fisheries show particular susceptibility to collapse and local extinction over other fisheries. This is because they are easily harvested in shallow coastal waters (even at low population levels), show little migration, mature late, and have low, sporadic recruitment rates which rely on high population densities (Battaglene and Bell, 2004;

Bell et al., 2008; Carleton et al., 2013; Perez and Brown, 2012). As a result, sea cucumber fisheries typically follow a pattern of serial depletion. Boom-bust cycles are the norm, with peak catches typically reached within five to eight years of initial harvests followed by rapid decline and closure (Anderson et al., 2011; Eriksson and Byrne, 2015; Kinch et al., 2008).

Globally, almost 60% of sea cucumber fisheries are now depleted or over-exploited, a figure more than twice that seen in the global stocks of finfish and other marine invertebrates (Purcell et al., 2013; Toral-Granda et al., 2008). In response, recent sea cucumber fishery closures have been documented in 24 countries, including in many PICs (Eriksson and Clarke, 2015; Purcell, 2014a; Purcell et al., 2013).

However, even with fishing moratoriums in place, stocks seem slow to recover. Recovery can take decades and local extinctions are increasingly evident (Anderson et al., 2011; Feary et al., 2015; Uthicke et al., 2004). Examples from the Pacific include the Micronesian island of Chuuk, where no recovery was documented for 50 years after a bout of intense harvesting in the 1930s (Battaglene and Bell, 2004). Other broadcast spawning invertebrate species in the Pacific, such as pearl oysters, have in places shown no recovery even 50 to 100 years after extreme exploitation events (Dalzell et al., 1996; Feary et al., 2015).

Palau's sea cucumber fisheries

Of the 28 sea cucumber species found within Palau's waters, 21 have been exploited commercially (Kinch et al., 2008; Pakoa et al., 2014b). In the 1980's, six species in particular were targeted for export: sandfish (*Holothuria scabra*), white teatfish (*Holothuria fuscogilva*), black teatfish (*Holothuria nobilis*), prickly redfish (*Thelenota ananas*), surf redfish (*Actinopyga mauritiana*), and hairy blackfish (*Actinopyga miliaris*) (Golbuu et al., 2012; Pakoa et al., 2014b). White teatfish and sandfish are two of the most highly valued species in the BdM trade (Brown et al., 2010). The black teatfish is also a high-value species. Prickly redfish is considered to be of medium-high-value and the final two species listed are medium-value species (IUCN undated).

As early as the beginning of the 20th century, Palau became known as one of the major sea cucumber producers for export within Micronesia. Palau supplied 84t dried weight per year on average between 1922 to 1938, making up 44% of Micronesia's annual export to HK and China (Pakoa et al., 2014b). Data remains patchy for the trade over the remainder of the century due to low catch rates for the six main commercial species, a decline in trade and a lack of accurate reporting during a politically tempestuous time; export data was not available until the 1990s (Pakoa et al., 2014b). A fall in commercial exports in the early 1990s prompted the 1994 ban on the commercial export of the six species. This memorandum remains in place to date.

Palau's sea cucumber fishery is managed under both state and national control. At the national level, the Palau Marine Protection Act of 1994 legislates against the export of the six commercially valuable species detailed previously. In addition, it bans the use of any underwater breathing apparatus in the collection of invertebrate species and reef fish (Pakoa et al., 2014b). However, under the constitution of Palau, the state government manages and controls all activities within their waters designated as lagoons, inshore areas and reefs extending 12 nautical miles outward from shore. Management is largely controlled by traditional chief lines although the national government maintains an advisory role (Pakoa et al., 2009).

Sea cucumbers also play an important role in Palauan food security. Palau is one of the few islands in the Pacific with an active local sea cucumber market; eight species are consumed domestically and select species are considered a traditional delicacy (Pakoa et al., 2014b, 2009). In addition to household consumption, Palau's subsistence sea cucumber fishery supplies both the local market and an export market: Palauan families living abroad. Over the years, Palau's subsistence market has developed into an important semi-commercial fishery supplying both these local and overseas markets. Yet, neither one of these markets is subject to the country's export laws (Pakoa et al., 2009).

Palau's 2011 sea cucumber harvest

In response to the lifting of the commercial ban on *Actinopyga spp* in 2011, five Chinese and Korean buying and processing operations established themselves in Palau (BMR 2011).

Beginning in June 2011, a trial harvesting strategy allowed fishing twice a week (Mondays and Thursdays) from 6am to 6pm. Catches were landed at one of four designated landing sites and catch was recorded by the Palauan BMR and state rangers. Landed catch was sold fresh, in standard 18-liter buckets, to processing companies at landing sites. Sales took place around 3pm on harvest days. This enabled full coverage of harvesting activities. Data was collected on species, volume sold (e.g. number of buckets or pieces), price and the purchasing company. Seven of Palau's 16 states partook in the sea cucumber harvesting, including Ngardmau state (Pakoa et al., 2014a).

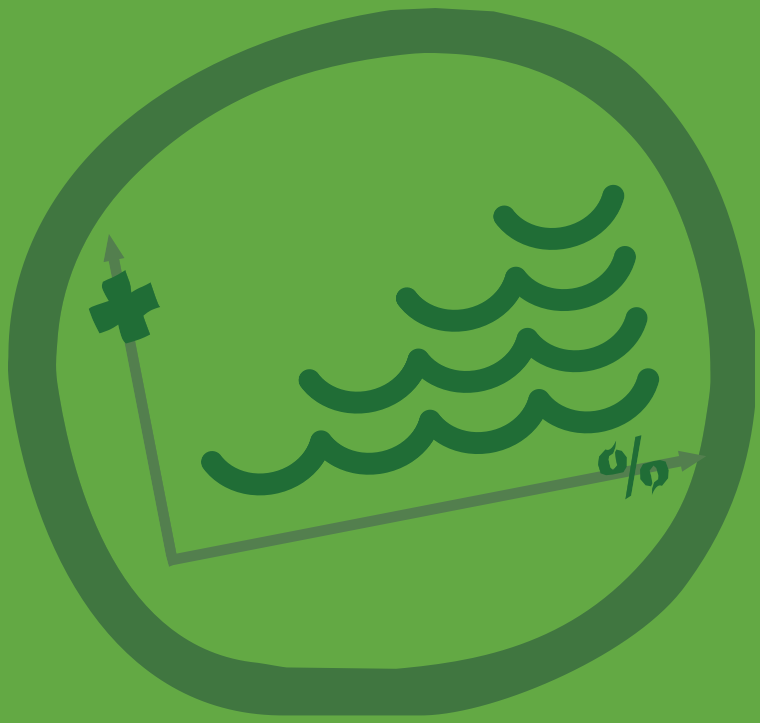
While harvest data was well-recorded, limited biological data was available on the effects of large harvest volumes on standing stocks. Concern over the potential impacts led to fishery closures by state governments in three states (Koror, Ngaraard and Ngeachelong). This was followed by an eventual national ban on commercial export. Ngardmau continued harvesting within its waters until the national ban took effect on January 1st, 2012 (Golbuu et al., 2012).

Of the 51,573 buckets collected nationwide, 47.2% originated from Ngardmau state. *Actinopyga spp,* for which the state is famous, accounted for 96% of their catch. Known locally as "erumrum", *Actinopyga spp.* are comprised of the hairy blackfish and stonefish species, which are not distinguished from each other locally. Under BMR classification, *Actinopyga spp.* was recorded as stonefish (*Actinopyga lecanora*), although recent reports suggest it to be hairy grayfish as well (Pakoa et al., 2014b).

Ngardmau captured 623,196 USD from the harvest. With a resident population of some 230 individuals comprising 46 households, community members still look back positively on the harvest; easy harvesting secured financial rewards of on average 26 USD a bucket for a previously non-commercial species. The harvest represented, on average, a 2,710 USD windfall for each Ngardmau resident.

During this time, Ngardmau's population of sea cucumbers, known to be one of the most abundant in Palau, experienced a dramatic decline. In-water surveys conducted by the

Palau International Coral Reef Center (PICRC) before and after harvest indicate that the harvest reduced the standing stock of this species to 12% of its pre-harvest density. Even Ngardmau's marine protected area (MPA), which was closed to fishing, experienced a 20% decline from illegal harvesting (Golbuu et al., 2012).



Methods

In this analysis, the potential economic returns of two very different management strategies are compared: the common, boom-bust approach vs. an alternative long-term, low-take sustainable harvest regime. From here on the report will refer to the boom-bust approach as business-as-usual management (BAU) and the sustainable low-take regimes as sustainable sea cucumber management (SSM).

A cost benefit analysis (CBA) was used to determine the net economic returns from both harvest regimes over a 20-year period. As the original Ngardmau harvest occurred in 2011, this was considered the starting year for analysis. For simplicity, the analysis was limited to the hairy grayfish species as it made up 96% of all trade emerging from Ngardmau.

The trade in sea cucumbers or, more specifically, BdM is a highly profitable one; additional benefits can be captured at the local level beyond mere extraction activities. For this reason, a value chain analysis (VCA) was also carried out across Palau as part of this study. The purpose of the VCA was to:

- describe the BdM value chain in Palau;
- describe the stages of BdM production, and in particular those that were carried out locally under BAU;
- identify and discuss what possibilities exist for local stakeholders to capture more value from this fishery through upgrading[1];
- determine input values for the CBA.

The results from the VCA provide information for the design of state and national sea cucumber management plans independent from the CBA results. However, the VCA results were also integral inputs into the CBA and this element of the methodology is therefore described first.

Value chain analysis

The value chain (VC) describes the sequence of activities in a specific industry that a product will pass through from conception to final consumption; at each stage in the chain the product gains value (Bui, 2013; Kaplinsky and Morris, 2001). VC activities are carried out by a series of actors who relate to each other in a variety of ways depending on the VC, with some holding more market power than others (Fries and Akin, 2004). In the sea cucumber market chain, the functions of each link in the chain tend to include: sourcing inputs (sea cucumbers), collection, processing into BdM, transport, export, import to final point of sale, and final retail (Brown et al., 2010).

1 **Upgrading** can refer to a number of interventions: **Process upgrading** refers to increasing the efficiency through increasing output with the same level of input or producing the same level of output with a lower level of input; **Product upgrading** is improving the quality of a product; **Functional upgrading** is when a firm is operating at a new level in the value chain; **Intra-sectoral upgrading** refers to operating in a new market channel within the same value chain; **Inter-sectoral** upgrading is when a firm is producing a completely different product in a completely new value chain (Dunn, 2005).

A VCA is a systematic way to understand the function and role of each of these actors in the VC (Fries and Akin, 2004). More specifically, VCA provides insight into the return on investment for each actor, their relationship with others along the chain, their constraints and opportunities, as well as factors in the enabling environment and supporting markets that affect competitiveness (Kaplinsky and Morris, 2001).

VCA can be used to support development and economic growth through identifying opportunities for upgrading (e.g., microenterprises, links to other actors in the chain, different end markets), thus enabling local communities to capture greater value within the chain. In addition, a better understanding of the entire supply chain is crucial in determining development and conservation entry points and moving towards a sustainable value chain (Seuring and Müller, 2008).

The particular VCA steps carried out here are as follows:

Palau's BdM value chain

The VCA describes Palau's BAU scenario. Palau's domestic VC was determined via surveys and key-informant interviews. Import, final wholesale and retail markets exist but were not present on the island and are therefore beyond the scope of this analysis. Information on these actors was therefore taken from gray and scientific literature.

A review of the literature and pre-existing sea cucumber VCs (both global and small island) provided initial data on possible actors and activities along the chain. Nine on-island economic activities were included in final survey design:

1. collection of sea cucumbers;
2. processing of sea cucumbers;
3. transportation of sea cucumbers or BdM;
4. exportation of sea cucumber or BdM;
5. on-island retail and restaurant vendors;
6. sending sea cucumbers or BdM to relatives overseas;
7. providing monitoring, law enforcement, resource management and/or verification services for Palauan fisheries;
8. providing supporting services to the sea cucumber industry/trade; and
9. other.

VCA surveys were piloted in October and refined. Final surveys were implemented during November and December 2014. Surveys were carried out under the supervision of OSCA by trained enumerators and conducted in the evening when heads of household were likely to be home. Respondents were interviewed regarding all activities within the VC that they were involved in during the 2011 harvest. Houses were initially selected at random, from which other fisher names were collected. All fishers present during the house call were interviewed, either together (if sea cucumber collection was conducted as a group) or separately. Fisher surveys were implemented across Ngardmau state in Palauan, and where necessary translated to local dialect. Interviewees involved in activities other than collection were targeted based on information provided by fishers and key informant interviews.

A total of 75 individuals were surveyed. As some individuals were involved in more than one activity, interviews resulted in a total of 88 activity surveys: 70 collection; 5 processor; 4 transportation; 2 exportation; 4 monitoring; and 3 supporting services.

Surveys were collected from both fishermen (70% of sample) and fisherwomen (30%). The percentages reflected in the sample should not be taken as indicative of the actual gender composition during the harvest, but highlight the entry of men into an activity previously dominated by women. Interviewees ranged from 11 years of age up to 73, with 94% aged between 18 and 65.

Key informant interviews were also conducted with BMR staff, shipping handlers and previous employees of foreign exporting companies. Where it was not possible to secure on-island data, proxy costs and benefits were taken from the published literature.

Cost benefit analysis

In a CBA the flow of costs and benefits are projected over the life cycle of the project, and financially adjusted with an appropriate interest rate to reflect the opportunity cost of the capital invested (Fleck et al., 2006; Lebo and Schelling, 2001).

The NPV for the boom-bust BAU scenario is compared with two SSM scenarios across two different stages in the VC: a total of four SSM scenarios are therefore presented for comparison.

CBA scenarios were developed using the following economic and biological data:

1. Economic
   - **a.** Species-specific price data for raw sea cucumbers and BdM along the VC
   - **b.** Volume of trade
   - **c.** Production costs along the VC

2. Biological
   - **a.** Population size
   - **b.** Repopulation rate
   - **c.** Sustainable harvest level
   - **d.** Conversion rates (raw to dried BdM)

Economic data

It was expected that Palau's VCA results would provide input values for CBA, however, given the nature of operations during the 2011 harvest this was not possible for all management scenarios. Processing-exporting entities were not required to report costs of production and significantly underreported the value added by processing for export. Palau's price data also represented a gross underestimation of fair market prices. Therefore we frequently used secondary data (i.e. gray and scientific literature) in order to establish representative input costs and pricing.

The BAU scenario is defined by actual events of 2011. Economic data was collected by BMR during this period and includes information on final volume traded and price, separated by species. Ngardmau's production costs are taken from the VCA analysis and equal zero, as equipment was provided from off-shore enterprises.

For SSM scenarios, secondary data was used to estimate costs and prices. In particular, a review of the existing VCA literature and Chinese trade data provided estimates for processing costs and price differentiation of sea cucumber across the VC. These values are seen as representative under the assumption that with the establishment of a longer-term strategy under SSM, Palau could access fairer pricing.

VCA for sea cucumbers are limited, although a few notable exceptions exist for the Indo-Pacific, i.e. Brown et al., (2010) and Simos, (2012). However, no reports existed which traced one specific sea cucumber species from collection to end market. Indeed, trade data codes lack species differentiation for sea cucumbers, which are instead grouped collectively under a generic BdM import code. This, and a secretive BdM industry, makes tracing specific sea cucumber species through the market chain difficult. However, a few key sources provided data on input costs and species-specific raw and export prices. These sources are described below.

Production costs along the value chain

Input cost estimates were taken from a Philippine VCA case-study (Brown et al., 2010). The analysis is one of the only analyses that accessed processors' and exporters' books and was therefore able to describe cost of finance, depreciation, opportunity costs, and other details.

The costs for harvesters in Palau are significantly lower than other producer countries because of the widespread practice of gleaning from near-reef areas versus common practices in other areas that include costly boat use, scuba gear and hired labor. Brown et al. (2010) reports only costs for travel to and from fishing grounds; collection and additional resource costs were calculated as 0 based on negligible values and reusable equipment. Within Ngardmau, collection incurred no travel costs to and from harvest sites; input costs were therefore estimated slightly higher than 0, at 0.10 USD per bucket. This is in order to capture any potential omitted costs and not underestimate costing under SSMs.

Processing costs recorded by Brown et al., (2010; Table 24 p.39) are 1.30 USD/Kg BdM. Processing within the Philippine study involved more complex and industrialized methods. However, no other processing data was available. While perhaps an overestimation of Palauan processing costs, results will give more conservative NPV estimates for sustainable management scenarios. Figures recorded are for Sandfish (*Holothuria Scabra*) a high-value species, however processing methods are assumed to be similar.

Export costs were also taken from Brown et al., (2010; Table 24 p.39): 1.38 USD/Kg BdM. This figure assumes Free On Board (FOB) HK, that is, the exporter pays all of the costs to the port of HK, as was seen to be the case in Palau. It is possible that freight costs are higher from Palau than from the Philippines. However Brown et al.'s figure also includes additional processing by the exporter to improve value of the final BdM product. It is anticipated that the higher proxy processing costs absorb this difference and combined costs of processing and export prove representative.

Pricing along the value chain

No price data is available for hairy grayfish due to the nature of its recent reclassification. Analyses were therefore run using price data for both stonefish *(A. lecanora)* and hairy blackfish *(A. miliaris)*. These two species closely resemble hairy grayfish, and have in the past been confused with the species. All species result in similar BdM products, all are considered medium-value and have an average dried length between 10 – 12 cm (Purcell et al., 2012b). They are therefore considered to be BdM substitutes for one another.

That said, in most cases examined, both fresh and dried stonefish received a slightly higher buying price than hairy blackfish (Purcell, 2014a). To account for this sensitivity, stonefish and hairy blackfish prices are modeled separately within the analyses.

BdM price data is taken from recent work by Purcell (2014a). Where necessary, prices are standardized to 2011 prices, extrapolating price inflation between 2000 and 2007 as per Carleton et al. (2013). Carleton et al. (2013) show that prices for stonefish and hairy blackfish have increased 2.4 and 10-fold, respectively, over that seven year period. BdM price increases are modeled at 13.3% per annum based on the data for stonefish. This lower price increase was seen as more reasonable for long-term projections as lower value species may experience high price inflation as they first enter the market, but this inflation then frequently levels off. The more conservative price increase ensures that modeled returns to SSM are conservative. In addition, price increases were modeled for the first ten years of analysis after which it was assumed to remain constant.

Information on price increases for raw sea cucumber proved limited. Ram et al. (2014) cite 2008 purchasing price ranges in Fiji for stonefish and hairy blackfish. Heemsoth (2013) provides insight into 2013 species prices in Fiji for small and large specimens. It was assumed that the low range value presented in Ram et al. (2014) cites small specimens and, likewise, the higher value pertains to large specimens. The annual price increase for each subgroup (species, size) was calculated and then averaged across the four groups to determine an average increase in price. This average price increase of 8.4% per annum was calculated and used within the analysis. Likewise, price increases were modeled for the first ten years of analysis only in order to present conservative values.

Reference prices extracted from the literature are displayed in Table 1. Final SSM analyses use maximum and minimum prices found in other PICs (highlighted in bold within Table 1) to give a range for NPV. Low values are taken to represent the lowest price that Palau could expect to negotiate if it organized the sea cucumber sector; high values represent prices that have been recorded and are optimistic but feasible with a strong negotiating position. We also include Palau's final selling price during the 2011 harvest for comparison. For the final wholesale value we take the higher value presented within the literature of 108 USD in order to give an upper threshold value. As noted, BAU analysis is based on primary data and events and therefore uses actual revenue realized, as per BMR data (2011).

TABLE 1. SSM PRICING DATA FOR SEA CUCUMBER & BDM

VC STAGE	COUNTRY	AVE. PRICE (USD)		YEAR	UNITS	SOURCE
		STONEFISH	HAIRY BLACKFISH			
Collection	Palau (H)	0.15	0.15	2011	raw/piece	Pakoa (2014)
	Fiji	0.70	0.65	2008	raw/ piece	Ram et al. (2014)
	Fiji (L)	0.47	0.37			
Processing & Export	Fiji	64.00	84.00	2011	dried/kg	Purcell (2014a)
	Tonga	56.00	48.00			
Wholesale	Hong Kong	94.00	75.00	2011	dried/kg	Purcell (2014a)
	Hong Kong (H)	108.00	79.00			

(L) represents lowest value recorded; (H) represents highest value recorded

Source: Compiled by authors

Biological inputs

Under the BAU scenario, it was necessary to determine if and when further harvests would occur. Recovery is determined by repopulation rates. A combination of primary and secondary data was used to determine the rate of repopulation.

In-water surveys of Ngardmau's sea cucumber fishery conducted by PICRC in 2009 and 2011 give pre- and post-harvest density and population estimates for *Actinopyga spp.* (Golbuu et al., 2012). At the request of Ngardmau state, a further surveying event was conducted to determine recovery rates since the 2011 harvest event (Rehm et al., 2014). These further surveys were conducted in February 2015, and provided density measurements and population estimates for 2014. Results from inside of the MPA, which witnessed a 20% harvest rate, showed recovery to pre-harvest levels. However outside the MPA, results indicate no increase in the density of *Actinopyga spp.* since the 2011 harvest. Although not significantly different from 2011 levels, density had actually further decreased slightly by 2015 (Rehm et al., 2014). This information was considered alongside previous case studies from the literature which cite recovery of drastically depleted populations to take decades (Feary et al., 2015; Uthicke et al., 2004). From this information, it was determined that recovery within Ngardmau's waters (exclusive of the MPA) was unlikely to show recovery to a level appropriate to allow another harvest in the next 20 years.

Determining the potential harvest under SSM requires knowledge on the initial volume of Ngardmau's standing stock, as well as the level of stock that can be sustainably harvested each period. Initial efforts were made to collect local and species-specific data in order to determine life cycles and appropriate harvest rates. However, as a recently reclassified species, biological data pertaining to hairy grayfish ecology proved impossible to find. Study of recent reports and ecological information found hairy grayfish occupy similar habitats as hairy blackfish. For example, both species prefer reef flats and sea grass, over the stonefish's preferred habitat of coral substrates (IUCN, undated). It was therefore decided that the ecological attributes of hairy blackfish would be used as proxy for those of hairy grayfish, for which limited though still deficient data are available. The few species for which good ecological data has been generated (for instance the high-value species sandfish or *Apostichopus japooicus*, a cold-water species and one of the only species to respond well to aquaculture) are not suitable as proxies due to obvious differences in size and habitat. As a result, it was not possible to generate a comprehensive fisheries harvest model to understand impacts on repopulation and determine the most economically rational harvest strategy.

Instead, harvest scenarios were developed using two data sources:

1. Limited secondary literature and expert opinion suggest that annual harvest rates above 5% of virgin biomass can be unsustainable.

2. PICRC survey data (Rehm et al., 2014) indicates that in 2015, *Actinopyga spp.* can experienced a full recovery from a 20% harvest in the 3-year period since 2011.

For 5% annual harvest rates, it was assumed that full repopulation would occur in the following year. For 20% harvest, it was assumed that full repopulation would occur in three years as the data suggested.

Original fishery size prior to the 2011 harvest was calculated using both the harvest data collected by BMR and the in-water density data provided by PICRC (Golbuu et al., 2012). Interviews revealed that some poaching was believed to have occurred within states not open to sea cucumber fishing, which was then sold at the Ngardmau dock. No data on this was available, but it is assumed that 90% of the final catch recorded at Ngardmau's dock originated from Ngardmau waters. PICRC's before and after density surveys revealed that 88% of Ngardmau's stock (outside of the MPA) had been harvested during the 2011 harvest event. Total traded volume from the 2011 harvest (BMR data) was then readjusted based on these figures to determine the initial volume of this fishery, which was used as the basis to calculate harvest volume.

In order to determine dried volume of BdM from raw weight, a conversion factor of 0.172 was used (Ngaluafe et al. 2013). In other words, hairy grayfish BdM weighed 17.2% of the original raw volume harvested, such that each 19Kg bucket sold at the dock represented 3.3Kg of BdM. Conversion weights specific to hairy grayfish were not available due to its recent reclassification. No conversion rates for hairy blackfish were found within the literature. The final conversion rate was taken for stonefish as per Ngaluafe et al. (2013).

Discount rate and time horizon

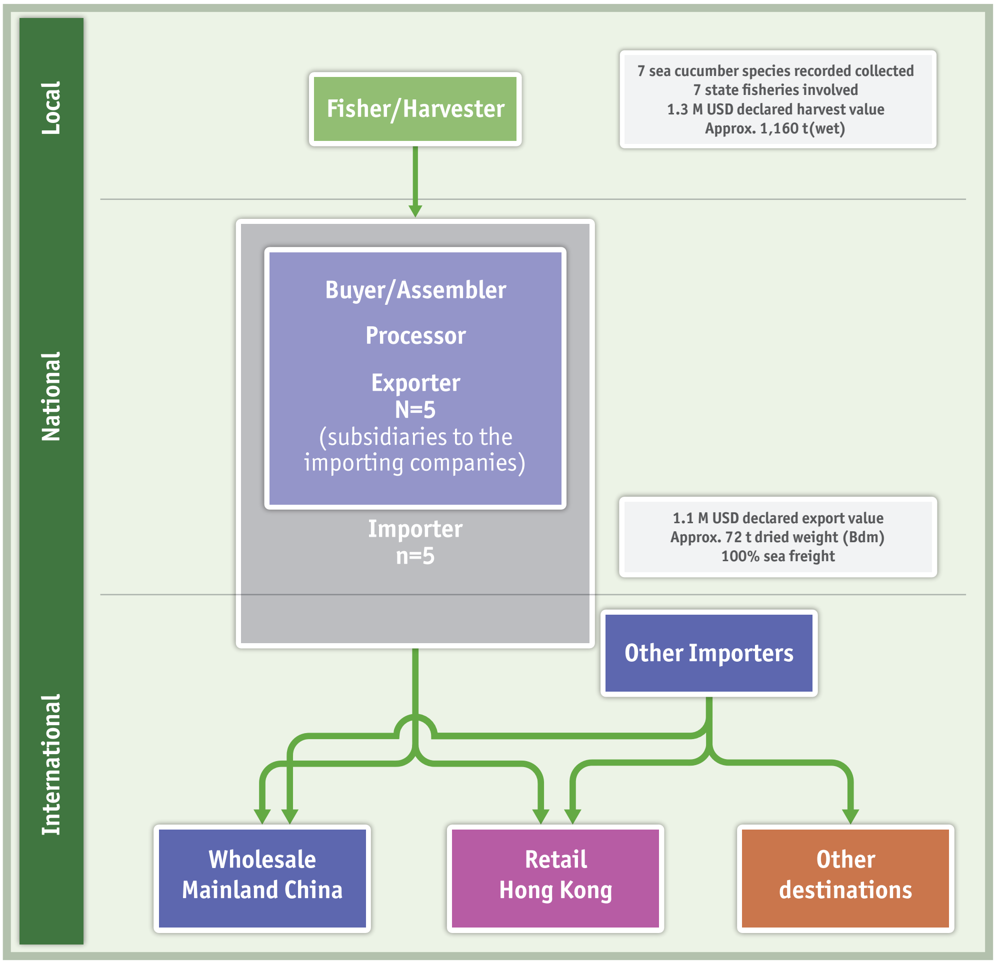
Scenarios were modeled across a 20-year time period, starting in 2011. A 7% discount rate was used for the analysis. There is no standard discount rate in the Pacific but 7% represents a mid-value suggested by the literature and Palauan banking rates (Buncle et al., 2013), as follows: the National Development Bank of Palau offers rates of 6 – 10% on loans (NDBP, 2015); the majority of CBAs carried out within the Pacific use rates of between 3 and 10% for Palauan projects (Buncle et al., 2013), utilizing a 'mid'-value of 7%; finally, as suggested by Harrison (2010) a sensitivity analysis was also carried out using the outlying values of 3 and 10%, the results of which are presented in Annex 2.

Results

Palau's BdM value chain

Surveys carried out as part of this study paint a picture as to the dynamics of the sea cucumber trade on island under the BAU. A diagrammatic representation is provided in Figure 1.

FIGURE 2. DIAGRAMMATIC REPRESENTATION OF PALAU'S BDM VC



Palau's BdM VC proved to be more simplistic than originally envisioned. Unlike in many established BdM exporting countries, the vast majority of VC functions were conducted by foreign exporting enterprises (the gray box in Figure 2). These companies controlled all aspects of the on-island VC with the exception of sea cucumber collection. However, while the companies did not carry out or control collection directly, they also showed a strong presence within this link. Each VC stage is discussed in greater detail in the following sections.

Collection under BAU

Over the course of Palau's 2011 sea cucumber harvest, seven species were recorded as collected for sale by BMR (2011). These were: brown sandfish (*Bohadschia vitiensis*), curryfish (*Stichopus hermanni*), deepwater blackfish (*Actinopyga palauensis*), greenfish (*Stichopus chloronotus*), lollyfish (*Holothuria atra*), stonefish (*Actinopyga lecanora*), and tigerfish (*Bohadschia argus*). Only three species were collected in Ngardmau, with stonefish initially listed as the predominant species collected. As noted, this was a classification error and we assume collections from Ngardmau to represent hairy grayfish. Total harvest volumes are displayed in Table 2.

Collection was carried out by Palauan fishers, as mandated by the state and the Palauan Ministry of Natural Resources, Environment and Tourism regulations. Fishers were limited to fishing within their own state waters, although this regulation was reported as often being ignored. Normally an activity of Palauan women, a wide range of community stakeholders took part over the course of the 2011 harvest.

TABLE 2. SUMMARY OF SEA CUCUMBER HARVEST BY SPECIES FOR PALAU AND NGARDMAU (BMR 2011)

Species	PALAU			NGARDMAU		
	Nº buckets	Nº pieces	Value (USD)	Nº buckets	Nº pieces	Value (USD)
Brown sandfish	15,856	*436,040*	175,534	887	*22,619*	8,951
Curryfish	16	-	465	4	-	52
DW blackfish	-	854	854	-	-	-
Greenfish	240	*5,400*	3,263	-	-	-
Lollyfish	-	213	213	-	-	-
Stonefish/ Hairy grayfish	35,461	*10,638,300*	1,123,206	23,467	*7,040,100*	614,193
Tigerfish	1	*27.5*	6	-	-	-
Total	**-**	**-**	**1,303,540**	**-**	**-**	**623,196**

Italicized figures represent estimates based on average number per bucket.

Source: Compiled by authors

Most fishers reported fishing two days a week, the maximum amount permitted. However, some fishers admitted to fishing outside of these periods and stockpiling sea cucumbers to sell on the allowed days. The average time fishers reported spent collecting was 2.3 days a week, 7.3 hours per day.

Over the course of the 7-month harvest period, the price of all but one species remained constant. The only species that increased in value was the hairy grayfish; buckets ranged in price from $10/unit at the start of the season to $45 at the end of the season. Prices appeared to be controlled initially by a limited number of buyers, and the price increase was perhaps in response to a growing number of buyers in later months as well as an increasing per unit effort required in gleaning sea cucumber.

While Ngardmau comprised well over half of the harvest volume of hairy grayfish (66.2%), the state only captured 54.7% of the species' total 2011 value. The first recorded sale of sea cucumbers in Ngardmau was October 13, four months after buying began in Palau. With a later entry into the market, one might expect a higher initial price per bucket but prices paid at the Ngardmau dock were in fact the lowest recorded for hairy grayfish throughout the open fishing season. Initial prices of $12/bucket were recorded in the state of Ngardmau and, to a lesser extent, in Airai. The average bucket price across the harvesting period for hairy grayfish in Ngardmau state was $26.20, compared with an average of $43.20 across all other states. Even the state with the next lowest average bucket price for *Actinopyga spp.* was much higher, at $39.50.

Export companies played a strong role in collection dynamics. Surveyed fishers reported that, in many instances, foreign entities provided the necessary inputs to enable sea cucumber fishing. For example, rice sacks for collection and buckets for storage were cited as equipment provided to fishers. In some cases, it was reported that companies hired boats to enable more elderly fishers to participate, taking them out to the sea grass flats and picking them up later.

Whilst exact input cost data was unavailable, overall fishers required very little equipment. Costs per unit effort (per bucket) were extremely low, consisting mainly of the need to acquire reusable rice sacks for collection. All other equipment was optional, although gloves were regularly cited.

Buying, processing and export under BAU

The respective market share of each of the five companies occupying this stage of the VC is shown in Table 3 below. Initially, trade was started by one company, ShunTat Co. A large Chinese owned company with offices in HK and mainland China, ShunTat also has branches in the Solomon Islands, Fiji and Africa. Although a buyer, processor and exporter in Palau as well as other countries, ShunTat's final function in the VC is as a sea cucumber wholesaler in HK. This company operated alone in Palau for six weeks before others entered the market. Reports suggest that ShunTat was the only company to file for a Foreign Investment Board (FIB) license; companies that arrived later collaborated with a local Palauan enterprise and ran their business under a Palauan name and subsequently paid Palauan partners commission.

TABLE 3. MARKET SHARE OF EXPORTING COMPANIES

EXPORTING COMPANY	DATE OF FIRST PURCHASE	VOLUME OF TRADE		PURCHASE VALUE (USD)	AVG. PER BUCKET PRICE (USD)	% PURCHASE VALUE
		Nº BUCKETS	Nº PIECES*			
ShunTat Co.	03 June	24,643	1,067	551,889	23.4	42.3
Sarang Trading Co.	14 July	9,831	-	263,741	26.8	20.2
Pin An Fishing Co.	25 July	7,776	-	233,426	27.2	17.9
Ngerurang	21 July	8,587	-	223,574	26.0	17.2
LE company	01 Aug	737	-	30,911	41.9	2.4

*larger species such as lollyfish (*Holothuria atra*) & deepwater blackfish (*Actinopyga palauensis*) where sold individually per piece for $1/sea cucumber and are presented under Nº pieces.

Source: Compiled by authors

These companies conducted all sea cucumber processing. Furthermore, all processing inputs were brought in from overseas, including processing staff. ShunTat was reported to have eight permanent on-island staff as well as a family member of the company to oversee operations, who travelled in and out of Palau as needed. The operation was composed of six processing staff (brought in from China), one manager (also Chinese) and a Palauan facilitator. Two to three Palauans were also hired to assist with buying and driving boats when needed (as mentioned in the previous section on collection). All Palauan staff worked on salary or daily pay and not commission. There were four additional processing plants on the island (one Korean and three Chinese operations), though these were smaller and employed only two or three Chinese processors.

Processing followed four main steps: remove intestines; cover in salt and marinate in a large pot; steam for couple of hours over low pressure gas (LPG) burner; and leave to dry in the sun for a day or two. Accordingly, processing inputs were reported to be a large pot (approx. 250 liters) for boiling, a LPG burner and large quantities of salt. A pot and burner reportedly cost 200 and 250 USD in China respectively, although on-island premiums could double these costs.

Product was exported by ship freight and only to HK. Exporting occurred every 2 - 3 months, once enough BdM had been processed to fill an export container. ShunTat exports reportedly landed in HK and then were shipped to a wholesale warehouse in mainland China where vendors would come to purchase for retail markets, including restaurants and shops. Unfortunately, it was not possible to get accurate pricing for these stages in the market chain. More generally, shipping costs from Palau in 2011, all-inclusive, were quoted at about 3,500 USD per container. The shipping company paid all costs at the point of origin prior to departure. Payments were generally made in cash.

Regulatory framework under BAU

Palau's BMR was primarily responsible for overseeing the 2011 sea cucumber harvest. This included monitoring and recording catch at dock sites. BMR was also tasked with overseeing all processing to ensure that no restricted species were added to the dried stock. Once dried, sea cucumbers were locked and stored within the processing plant. Once there was sufficient volume for export, it was moved and repacked following one final check at the BMR offices, during which processed bags were weighed and counted. The following forms were necessary for export: 1) a marine export declaration form, which included information on exporter name and address, number of pieces and volume, species being exported and final value, and 2) marine resource export certificate.

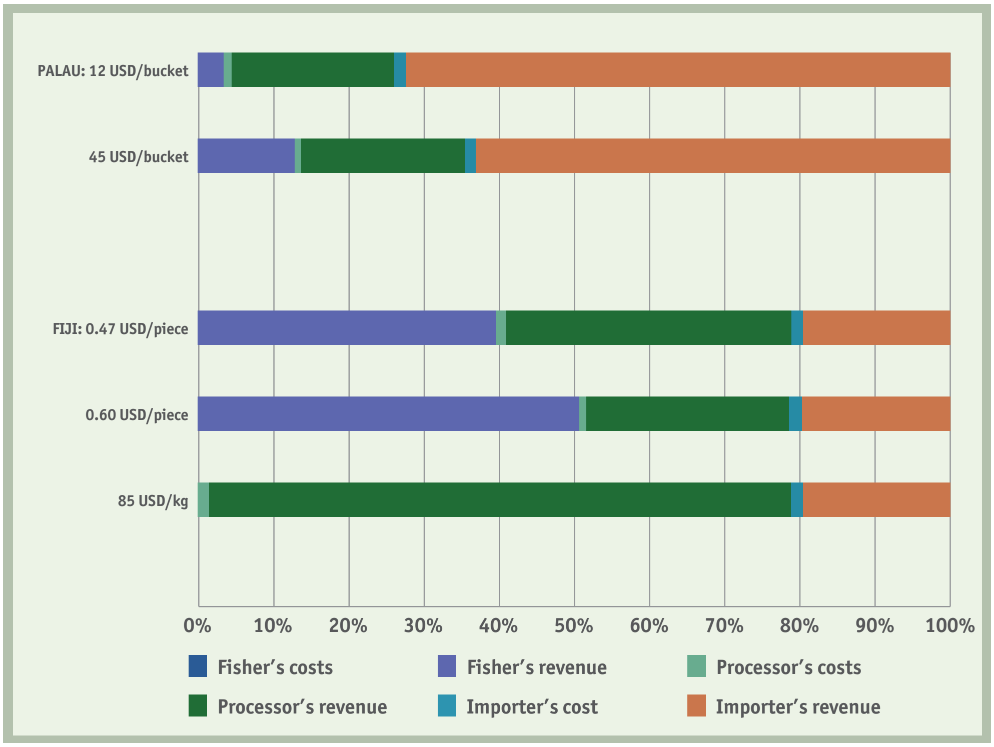
Often the buyers themselves filled out these forms. The average value stated for BdM leaving Palau was 23.5 USD/Kg. This was a serious undervaluation of the final value and likely an intentional means for exporting companies to evade taxes and duties on both export and import. A four percent export tax was charged by Palau on all BdM exports based on final export value. Additional paperwork costs at the time amounted to 10 USD per shipment.

Returns on investment

The average wholesale value in HK of Ngardmau's hairy grayfish harvest under the BAU was approximately 7.37 million USD in 2011, based on the recorded wholesale prices of 108 USD/Kg. The income realized by Ngardmau represented only 8.3% of this value, or as little as 2.8% of final retail value; retail prices for BdM can be up to three times higher than wholesale.

The value captured by Ngardmau fishers compared with Fijian fishers is displayed in Figure 3 for illustrative purposes. Assuming the highest wholesale price of 108 USD/Kg, Palauan fishers captured only 3.3% of the final wholesale value for a 12 USD bucket. This increases to 12.6% at a bucket price of 45 USD. In contrast, Fijian fishers who sell raw *Actinopyga spp.* can retain between 40 to 50% of the wholesale price, even at the lower reference prices. By involving themselves in the processing stage, Fijian fishers end up retaining as much as 77.8% of wholesale value.

FIGURE 3. PERCENTAGE OF WHOLESALE VALUE CAPTURED BY VARIOUS PLAYERS WITHIN BDM VC PER KG BDM



Source: Compiled by authors

Results of cost benefit analysis

Harvestable volume under alternative management scenarios

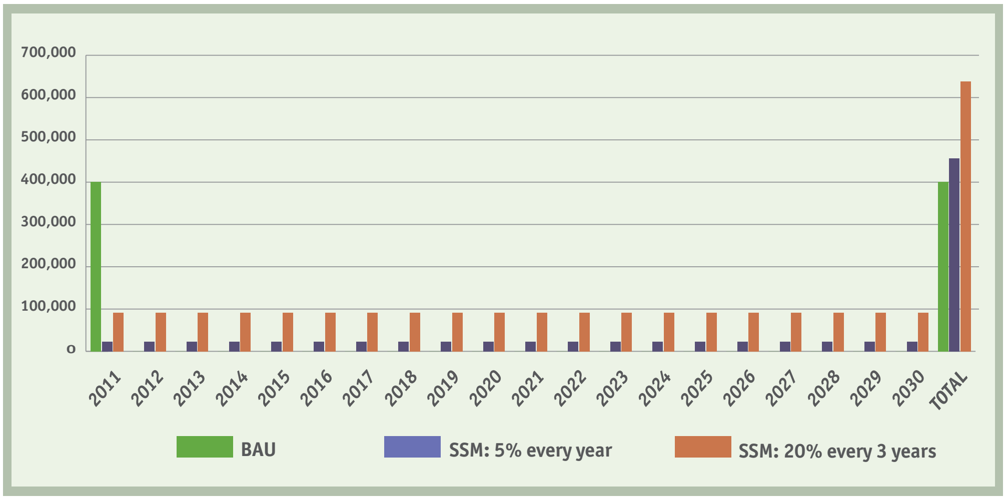
Even with a low 5% take, harvest volumes under the SSM proved larger over the 20-year analysis period than the original BAU. Under a 20% take every 3 years, harvest would be 1.5 times as large. Even at the more conservative 5% take value per year, the sea cucumber harvest could have been 13.6% higher over the course of the project. The volumes associated with various management scenarios can be seen in Table 4. The results are displayed in graphic form in Figure 4.

TABLE 4. CHARACTERISTICS OF HARVEST UNDER ALTERNATIVE MANAGEMENT SCENARIOS

HARVEST SCENARIO	NO. HARVESTS	VOLUME OF HARVEST (KG)	TOTAL VOLUME HARVESTED (KG)
BAU	1	401,277	401,277
SSM 5% per annum	20	22,800	455,997
SSM 20% every 3 years	7	91,199	638,395

Source: Compiled by authors

FIGURE 4. ANNUAL AND FINAL HARVEST VOLUMES OF ALTERNATIVE HARVEST SCENARIOS



Source: Compiled by authors

CBA scenario results

Returns from BAU

Results from the VCA indicate that fishers bore no significant input costs, because these costs were borne by exporters. Costs were therefore assumed to be zero. Under BAU, Palauan entities were not involved in any processing or export and so income results pertain to the collection stage only. Based on the VCA results, Palauans captured revenue only from collection and as such no additional benefits from processing are considered.

Under these conditions, revenues to Ngardmau fishers under BAU were USD 613,474 for hairy grayfish harvests.

Collection under SSM

Economic returns to collection under both SSMs (in present value terms) proved more profitable than under BAU. This is true even if it is assumed that the price received under SSM would not exceed the final BAU selling price for hairy grayfish (0.15 USD/piece): at this price, SSMs generate an NPV of 1.1 or 1.7 million USD compared to 0.6 million USD under the BAU.

Potential NPV under the 5% annual harvest SSM reaches 6.3 million USD if Ngardmau sold at the higher reference price. This value exceeds BAU by 5.7 million USD. Under this SSM scenario, it would have taken Ngardmau only 1.9 years to capture a value from their sea cucumber fishery equivalent to that captured under BAU. Under the lower recorded reference price, potential returns were still almost six times higher than the BAU, and an equivalent value could have been secured in approximately 3.5 years.

Returns to the 5% annual take SSM under the various reference prices can be seen in Table 5.

TABLE 5. NPV FROM COLLECTION UNDER 5% ANNUAL SSM

Initial harvestable volume (buckets)	23,999.83
Harvest rate	0.05
Collection cost (bucket)	0.10
Price increase (years 0 – 10)	0.08
Discount rate (%)	7.00

REFERENCE COUNTY/ SPP.	REFERENCE PRICE/PIECE (USD 2011)	NPV (USD million)	2011 REVENUE (USD million)	DIFFERENCE FROM BAU NPV (USD million)	# YRS TO REACH BAU NPV
Fiji / stonefish	0.89	**6.31**	0.32	5.70	1.90
Fiji / blackfish	0.47	**3.34**	0.17	2.72	3.56
Palau / grayfish	0.15	**1.06**	0.05	0.45	10.69

Source: Compiled by authors

Under the higher take SSM scenario of a 20% harvest every 3 years, returns from collection prove to be even higher, as displayed in Table 6. At the higher reference price, Ngardmau's fishery could have secured an NPV of 10.1 million USD. At the lower price this NPV would have been 5.3 million USD. In both cases, the SSM would have realized at least as much revenue as the BAU in the first year of harvest alone.

TABLE 6. NPV FROM COLLECTION UNDER 20%/3-YEAR SSM

Initial harvestable volume (buckets)	23,999.83
Harvest rate	0.05
Harvest interval (years)	3
Collection cost (bucket)	0.10
Price increase (years 0 – 10)	0.08
Discount rate (%)	7.00

REFERENCE COUNTY/ SPP.	REFERENCE PRICE/PIECE (USD 2011)	NPV (USD million)	2011 REVENUE (USD million)	DIFFERENCE FROM BAU NPV (USD million)	# YRS TO REACH BAU NPV
Fiji / stonefish	0.89	**10.09**	1.29	9.48	0.48
Fiji / blackfish	0.47	**5.33**	0.68	4.72	0.91
Palau / grayfish	0.15	**1.70**	0.22	1.09	8.63

Source: Compiled by authors

Processing and export

In-country processing and exporting could also add substantial additional benefits to the SSMs. The coordination necessary to move into these activities is judged to be improbable under BAU. The potential returns from upgrading into processing and export are shown in Table 7 and Table 8 for the 5% annual take SSM and the less conservative 20%/3-year SSM, respectively. The additional costs to processing and exporting prove minimal in comparison to potential returns on investment and result in NPVs between 5.0 and 11.9 million USD. Returns matching the BAU would be realized in at least 3.2 years for all SSMs, and in less than a year for all 20%/3 year take SSMs. These NPVs are based on reference prices from Fiji and Tonga. The wholesale price for stonefish of 108 USD/Kg reveals that the wholesale value in HK was approximately 11.5 and 15.3 million USD under the two SSMs, and demonstrates the price ceiling.

TABLE 7. NPV FROM COLLECTION AND PROCESSING UNDER 5% SSM

Initial harvestable volume (dried/kg)	78,431.44
Harvest rate	0.05
Processing cost (dried/kg)	1.30
Exporting cost (dried/kg)*	1.38
Price increase (years 0 – 10)	0.13
Discount rate (%)	7.00

REFERENCE COUNTY/ SPP.	REFERENCE PRICE/KG (USD 2011)	NPV **(USD million)**	2011 REVENUE (USD million)	DIFFERENCE FROM BAU NPV (USD million)	# YRS TO REACH BAU NPV
Fiji / blackfish	84	**8.90**	0.32	8.28	1.87
Tonga/ blackfish	48	**5.03**	0.18	4.42	3.20
HK / stonefish	108	**11.47**	0.41	10.86	1.46

Source: Compiled by authors

TABLE 8. NPV FROM COLLECTION & PROCESSING 20%/3 YEAR SSM

Initial harvestable volume (dried/kg)	78,431.44
Harvest rate	0.05
Harvest interval (years)	3
Processing cost (dried/kg)	1.30
Exporting cost (dried/kg)*	1.38
Price increase (years 0 – 10)	0.13
Discount rate (%)	7.00

REFERENCE COUNTY/ SPP.	REFERENCE PRICE/KG (USD 2011)	NPV **(USD million)**	2011 REVENUE (USD million)	DIFFERENCE FROM BAU NPV (USD million)	# YRS TO REACH BAU NPV
Fiji / blackfish	84	**11.85**	1.28	11.24	0.48
Tonga/ blackfish	48	**6.70**	0.71	6.09	0.86
HK / stonefish	108	**15.29**	1.65	14.67	0.37

Source: Compiled by authors

Discussion

The demand for sea cucumbers shows no signs of abating. The BAU story described here has been, and continues to be, seen countless times across the globe.

Strong market signals, a growing affluent Chinese population and declining stock from traditional trade routes mean that importers – and their roaming buyers – will continue to turn to new trade routes and fisheries. New potential trading partners face intense pressure and incentive to sell prior to developing sustainable management strategies alongside sufficient market knowledge or favorable market linkages.

High mobility combined with large profit margins incentivizes short-term business planning on the part of foreign enterprises: clean up and clear out. If island nations and their coastal communities hope to benefit from the sea cucumber trade over the longer term, they will need to take firm control of their management and markets. In doing so they will secure much higher benefits for fishers and their economies, not only over the long-term but also in the short to medium-terms.

Report recommendations to promote sustainable sea cucumber management in Palau

The main finding of this report is that sustainable sea cucumber fisheries management proves to be the ecological and economical choice. Substantial economic gains from sea cucumber fisheries can be seen with low harvest rates and can guarantee the longevity of these fisheries. By participating in the classic boom-bust transaction instead of developing a sustainable approach, Ngardmau sacrificed long-term revenue in the millions. In addition, the results do not consider any further benefits associated with the ecological function of intact sea cucumber populations that may have been lost.

Ngardmau's pre-2011 fishery had great potential to provide long-term benefits the community. However, in order for Ngardmau state to develop and profit from a sustainable sea cucumber fishery, it will first need to allow recovery of its currently depleted stock. Results from Rehm et al. (2014) suggest that the recovery of Ngardmau's sea cucumber fishery will be a long one and any fishing in the near future will further set back its recovery. While the science is inconclusive on the time period required, the literature suggests recovery could be in the order of decades and so it is recommended that Ngardmau implement a ten year moratorium on commercial sea cucumber harvesting across its waters. During this time it should monitor sea cucumber populations in order to determine if the moratorium should be extended or the fishery reopened after this period.

If Palau, and in later years Ngardmau, wishes to support the sustainable management of its sea cucumber fisheries it should consider investing in the following:

Improve local knowledge on market prices and price determinants

If Palau wishes to capture fair values it will need to improve its knowledge of BdM prices and determinants of pricing. Such information will improve its negotiating position and can also promote improved management strategies.

In the past, keeping up-to-date with the relevant information has proven difficult, as exporters typically take advantage of their leverage in the VC to impede the flow of information. For example, while curryfish (*Stichopus herrmanni*) commands low prices for fishers, it can sell for as much as USD 214/Kg in HK retail stores (Purcell, 2014a). The prices offered to fishers across the PICs vary widely from island to island; likewise purchase prices found in-country can differ two to six-fold (Purcell et al., 2012a).

Important lessons on minimum prices can be learned from other countries, in particular other PICs, and Palau should aim to create minimum price floors, either through government regulations or through state and fisher cooperation. Cooperatives that offer consistent (and well-informed) prices will hold greater negotiating power than individual fishers, particularly if fishers previously underbid each other. Other costs, which often limit fishers' earning and bargaining power, could also be shared and minimized. For example, in the event that a more complex market does emerge, transportation costs to fish markets with more competitive pricing could be shared.

Information on price determinants, such as species and size, are also accessible. Such pricing information can enable Palau to maximize its revenues by positioning itself as a low-volume high-value fishery and prevent it from becoming a high-volume low-value provider as it did in 2011. Likewise, improving transparency and access to end-of-market preferences can improve efficiency and reduce waste. For example, species and product length have been shown to have major effects on retail prices of BdM (Purcell, 2014a).

Fortuitously, these markets preferences support the use of minimum catch size requirements, as mid to large specimens command higher prices. Due to the shrinkage associated with drying, smaller specimens are often rejected by buyers. In addition, for many sea cucumber species, BdM end-markets prefer medium-sized sea cucumbers. From a natural resource management perspective, this encourages preservation of both adolescent and larger, reproductive animals.

Invest in product upgrading

With minimal capital input, Palau could generate a significant return on investment by investing in on-island processing and export. Improving processing can be both a low cost and relatively low-skill enterprise.

The ability of Palau and Ngardmau to control price will depend on their negotiating position. Relatively low annual volumes, the remoteness of the fishery and the perishability of the raw product decrease market power. In upgrading to processing, Palau will increase the product's shelf life (properly processed BdM can be stored for over a year) reducing any urgency to sell, enabling stockpiling and reducing overall export costs, thereby placing greater power into the hands of the seller.

Control over when to sell offers a chance to significantly improve profits. For example, BdM prices often increase in winter months when harvests are low and also around the Chinese new year, when prices can increase by as much as 20 to 30% (Kinch et al., 2007; Ram et al., 2014; Toral-Granda et al., 2008).

However, the quality of processing is the critical determinant of end-market value. Important criteria include how well the sea cucumbers are sized, cut, cooked, dried and stored. Given cost structures, a focus on the highest quality processing will enable the greatest return on investment. Indeed, the higher reference prices recorded in Fiji in part reflect their higher processing standards (Purcell et al., 2012a). For each species harvested in Palau, high quality processing could be supported by technical trainings and materials.

For each species that will be commercially traded, Palau should also try to understand specific end-market demands so that the best practices in processing can be applied on a species-by-species basis. Palau needs to better understand what species, and in what form are most demanded by consumers, and make market decisions accordingly. For instance, profit maximization from exporting to wholesale markets (in large sacks) likely requires a different strategy than trying to reach individual consumers in a retail market.

All strategies must align with reasonable in-country capacity to meet those demands. If the final product is BdM, one would assume based on other PICs that capabilities exist in country. Indeed, manuals are now readily available to assist PICs in processing sea cucumbers into high quality BdM (Purcell, 2014b). However, processing can be unpleasant and time consuming. Therefore local interest may be the limiting factor. Under this scenario, Palau should consider beneficial partnerships with Palauan, or foreign-based entrepreneurs – but with an understanding of the final market value of any exported products.

While exporting entities in PICs continue to be dominated by foreign companies, it is feasible for Palau to undertake this function in the VC. While far less common, non-Chinese processor/exporters exist; in Kiribati, they comprise one third of the processor/exporters (Ram et al., 2014). Exporting involves additional risks and demands more sophisticated business operations, as reported by other PICs. For example, undersized, damaged and poorly processed products were cited as frequent problems for many exporters in Fiji, Kiribati, New Caledonia and Tonga (Purcell, 2014a). However, it is possible to mitigate these risks, to some degree. Lessons from other PICs suggest that improving links between fishers and processors can improve product quality and reduce waste. Improved information on end-of-market preferences will also reduce waste products.

If Palau does not wish to upgrade exportation of BdM due to these additional risks or a perceived difficulty in entering an established market, it should, at the very least, retain more value on-island. During the 2011 harvest, costs associated with export were very low; informational asymmetries allowed exporters to under-report the value of BdM exports and therefore pay lower export taxes. In the future, Palau should independently validate export values, which should be standardized. In addition, permit costs and tax levels should also increased.

Develop novel products and trade routes

It may be fruitful to explore alternatives to traditional trading hubs such as HK. The Chinese diaspora present a potentially interesting opportunity in terms of niche trade prospects with new partners. Because the consumption of BdM is predominantly Chinese, as increasing numbers of Chinese people move to other parts of the world, new markets open up for smaller trade partners that may not have the volumes attractive to HK buyers, for instance. These may represent an opportunity for Palau.

There may also be opportunities for increasing sea cucumber trade for medicinal purposes and other novel sea cucumber products. Studies are underway for a variety of applications (Simos 2015). Should these be successful, they could bring considerable changes in sea cucumber trade and allow PICs to bypass well-established trade routes. New markets do not of course guarantee sustainability (in fact they likely incentivize the opposite), but there is at least potential to combine access to more profitable markets with sustainable harvest.

Invest in improving biological understanding

To a greater degree than many other high-value fisheries, data on sea cucumber biology and life cycles is lacking.

Many of the commercial sea cucumber species are Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) listed. *A.miliaris* and *A.lecanora* were listed as of medium concern at a recent CITES workshop for the conservation of sea cucumbers. The IUCN red list records these two species as vulnerable and data deficient, respectively. No data is available on the hairy grayfish. Larger, more commercially valuable species not analyzed in this document, such as the sandfish (*Holothuria scabra*) and the black teatfish (*Holothuria nobilis*) were listed as of high concern during the same workshop and are considered endangered (Bruckner, 2006; IUCN undated).

Sustainable management will hinge on improving general and species-specific knowledge. At present, little information exists as to the appropriate harvest rates, especially for lower value species; the harvest rates used within this analysis pertain to the larger high-value sandfish which may represent an overly conservative harvest rate for *Actinopyga spp*. Understanding stock levels necessary to maintain a sustainable supply for the trade will take considerable effort (especially on a species-specific basis).

Adaptive management can be used to determine if initial harvests rates of 5% are too low for *Actinopyga spp,* or the species in question. This will, however, require at the very least a full species-specific stock assessment. States hoping to open their sea cucumber fisheries may wish to consider partnering with national research institutes such as PICRC in order to carry out initial stock assessments as well as further extraction experiments in order to determine sustainable harvest rates. It is possible that harvest rates for smaller species could be higher than those used within this report, which transferred findings from the larger high-value sandfish species for the more conservative harvest scenario.

The hairy grayfish appears to display a fairly simple life cycle growing to about 20 cm and residing in sandy sea grass beds throughout its life cycle. However, other larger species have been documented as having more complex ecologies, migrating from sandy beds to reefs in later stages of their life cycle (Feary et al., 2015). Harvesting decisions will need to consider these additional attributes in their management and modeling. For example, in certain species such as the teatfish, larger specimens have higher fecundity and a greater ability to repopulate the fishery; here, along with low harvest rates, minimum and maximum size restrictions might be appropriate.

Improve monitoring and regulation of BdM

While efforts were made to regulate Palau's sea cucumber fishery in 2011, monitoring and regulation proved unsuccessful in protecting the resource from over-exploitation. This was due in large part to inadequate biological information, but also due to the misidentification of many collected species. Stock assessments will inform species-specific harvest quotas, but enforcing quotas will require additional monitoring, enforcement and training on species classification.

As mentioned previously, tariffs should be increased to reflect the high commercial value of the resource, as should fines for anybody caught poaching. An appropriate percentage of revenues raised should be fed back into the monitoring and evaluation of relevant fisheries.

With a market predominately for export overseas, monitoring bottlenecks such as export hubs may prove to be a cost-effective element of an overall monitoring strategy. Likewise, if on-island processing is carried out by only one or two entities, monitoring processing plants may be fruitful.

However, an increasing on-island demand for BdM products as a result of Palau's growing Chinese tourism market means that additional monitoring and enforcement will also be necessary. Likewise, there are growing anecdotal reports of foreign buyers purchasing raw sea cucumber at the fish markets which are likely being exported as personal items via airplane and not through the traditional sea freight channels.

With species-specific size guidelines of both wet and dry sea cucumber for collectors and processors, local fishers will be able to maximize profit-seeking activities while concurrently ensuring stock sustainability. In addition, local market incentives could include price premiums paid by exporters for higher-grade products (that follow species-specific guidelines) and in turn exporters could receive tariff reductions for proof of verified product (by Palau's BMR or other enforcement or certification entity), while non-compliance could warrant both high export tariffs and fines.

In Palau, states control access to their coastal waters and therefore their sea cucumber fisheries. States hold property rights over these fisheries and can legally exclude others from harvesting these resources. It should be noted that this tenure is vital, although not sufficient, for sustainable harvesting. Other countries hoping to emulate sustainable management will need to both control and limit access.

Promote regeneration of stocks

Given the potential returns from this fishery when healthy, Ngardmau may wish to explore and invest in methods by which to expedite its recovery. Although aquaculture has had limited success within most sea cucumber fisheries, recent work continues to focus on advancing restocking and sea ranching operations (Hair 2010).

Conclusion

Unsustainable fishing practices and a lack of comprehensive management plans affect the potential of sea cucumber fisheries to contribute to coastal livelihoods and national budgets. Effective sea cucumber management plans are needed at both the local and national level. Yet such management plans and the enforcement capacity to mitigate powerful incentives to overharvest are currently lacking. Forgoing immediate benefits in favor of greater long-term returns will require a change in management, improved governance, and local buy-in and compliance.

The case study presented here demonstrates that the potential returns from low extraction sustainable management plans are economically rational. The results presented demonstrate that Ngardmau state suffered a large economic and ecological loss. The findings are relevant to Palau, other island nations and, similarly, are significant for other high-value marine species. It is therefore hoped that this document will foster the political and local will needed to develop sustainable sea cucumber management plans which balance the needs of local communities with long-term fishery sustainability. The recommendations included provide some important initial steps along that path.

Policy recommendations, based on this report, detailed by OSCA and adopted by leadership are available in Annex 1.

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Annexes

Annex 1. Results of policy consultation with Ngardmau state leadership

This analysis was shared with Ngardmau state decision-makers in November 2015. Since the sharing of these results Ngardmau's conservation organization OSCA drafted the Policy Recommendations listed below; these have since been approved by the Legislate and Klobal governing bodies, including Ngardmau's High Chief and Governor.

Policy Recommendations:

We recommend to the Ngardmau State leadership and community that we cooperate to sustainably manage Ngardmau State's sea cucumber resources so that the population can recover as quickly as possible, and after recovering may be used to produce the best economic benefit for our community. This includes taking the following steps:

1. We respectfully recommend that the Ngardmau State Klobak consider discussing **the establishment of a BUL for outside the Ngarmasech conservation area** to prohibit any commercial harvesting for ten years, based on scientific monitoring. When the Ngardmau state sea cucumber population is restored to 2009 levels, it is recommended that an annual harvest of 5% be implemented if a State sea-cucumber sustainable management and economic development plan is adopted and in force.

2. During the time of the BUL it is recommended that **only members of Ngara Tum Tum and Ngara Ekil be allowed to harvest sea cucumbers in Ngardmaus State, for subsistence and traditional use only.** It is recommended that during this time the Klobak will maintain updated list of members of Ngara Ekil and Ngara Tum Tum and that list be made available to Ngardmau State Conservation Enforcement officers.

3. It is recommeneded that a **joint meeting of Ngardmau State Klobak, Ngara TumTum, Ngara Ekil, and Ngara Okelout, and the OSCA Board** be convened to discuss and agree to the terms of the BUL.

4. It is recommended that effective **biological monitoring, with help from PICRC**, is conducted by the community outside of the MPAs sites as well as ongoing monitoring by OSCA in the MPAs. It is also recommended that Ngardmau State work with PICRC to consider best options for restocking populations outside the MPA.

5. It is recommended that the Ngardmau State leadership consider looking at **options for incentives for reporting poachers as well as rewards for good behavior.**

6. It is recommended that Ngardmau State leadership develop **and adopt a clear plan to prepare for capturing more of the value chain** for bringing more benefits to the community after 10 years. This plan should include:

   a. Cooperative in efforts for controlling the selling and pricing of the resources.
   b. Next steps with regard to participating strategically in the market, capturing more of the value chain, and using science to ensure sustainability.
   c. Researching prices prior to selling.
   d. Selling to buyers as a State cooperative in order to gain the most economic benefit to the community.

Annex 2. Sensitivity Analysis: Discount rates

The following discount rates have been suggested by the literature for sensitivity analysis.

TABLE A1 NPV FROM COLLECTION UNDER 5% SSM

Initial harvestable volume (buckets)	23,999.83
Harvest rate	0.05
Collection cost (bucket)	0.10
Price increase (years 0 – 10)	0.08

DISCOUNT RATE:		3%		7%		10%	
Reference county/ spp.	Reference Price/piece (USD 2011)	NPV (USD M)	# yrs to reach BAU NPV	NPV (USD M)	# yrs to reach BAU NPV	NPV (USD M)	# yrs to reach BAU NPV
Fiji / stonefish	0.89	9.15	1.87	6.31	1.90	4.97	1.93
blackfish	0.47	4.83	3.40	3.34	3.56	2.63	3.70
Palau / grayfish	0.15	1.54	9.16	1.06	10.69	0.84	12.53

Source: Compiled by authors

TABLE A2 NPV FROM COLLECTION UNDER UNDER 20%/3 YEAR SSM

Initial harvestable volume (buckets)	23,999.83
Harvest rate	0.05
Harvest interval (years)	3
Collection cost (bucket)	0.10
Price increase (years 0 – 10)	0.08

DISCOUNT RATE:		3%		7%		10%	
Reference county/ spp.	Reference Price/piece (USD 2011)	NPV (USD M)	# yrs to reach BAU NPV	NPV (USD M)	# yrs to reach BAU NPV	NPV (USD M)	# yrs to reach BAU NPV
Fiji / stonefish	0.89	14.84	0.48	10.09	0.48	7.88	0.48
blackfish	0.47	7.85	0.91	5.33	0.91	4.16	0.91
Palau / grayfish	0.15	2.50	8.10	1.70	8.63	1.33	9.11

Source: Compiled by authors

TABLE A3 NPV FROM COLLECTION & PROCESSING UNDER 5% SSM

Initial harvestable volume (dried/kg)	78,431.44
Harvest rate	0.05
Processing cost (dried/kg)	2.68
Price increase (years 0 – 10)	0.13

	DISCOUNT RATE:	3%		7%		10%	
Reference county/ spp.	Reference Price/Kg (USD 2011)	NPV (USD M)	# yrs to reach BAU NPV	NPV (USD M)	# yrs to reach BAU NPV	NPV (USD M)	# yrs to reach BAU NPV
Fiji / blackfish	84	13.25	1.84	8.90	1.87	6.84	1.89
Tonga/ blackfish	48	7.50	3.09	5.03	3.20	3.87	3.30
HK / stonefish	108	17.08	1.44	11.47	1.46	8.84	1.47

Source: Compiled by authors

TABLE A4 NPV FROM COLLECTION & PROCESSING UNDER 20%/3 YEAR SSM

Initial harvestable volume (dried/kg)	78,431.44
Harvest rate	0.05
Harvest interval (years)	3
Processing cost (dried/kg)	2.68
Price increase (years 0 – 10)	0.13

	DISCOUNT RATE:	3%		7%		10%	
Reference county/ spp.	Reference Price/Kg (USD 2011)	NPV (USD M)	# yrs to reach BAU NPV	NPV (USD M)	# yrs to reach BAU NPV	NPV (USD M)	# yrs to reach BAU NPV
Fiji / blackfish	84	17.18	0.48	11.85	0.48	9.31	0.48
Tonga/ blackfish	48	9.72	0.87	6.70	0.86	5.26	0.86
HK / stonefish	108	22.15	0.37	15.29	0.37	12.00	0.37

Source: Compiled by authors

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