The status of sea cucumbers exploited by Palau's subsistence fishery

Kalo Pakoa,[1] Ferral Lasi,[1] Emmanuel Tardy[1] and Kim Friedman[2]

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1 Introduction

In some Pacific Island countries, the subsistence harvest and use of sea cucumbers occurred long before they were harvested commercially. Of the more than 40 species of sea cucumbers found in the coastal marine environments of the Pacific Islands, more than 20 species are commercially exploited for the dried beche-de-mer export industry, while the rest are regarded as having low or no commercial value. Of the commercially valuable species, only a small portion — along with a few non-commercial species — are traditionally consumed in a number of island countries. Countries that are known to have traditionally consumed sea cucumbers include Cook Islands, Federated States of Micronesia, Fiji, Palau, Papua New Guinea, American Samoa, Samoa and Tonga. The most important species in the subsistence sea cucumber fishery in these island countries are the high-value *Holothuria scabra, H. nobilis* and *H. fuscogilva*; the medium-value *Stichopus vastus*, *S. herrmanni* and *Actinopyga* sp.; and the non-commercial *H. leucospilota, H. cinerascens* and *S. horrens.*

In Fiji, the body wall of *Holothuria scabra* is popularly consumed by most coastal inhabitants while in other areas it is eaten only during times of hardship (e.g. after a cyclone). The animal is marinated in papaya (pawpaw) sap, and then boiled in water for an hour or two before being gutted and scrapped to remove the epidermal layer. The end-product is re-boiled in coconut milk before eating. In Samoa, Tonga, and polian vesicles of *Stichopus horrens* are extracted and marinated in fresh lime juice before being eaten as a delicacy (Lambeth 1999). In Samoa, the guts of *S. horrens*, locally known as "sea", are a local delicacy. Fishing for and preparing *S. horrens* are popular income activities for women who work in groups, extracting and storing the product in bottles to sell or share with relatives. Gutted animals are returned to the sea where they regenerate in a few days. Sea is sold in Samoa's municipal markets for 15–20 tala for a bottle of 'sea",[2] with women using distribution networks to send sea across from Savaii to the main island of Upolu.

In Chuuk State (Federated States of Micronesia), *Stichopus vastus* (which was previously mistakenly reported as *S.* herrmanni) is used in the same way as *S. horrens* in Samoa (Lambeth 1999). As in Samoa, Chuukese women collect the Polian vesicles in bottles and sell them in jars or empty soft drink bottles mixed with fresh lime juice or salt water to preserve them. In Cook Islands, the intestines of *Holothuria leucospilota* and *H. cinerascens* are occasionally eaten by older people for homeopathic purposes. The guts of *H. leucospilota* are collected during the cool months of the year at which time the gonads have fully ripen. In most of Melanesia — despite some subsistence use being reported in Papua New Guinea for *H. fuscogilva*, *H. nobilis* and *Thelenota ananas* and in Vanuatu — sea cucumbers are not as popular a food item as in Polynesia and Micronesia. In some islands, such as Vanuatu, sea cucumber consumption is slowly disappearing. In other islands, sea cucumbers are not found on either traditional or modern menus.

[2] At the time of publication, 1US dollar = 2.82 Samoan tala.

1.1 Palau's subsistence sea cucumber fishery

The subsistence harvest and use of sea cucumbers in Palau occurred long before they were harvested commercially. Over the years, the sea cucumber harvesting has developed into an important semi-commercial fishery that supplies both the local market and the export market (for Palauans living abroad). The raw sea cucumber products in Palau (different from the traditional commercial dried product normally exported to the Asian market) is consumed mainly by native Palauans as a traditional delicacy. Export of the product is entirely for home use by Palauans based in Guam, Saipan and the USA. In total, 8 of the 31species of sea cucumber present in Palau are harvested by the subsistence fishery. These include *Holothuria scabra* (molech), *H. impatiens* [3] (sekesakel), *Actinopyga* sp. (ceremrum), *Stichopus vastus* (ngimes), *S. horrens* (irimd), *Thelenota ananas* (temtamel), *Bohadchia similis and B. vitiensis*. The most commonly eaten ones are molech, ceremrum, ngimes, sekesakel (Table 1 includes both the scientific and local common names).

The guts of ngimes, sekesakel and molech are consumed as a delicacy and the flesh from the body wall of molech and ceremrum is processed into an edible form and consumed raw. Of these four sea cucumbers, molech (*H. scabra*) is the most important because the whole animal (body wall and guts) is eaten. *Sekesakel* (*H. impatiens*) is not as common as the other species and is known to be present only in Ngarchelong State where the present supply mostly originates from. Because of its local rarity, sekesakel is regarded a high-value local delicacy. About 20 animals make a "pack" of sekesakel guts, which are sold at the local market for USD 5.00 per pack (Harvey Renguul, Fisheries Development Specialist, Bureau of Marine Resource, pers. comm. 2008). The guts and flesh of other species (e.g. molech and ceremrum) are sold locally at USD 1.50–2.50 per pack for one half and one kilogram packs.

Palau's subsistence sea cucumber fishery supplies three categories of consumers: household consumption, local market sales and export for home use by families living abroad in Guam, Saipan, Hawaii and the mainland USA. Landings of raw sea cucumbers by this fishery from 1989–1998 averaged at 11.3 mt per year. From these annual landings, 6 mt (52%) were directly consumed at the domestic household level, 5.4 mt (48%) were sold locally, and 0.52 mt were exported for home use overseas (Palau Conservation Society 2000).

The high-value *H. scabra* is protected under the 1995 commercial moratorium, although harvesting by the subsistence fishery is legally allowed. This loophole can cause serious depletion of the species, which can defeat the whole purpose of the original commercial ban placed on this species.

1.2 Collecting and processing sea cucumbers

Palau is one of a few Pacific Island countries whose inhabitants have, over many years, discovered different processing techniques for sea cucumbers. Over 10 species of sea cucumbers are considered edible by indigenous Palauans. Collecting and processing is primarily done by women, although some men do participate. The four species of

[3] Sekesakel is one of several species of the *Holothuria impatiens* group that need to be reclassified and renamed from results of ongoing genetic studies.

importance to the subsistence fishery (and which will be looked at in this assessment report) are *Holothuria scabra, Actinopyga* sp., *Stichopus vastus* and *H. impatiens*. They are shallow water inshore species found in soft bottom seagrass beds which are associated with mangroves. Collecting is done in groups of two or more fisherwomen at low tide by wading and by snorkeling. A canoe, dinghy or raft is used to load the catch. Gutting and cleaning is done on the beach for ceremrum and molech. For ngimes and sekesakel, only the gut is edible, which is removed at sea and kept in bottles. Processing, treatment and preparation methods are provided in the results section of this report.

1.3 Management of the sea cucumber fishery

Palau's sea cucumber fishery is managed under Palau's Marine Protection Act 1994. Under this legislation, the commercial export of six species is prohibited. These species are *Holothuria nobilis* (black teatfish), *H. fuscogilva* (white teatfish), *H. scabra* (sandfish), *Thelenota ananas* (prickly redfish), *Actinopyga mauritiana* (surf redfish) and *A. miliaris* (blackfish). *H. scabra* is consumed locally as a delicacy and is allowed to be harvested for subsistence purposes which include also domestic sales. The subsistence harvest and sale of *H. scabra* for domestic consumption, local market, retail sale and export to relatives abroad for subsistence use continues to take place. Increasing exploitation by the subsistence fishery today can have the same devastating impact on the resources just as the commercial export oriented fishery. As being experienced in Palau regulating against commercial exploitation of only a few species can be challenging. For instance, a sea cucumber trader in Palau exported dried sandfish (a banned species) under the name of dried *S. vastus* which is not protected. Other management policies in Palau include a restriction on gear, such as scuba and hookah, for reef associated fishing including sea cucumber.

The marine tenure system is a strong tradition in Palau and is known as "buls". Buls are controlled by traditional chiefs in each state to help manage resources. In recognition of this role, Palau's constitution maintains that each state has the responsibility to own, manage and control all activities within their lagoons, inshore areas and reefs extending 12 nautical miles outwards from the shoreline. Inshore fisheries are managed by the states whose functions are influenced largely by traditional chiefly lines. The national government maintains an advisory role to states in all matters, including resource management. Access to fish within a state is granted by the traditional leader's institution, which is an integral part of the state administration.

Mariculture development for brown curryfish *(Stichopus vastus)* was initiated in Palau in 2000 by a private Korean-owned company in joint venture arrangement with a local interest. Farming operations, involving cutting up *S. vastus* and seeding them in fenced areas on the reef, were conducted in Ngaremlengui State. Harvests were made a month later and trials were conducted in drying products. A small quantity of exports was made between 2000 and 2003. This activity was terminated in 2004 for illegally exporting dried *Holothuria scabra* as dried *S. vastus*.

2 Aim of this report

Domestic consumption of sea cucumbers has been an important part of food security needs for Palauans for many years. At the same time, demand for this local delicacy to the working population in Koror and abroad has opened an outlet market for Palau's fisherwomen. Sale of sea cucumbers is today an important income activity for some rural fisherwomen. But for many years, little was known about this resource, particularly fishery status information for management decisions. There are no harvesting control measures on *Stichopus vastus*, *Actinopyga* sp. and *Holothuria impatiens*. *H. scabra* is the only species protected for commercial export under the Marine Protection Act 1994; however, a fishing exemption placed on the subsistence exploitation has seen continuous fishing of *H. scabra* even though there is a national ban on this species. During the Palau national sea cucumber development plan workshop in August 2008, exploitation of sea cucumbers by the subsistence fishery was a significant sector requiring some attention. Thus, this status report serves to document this fishery and the main resources involved in order to assist in the management and decision-making processes. Specifically this report aim to:

1. Provide the status of Palau's subsistence sea cucumber fishery in support of the development of a sea cucumber management plan for Palau.
2. Clearly identify issues and provide information on traditional sea cucumber processing techniques used in Palau.
3. Present the results of the comparative study on the status of the four sea cucumber resources in the states of Ngarchelong, Ngatpang, Airai and Koror, based on PROCFish/C surveys conducted in 2007.
4. Provide recommendations for management improvements based on resource survey results and existing management policies.

3 Methodology

3.1 Interviews and discussions

Information on sea cucumber processing techniques in Palau was obtained by talking to fishers and Bureau of Marine Resources (BMR) fisheries officers during the resource survey mission in April 2007 and the sea cucumber management workshop in August 2008. More informative discussions and interviews were made with past sea cucumber traders, sellers and fisheries officers from BMR during the sea cucumber management workshop. Visits were made to Yanos Market, a local shop specializing in local food products, and the local market in Koror, which opens once a week. In addition, published works by other authors — for example, Kitalong (2008) and Mathews 2003 — provided benchmark information for this report. Production estimates from the four sites of Ngahelong, Ngatpang, Airai and Koror were collected from structured interviews conducted by Mecki Kronen, Secio-economic specialist of the PROCFish/C Project in April 2007.

3.2 Resource survey methodology

The sea cucumber resource assessment at the four sites (Ngachelong, Ngatpang, Airai and Koror) was conducted by the PROCFish/C project, which was implemented by the Reef Fisheries Observatory of the Secretariat of the Pacific Community (SPC). The survey methodology adopted was based on the standardized resource surveying protocol being refined in 17 Pacific Island countries. Belt transects on soft benthos habitats (soft

benthos transect) was used to assess sea cucumbers inhabiting soft bottom areas, including seagrass beds near mangroves. Local knowledge from local fishermen is very helpful in locating aggregation and suitable habitats. Marine protected areas should be identified by asking villagers.

Six belt transects (40 m x 1 m wide) or replicates were assessed per station. Two observers snorkeles on either side of the transect line and record sandfish and other invertebrates within the 1 meter width (Fig.1). Each surveyor completes 3 transects each to make up the 6 replicates. Species associated to sea grass beds include sea cucumbers, sea urchins and gastropods. Transects are randomly positioned across environmental gradients where possible (usually across a reef flat and not along reef edges). A single waypoint was recorded for each station (to an accuracy of ≤10 m) and habitat features were noted for each transect.

Sandfish can be nocturnal (active at night) but they can be found easily at daytime. At daytime they burrow in the sand during daytime although the can easily be located by experienced eyes. Where there are high aggregations, many sandfish can easily be seen exposed on the bottom. All sea cucumbers contract in size when they are disturbed. Therefore, the best length measurement is taken as soon as the animal is picked up. For some larger species, measurements can be taken while the animal is lying on the bottom (i.e. without actually picking it up).

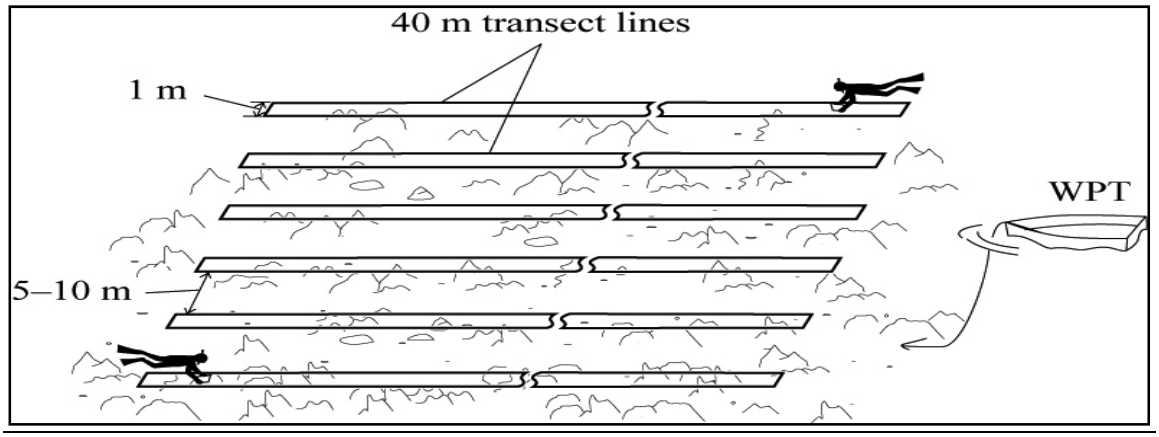


Figure 1: Soft benthos transect assessment technique.

Data entry, cleaning, analyzing and reporting were made using the Reef Fish and Invertebrate Database (RFID) at SPC's headquarters in Noumea, New Caledonia.

4 Results

4.1 Species identification and use

Identifying sea cucumbers to the species level is problematic. Many species have been renamed as new study results are able to verify their genetic composition. At the local level, mis-identification leads to poor knowledge about the resource and its management. In Palau, two of the four locally exploited species — blackfish (*Actinopyga* sp.) and brown curryfish (*Stichopus vastus*) — are of national importance for food security, although both have been repeatedly misnamed. Proper species identification is necessary for a general understanding of species diversity, product marketing, and developing resource management measures. Here we provide corrections to the existing confusion over these species.

4.1.1 Actinopyga sp.

Actinopyga sp. have remained undescribed for many years because biologists visiting Palau and other countries in its distribution range in the past have failed to closely examine specimens of this species. They have apparently confused the species with *Holothuria lessoni* previously described as a sub-species of *Holothuria scabra*. A close examination reveals though that the species cannot be from the genus *Holothuria* given the presence of the five anal teeth (Figure 2A), which is typical of the genus *Actinopyga*.

The species has also been wrongly named in Palau as *Actinopyga miliaris*. This confusion is understandable given the similarity in the appearance or features of the two species, along with an overlap of their habitat. *Actinopyga* sp. has a black color morph (Fig. 2B), which makes it look very similar to *A. miliaris*. In Yap State, in the Federated State of Micronesia, this species was sold under the commercial name of “sandfish”. The species is currently named as *Actinopyga* sp. and should be described soon by specialists from the University of Guam.

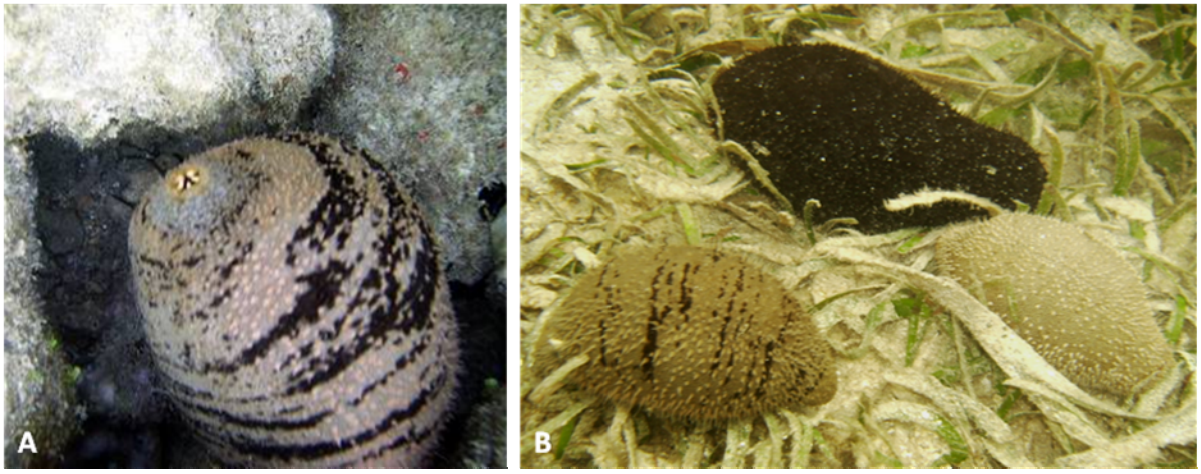


Figure 2: *Actinopyga* sp. found in Palau and Yap states, Federated States of Micronesia. Note the anal teeth (A) and three color morphs: black, beige and striped (B).

Processing technique

Actinopyga sp is mostly collected by women although men are sometimes involved. All sizes of *Actinopyga sp* are eaten by Palauans. Smaller and younger animals (6–10 cm) are normally preferred over larger specimens because their body wall is soft and tender and can be eaten raw or prepared directly without further processing. The body wall of larger animals goes through a specialized processing technique before they are ready for preparation into an edible form. Processing is done in two steps, cleaning and softening. Before gutting, the catch is cleaned by adding salt to a sack of animals and then rubbing them against a rock or repeatedly stomping on the sack (see Fig. 3). In this process, animals are rubbed against each other and the excessive body mucus is squeezed out. In pre-colonial times when salt was not available, ash from wood was used instead.

The body wall of the animal is normally tough and has to be softened in a process called "hanging". The cleaned pieces are placed in a mesh basket (normally made of chicken wire mesh) and hung out overnight. The body wall slowly melts into a jelly-like form and drips through the mesh by gravity into a basin placed underneath the basket. The softened meat is cut up into fine slices or is minced, and eaten raw with lemon juice or packed for sale to shops, restaurants and the local market in Koror.

Figure 3: Processing ceremrum (*Actinopyga* sp.) in Palau. Fisherwomen of Airai State catch and clean their catch at Ngatpang by 'stomping' on the catch (left) followed by cutting and cleaning (right).

4.1.2 Stichopus vastus

The brown curryfish, *Stichopus vastus* is quite common in Palau, inhabiting the same habitat as *Actinopyga* sp. Both species tend to have a wider distribution range, with larger specimens occupying deeper soft or coral rubble areas outside of seagrass beds. Confusion over the identity of this species is apparent. For instance, Lambeth (1999) reported it as curryfish, *S. herrmanni*, which was previously named *S. variegatus*. The species is often also called *S. horrens* by some researchers. Recent analysis, however, shows that this cannot be the case because both species are markedly different. The presence of the depressed harlequin pattern on the body surface and the ease with which specimens disintegrate has ruled out the possibility that the species in question were juvenile *S. herrmanni*. The Palau Coral Reef Centre has labeled a photographed specimen as *Stichopus* sp.

On the ventral side of the species, the color has a reddish-pink tone and is yellowish in some specimens. The other conspicuous features are wart-like protrusions on the body surface of smaller specimens or juveniles. These wart-like structures disappear as the animal reaches adulthood. Adult specimens are usually very large (over 300 mm) and are seldom seen in large aggregations. Different color morphs are found in Palau and Yap (Fig. 4). The specimens resemble brown curryfish and, therefore, can be named *S. vastus*, although they could possibly be a different species. Further genetic examination is warranted to confirm the identification.

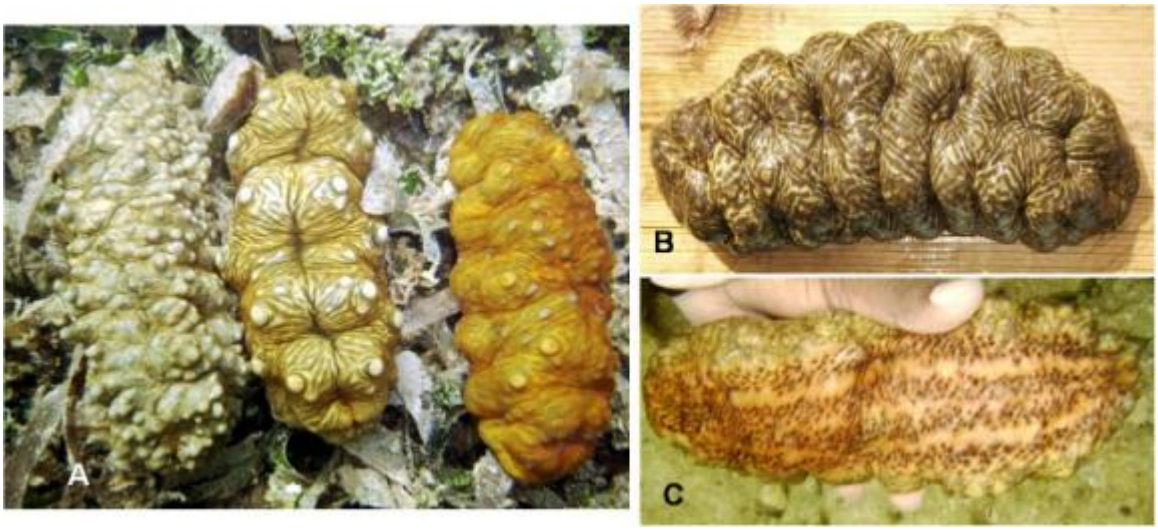


Figure 4: *S. vastus* (ngimes) morphological types found in Palau (A) and the same species from Yap State in the Federated States of Micronesia (B & C).

The highly skewed size distribution in Palau (favoring smaller size classes) (Fig. 4A) suggests that: 1) due to over-crowded conditions, animals have become stunted in growth, hence many of juveniles could actually be adults; 2) the species may not be *S. vastus* at all but a totally new or different species of *Stichopus*. Because of this, a number of samples of the species were taken and sent for DNA testing.

Processing technique

Ngimes (Fig. 3C) is exploited in Palau for its Polian vesicles in the same manner as *Stichopus horrens* (irimd) is being exploited in Samoa. Although fishers in Palau harvest the animals at any time that is convenient to them, collection is preferred just before low tide in the morning when the animals' guts are free of sand and other impurities. The animals are cut into half along the latitudinal plane to extract the viscera. *S. vastus* is a fissiparous sea cucumber species that reproduces asexually by splitting, whereby the posterior end develops a new anterior and the anterior end develops a new posterior. Cutting the animal into two pieces would resemble natural process of splitting which give rise to two separate animals. This would be less damaging and would incure less stress on the animal as compared to if it was cut to more than two pieces. Sliced animals are released back into the seagrass beds to regenerate. *S. vastus* fishers usually target the same seagrass beds because animals with newly re-grown guts are known to taste better than animals that were never gutted before (Harvey Renguul, Fisheries Development Specialist, Bureau of Marine Resource, pers. comm. 2008). At home, fishers spread the intestines out over a pile of green leaves in order to drain out excess sea water before they are prepared into an edible form (usually raw). The taste is rich and slightly metallic, with a strong but pleasant aftertaste (similar to raw oysters), and is often enjoyed with a little lime juice and is eaten with cooked fish, tinned fish, smoked fish or spam. Ngimes intestines are also sold locally in half kilo plastic packs and sold for USD 2.50–2.95 at the local market and in Koror.

4.1.3 Holothuria impatiens

Holothuria impatiens has more than 10 recorded sub-species throughout its range. The sub-species that have wide variation in features are lumped together under the *H. impatiens* complex which is known collectively as "sekesakel" in Palau. The species has a narrow distribution range compared with the other three species. The animal has a number of color morphs, ranging from grey to pale-white. Their body is covered with many blunt stud-like protrusions (Fig. 5). It is thought that the morphs may actually be different sub-clades of the species. When touched or disturbed, the animal very quickly contracts in size, an adaptive response to escape from predators and living in confined spaces. Compared with other sea cucumbers of commercial importance, this species has a very thin body wall, making it unsuitable for export. In Palau, the observed habitat for *H. impatiens* is soft substrate under mats of macro-algal assemblages (e.g. *Halimeda* sp., *Clathrus clathrus*, *Caulerpa* sp. and *Dictyota* sp.) in 0.5–1.0 m of water. In Ngachelong, the algal mats are usually found in crater-like depressions within seagrass beds on very soft substrates. An extensive flat containing such assemblages is found in the eastern end of Ngarchelong where the species is found in high abundance. However, no proper assessment of this resource was made because the species was regarded as having no commercial importance. A rough estimated density of 20 animals/m^2 was recorded in some stations of the site.

Figure 5: Two color morphs of *H. impatiens.* Note presence of studs on the body surface.

Processing technique

H. impatiens is used in the same manner as *S. vastus*. Collected animals are incised in the field and the Polian vesicles (Fig. 6) are collected into bottles. *H. impatiens* is a non-fissiparous species that does not regenerate after cutting. The animal is killed in order to remove the intestines which explains its existing low population in the four sites. *H. impatiens* was recorded only in the northern State of Ngarchelong. According to local Fisheries Officers, the species is also very rare elsewhere in the country (Harvey Renguul, Bureau of Marine Resource, pers. comm. 2008). *H. impatiens* seems to have a narrow distribution and is not harvested as often as the other three species. Its rare taste make *H. impatiens* guts more exotic and seen as a prestigious food item compared with the other locally exploited species. this product is uncommon at Koror Market and is sold at USD 5.00 per half a kilo pack. In total, 50 or more animals are killed to produce half a one-kilo pack of *H. impatiens* product.

Figure 6: Incised *H. impatiens* specimen showing the edible Polian vesicles.

4.1.4 Holothuria scabra

H. scabra (Fig. 7) is a premium value species in the commercial dried beche-de-mer trade. Commercial harvesting of *H. scabra* is illegal under a ban instituted in 1994, with the exception of subsistence harvesting. *H. scabra* has been continually targeted by subsistence fishers, because: a) both its meat and guts can be eaten, b) all sizes are used regardless of where they are collected on the reef (but larger animals are fleshier than smaller ones), c) there is more meat in molech than in *Actinopyga* sp or *S. vastus*, thus it is more valuable, and d) they are easy to process. *H. scabra* is uncommon is not widely distributed because of its particular habitat needs. A good aggregation in Palau was recorded in a state-run marine protected area at Ngatpang State.

Figure 7: ***Holothuria scabra***

Processing technique

Unlike *Actinopyga* sp which takes time to process, and *S. vastus* which is collected from specific places, *H. scabra* is collected regardless of size and where they are found. The body wall is immersed in warm water to soften the outer skin layer, which is then scraped clean before being cut into thin slices and eaten raw with lemon juice. The guts are extracted and consumed separately also with lemon juice and both products are sold separately at the market. *H. scabra* is protected from commercial harvest (dried product) but is allowed for subsistence use which include also local sales.

4.1.5 Other locally used sea cucumber species

Other sea cucumbers exploited by Palau's subsistence fishery include *Stichopus horrens*, *Bohadchia similes, B. vitiensis*, and *Thelenota ananas* but are less common than the afore-described species. The processing methods of these and the previously mentioned four sea cucumber species are presented in Table 1.

Table 1: Sea cucumbers exploited by Palau's subsistence fishery.

Species	Common name	Local name	Local use	Protected	Processing method
Stichopus vastus	brown curry	ngimes	✓	X	Intestines only are edible raw.
Holothuria scabra	sandfish	molech	✓	✓	Intestine and meat eaten raw. Meat is soaked in warm water, skin scraped off, cut into slices.
Actinopyga sp	blackfish	ceremrum	✓	X	Meat only is edible raw, cleaned and gutted, hinging overnight to soften, prepared next day.
Holothuria impatiens		sekesakel	✓	X	Guts only are eaten raw.
Bohadschia similis	chalkfish	esobel	✓	X	Gonad is edible raw but uncommon.
Bohaschia vitiensis	brown sandfish	delai a mermarch	✓	X	Meat only is edible, soaked in warm water, cleaned, slice and fry with soy source.
Stichopus horrens	peanutfish	irimd	✓	X	Intestine only is edible raw.
Thelenota ananas	prickly redfish		✓	X	Meat only is edible, soaked in warm water, skin scraped off, sliced and mixed with leaves of titimel (Polynesia vi-apple *Spondius dulcis*) over night to soften. Prepared a day after, eaten raw.

4.1.6 Production and marketing

Products

Palau's subsistence sea cucumber fishery can be divided into three categories: subsistence consumption, local market sales and export for home consumption to relatives overseas. The final product comes in three forms (thinly sliced only, guts only and minced) and is sold in two size packs (half-pound packs as shown in Fig.8 A, B & C) and a one-pound pack as shown in Fig.8D). Molech, ngimes and sekesakel products are sold only in half-pound packs while ceremrum products are sold in both half pound and one-pound packs, especially for the minced form. Each pack is clearly labeled with the local sea cucumber name, product type and price. Sea cucumber products comprise a fair proportion of invertebrate products offered on Sale at Yanos Market Figure 9.

Figure 8: Raw sea cucumber products packed for sale at local market in Koror: sliced *H. scabra* meat in 0.5kg pack (A), sliced *Actinopyga* sp meat in o.5kg pack (B), *H. scabra* guts in 0.5kg pack (C) and minced *Actinopyga* sp meat in 1kg pack (D).

Figure 9: Typical raw invertebrate seafood on the shelf at Yanos Market in Koror, Palau. Products (A) and (B) are other products of invertebrates other than sea cucumber, the rest are sea cucumber products

Pricing

The retail pricing information were from the Yanos Market and the local market price were from the once weekly local market at Koror. A fisherwoman from Ngatpang Stat who also supplied products to Yanos Market was interviewed in September 2008. She sells over 120 packs of sea cucumber (all species combined) to shops and restaurants in Koror weekly on order. *S. vastus* and *S.horrens* products were most popular products but she prefers selling *H. scabra* because she earns more from it. Both the meat and guts of *H. scabra* are sold and the processing is easy.

When out fishing she would choose to collect *H. scabra* which is rare nowadays while Actinppyga sp and S. vastus are more common. She employs another women to help her out in her business. A summary of local market prices for sea cucumbers products are presented in Table 2. Note that *H. impatiens* was not on sale at the time of visit so is not included. H. impatiens is known to be sold at US$5.00 per pack.

Table 2: Sea cucumber product prices at the local markets in Palau.

Species	Product	Package weight (kg)	Fishers' sale price (USD)	Retail price (USD)	Mean package price (USD)
Ceremrum	meat sliced	0.5	1.50	1.95	1.73
Ceremrum	meat minced	0.5	1.50	1.95	1.73
Ceremrum	meat minced	1.0	2.50	2.95	2.73
Molech	meat sliced	0.5	2.50	2.95	2.73
Molech	gut	0.5	2.50	2.95	2.73
Ngimes	gut	0.5	2.50	2.95	2.73
Irmid	polian vesicles	0.5	1.50	2.95	2.73
Mean		**0.57**	**2.07**	**2.66**	**2.44**

An income idea can be worked from information provided at least for this one fisher. With her sale of 120 packs of sea cucumbers per week, at an average sale price of USD 2.07 per pack, she would make around USD 248.00 per week from selling sea cucumbers alone. Provided she sells four times in a months, her monthly produce would be 480 packs or 273.6 kg at an average weight of 0.57kg per pack. This would generate an income of approximately US$993.00. If this level of production is maintained throughout the year (12 months), her total production would be 3,283 kg (or 3.283 mt) valued at USD 11,923. On the other hand if she is active only half of the year (six months) her total production would be 1,641 kg and she would earn around US$ 5,961.00. These are rough estimates but give some understanding of the level of impact of the fishery in fishers income generation and resource sustainability.

Export for home consumption

As a traditional delicacy, native Palauans living abroad also grave these products. Home consumption of sea cucumbers by Palauans living abroad is a strong part of this fishery. Export for this purpose cannot be classed as the traditional commercial bech-de-mer trade but rather an extension of the subsistence sector. Current export trend in this category is unclear due to lack of inpromation, but according to local fisheries officers, the export of raw sea cucumber products is now a significant component of this fishery. Inspection activities at the airport was effective although data may not be their main focus. According to Harvey Renguul fo BMR, sea cucumber products are shipped on nearly all flights out of Palau and the sizes of cooler boxes (normal packing method) have increased (small boxes in the past, bigger boxes more recently).

Production

Landing of raw sea cucumbers from 1989–1998 was averaged at 11.3 mt/year. From these annual landings, 6.0 mt (52%) were directly consumed at the domestic household level, 5.4 mt (48%) were sold locally, and 0.52 mt was exported for home use overseas (Palau Conservation Society 2000). Productions at the four sites in Palau studied in 2007 by the PROCFish/C Project provided some useful figures. The results of the socioeconomic survey (Table 3) indicates higher productions for the two northern states of Ngatpang and Ngarchelong than the two central sites of Airai and Koror. At the species level (Table 3), production of *Actinopyga sp* were more important in Ngatpang and Koror while *H. impatiens* was produced only in Ngarchelong State.

Table 3: Total estimated catch (wet weight) of sea cucumbers in the sites (2007 PROCFish/C socioeconomic surveys).

Sites	Total annual catch surveyed (mt)	total annual catch estimated (mt)	% sale	% home consumption
Ngatpang	6.3	18.7	8.7	10.0
Ngarchelong	7.7	27.4	9.7	17.7
Airai	3.9	7.5	1.0	6.5
Koror	3.0	12.0	0.0	12.0
Total	**20.9**	**65.6**	**19.3**	**46.2**

Table 4: Production estimates (mt) by species by sites (2007 PROCFish/C socioeconomic surveys).

Local name	Species	Ngatpang	Ngarchelong	Airai	Koror
Ceremrum	*Actinopyga* sp.	14.9	5.6	2.1	11.4
Ngimes	*Stichopus vastus*	2.2	6	3.5	3.6
Molech	*Holothuria scabra*	0.9	2.3	0.7	0.5
Sekesakel	*Holothuria impatiens*	0.0	11.2	0.1	0.2
Irimd	*Stichopus horrens*	0.6	2.3	1.0	0.0
Total		**18.7**	**27.4**	**7.5**	**15.7**

It should be noted these data are based on estimates, and although they provide useful information, they should be looked at against landing data to balance the view of production trends.

5 Resource survey results

5.1 Survey coverage

The survey coverage is shown in Figure 10. The four sea cucumber species — *Holothuria impatiens*, *H. scabra*, *Stichopus vastus* and *Actinopyga* sp. — were among 31 species of sea cucumbers found in the four study sites.

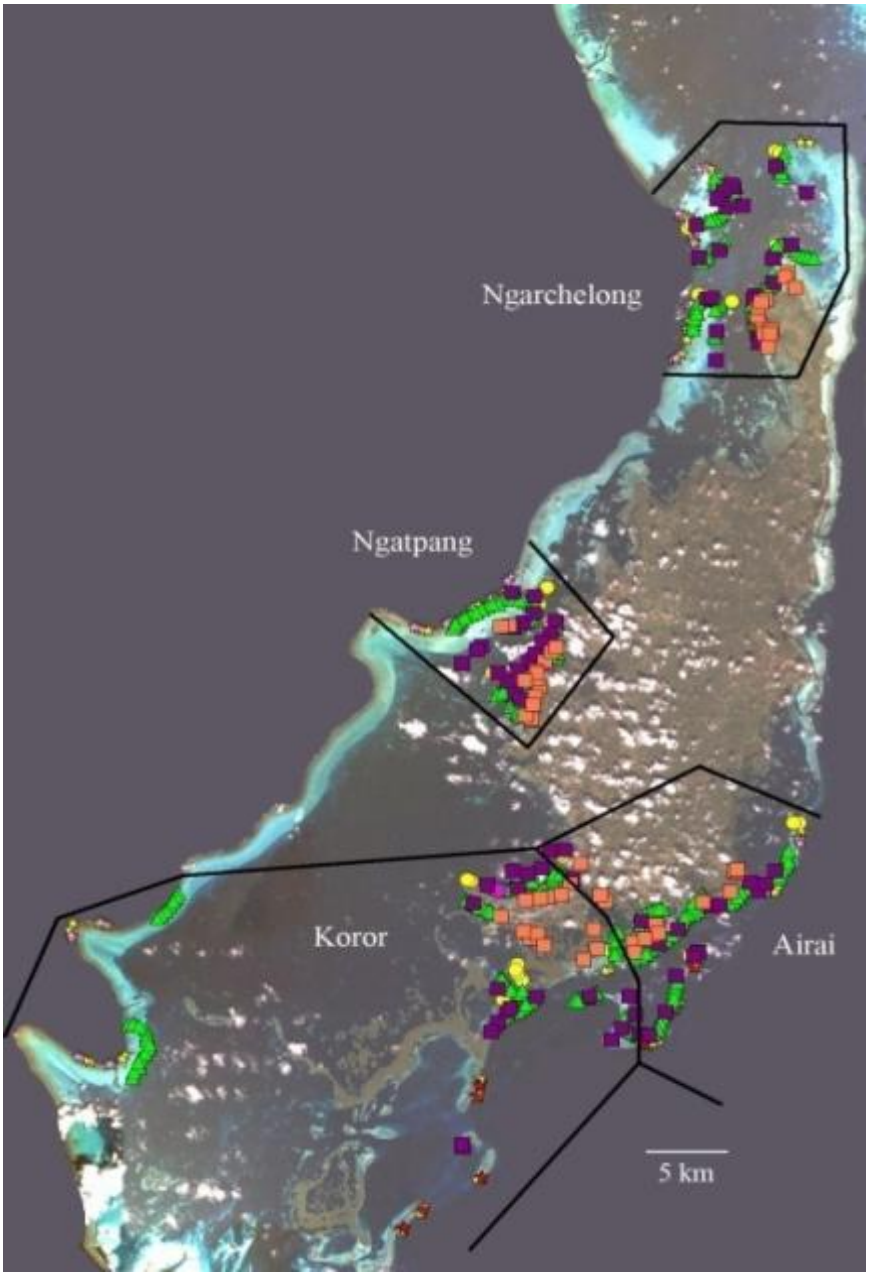


Figure 10: of the four survey sites in Palau. Color codes denote different survey methods used: soft benthos transect (purple square); manta tow (green triangle); sea cucumber day search (yellow circle); reef front search (yellow star); reef benthos transect (red square).

5.2 Densities of sea cucumber species

S. vastus was present in the highest average density of all the sea cucumber species recorded at soft benthos transect (SBt) stations (5,281 ± 1,732SE/ha) and was present mainly in the inner lagoon areas on seagrass beds near mangroves (Table 5 and Fig. 11). Densities recorded recorded at the four sites were good but the highest densities occurred in Airai 3,163.7 ± 1,689 SE/ha and 17,445.5 ± 6,071 Ngarchelong. The mean sizes and densities of *S. vastus* contrasted sharply with those of similar sites in the Pacific. For instance, high densities of smaller sized specimens with only a few large specimens were present in Palau, whereas in other Pacific Island sites, juveniles are rare and adults are rare to find.

Actinopyga sp. was ranked third common in terms of density of all sea cucumbers, with 2,128 ± 1,084SE/ha at SBt stations. *Actinopyga* sp. is found in Palau and on the neighboring island of Yap (Federated States of Micronesia). High densities were recorded at Ngarchelong and Ngatpang while densities in Koror and Airai were low (Table 5; Fig. 12).

Holothuria scabra was recorded in low to medium densities in Ngarchelong, Ngatpang and Airai states while no specimens were recorded in Koror State. Again the two northern sites had higher densities than other sites. Average densities for *H. scabra* were low at 281.1 ± 110.7SE/ha (Table 5; Fig. 12). *H. scabra* has a narrow distribution range and its typical habitat is soft substrate among strands of tall seagrass (*Enhalus acoroides*). These habitats are found in the sites surveyed but densities were relatively low to moderate. In Ngarchelong and Airai, high numbers were found on clean sandy areas with relatively clear waters while in Ngatpang they were found near the mangroves inside a state-enforced marine protected area. This species can reach several thousand specimens per hectare (Conand 1988); the highest density recorded in Palau was 4,708 specimens/ha at one SBt station of Ngatpang.

Holothuria impatiens is a cryptic species that seems to have a narrow distribution range. Data collected was not enough to provide a good picture of this species. If density estimates are needed, then dedicated surveys should be conducted. Average densities for all sea cucumber species is provided in Table 5.

Table 5: Average densities of all sea cucumber species recorded at SBt stations at Ngarchelong, Ngatpang, Koror and Airai states in Palau.

		Airai		Koror		Ngarchelong		Ngatpang		All sites	
Species	Local name	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE
Actinopyga echinites		53.6	44.4			16.0	7.5	2.8	2.8	18.2	11.5
Actinopyga lecanora		3.0	3.0			3.2	3.2			1.5	1.1
Actinopyga miliaris	ceremrum	20.8	14.3					108.3	94.1	34.8	26.0
Actinopyga sp.	ceremrum	113.1	86.3	12.8	9.9	3682.7	2267.3	4494.4	3422.0	2128.0	1084.4
Bohadschia argus						12.8	12.8	5.6	3.8	4.5	3.2
Bohadschia similis		1381.0	1027.9	3.2	3.2	496.8	384.9	2.8	2.8	470.5	280.2
Bohadschia vitiensis		943.5	444.3	125.0	111.5	439.1	254.3	16.7	7.9	378.0	136.4
Holothuria atra		3360.1	1164.6	7689.1	1653.8	897.4	229.6	3247.2	1393.5	3770.5	687.3
Holothuria coluber		50.6	25.2	51.3	41.4	67.3	34.2	55.6	39.4	56.1	17.3
Holothuria edulis		544.6	340.3	384.6	260.0	105.8	88.8	2.8	2.8	255.3	109.3
Holothuria flavomaculata		1104.2	1104.2	16.0	13.0			2.8	2.8	285.6	281.0
Holothuria hilla		32.7	19.6	3.2	3.2	28.8	15.9			15.9	6.4
*Holothuria impatiens***	sekesakel										
Holothuria nobilis								2.8	2.8	0.8	0.8
Holothuria pervicax		3.0	3.0							0.8	0.8
Holothuria scabra	molech	44.6	31.0			455.1	207.7	594.4	350.7	281.1	110.7
Stichopus chloronotus		3.0	3.0			25.6	13.8			6.8	3.5
Stichopus hermanni		14.9	10.3							3.8	2.7
Stichopus horrens	irimd	14.9	14.9	19.2	13.8	19.2	11.2			12.9	5.6
Stichopus vastus	ngimes	3163.7	1689.4	586.5	333.7	17445.5	6071.2	783.3	458.7	5281.1	1731.8
Synapta maculata		6.0	4.0	41.7	21.6					11.4	5.6
Synapta sp.		8.9	6.4	64.1	38.5	22.4	10.1	5.6	3.8	24.2	9.8

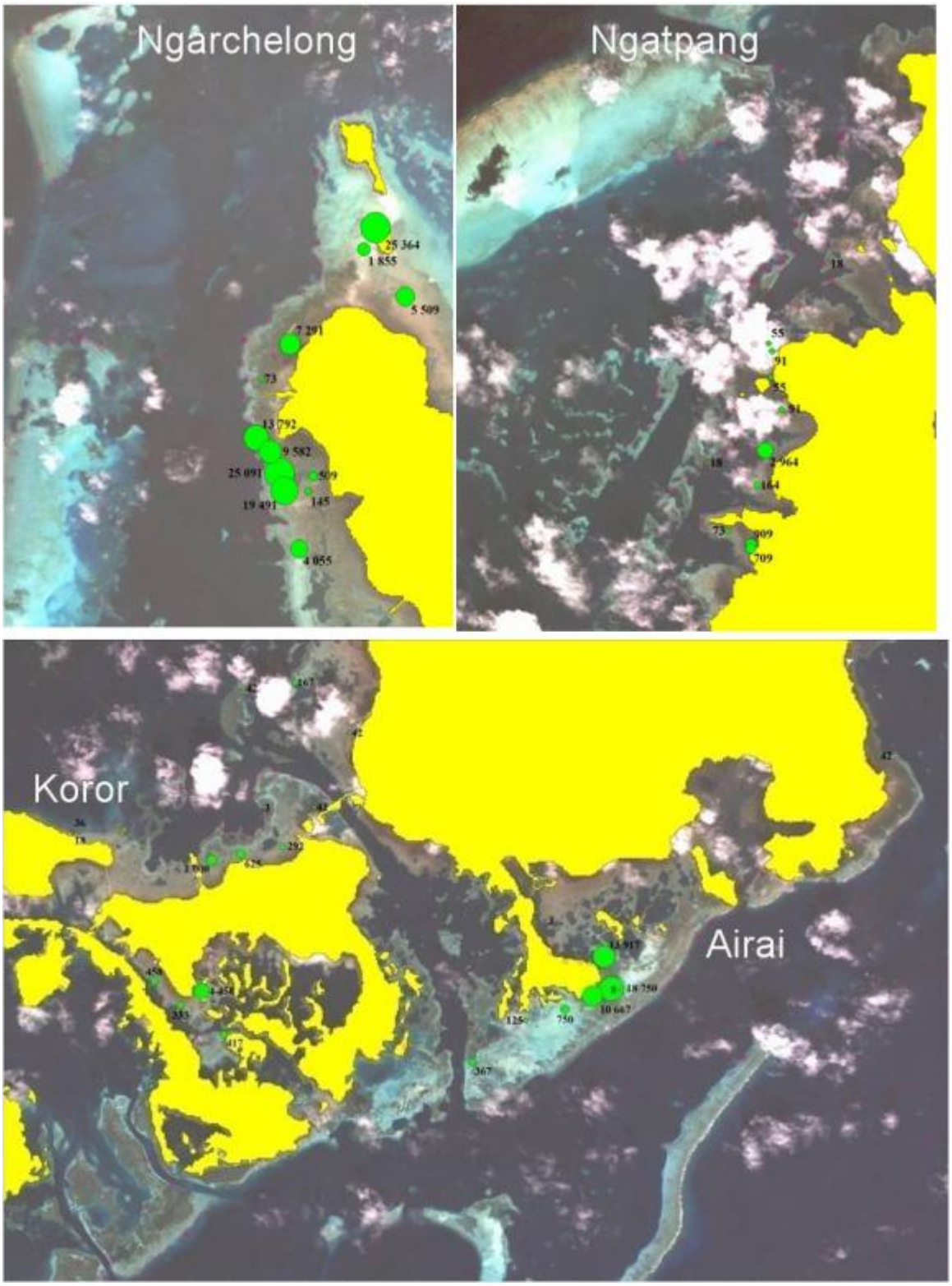


Figure 11: *Stichopus vastus* (ngimes) density distribution at the four sites in Palau.

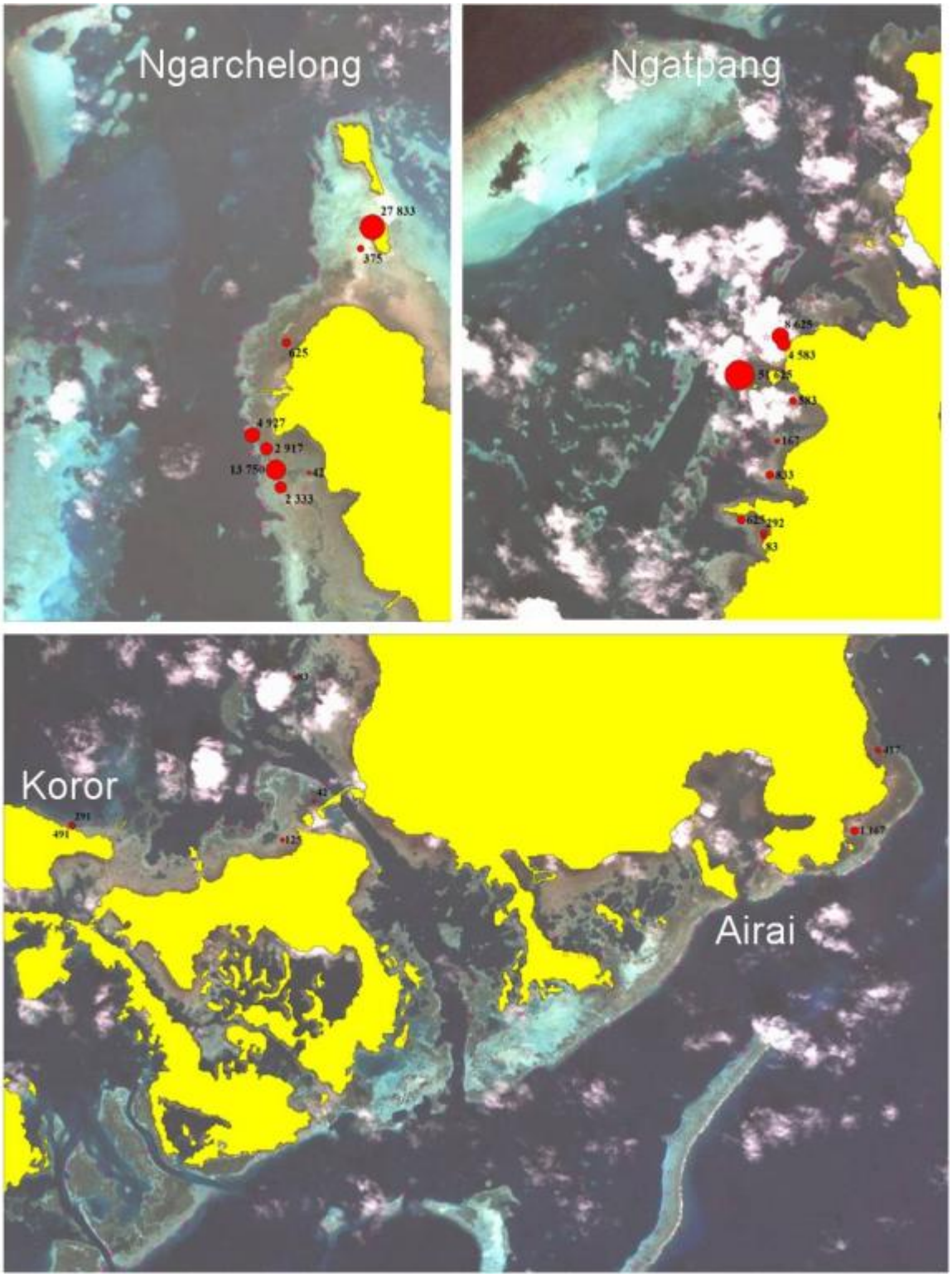


Figure 12: Density distribution (specimens per hectare) of *Actinopyga* sp. at the four sites in Palau.

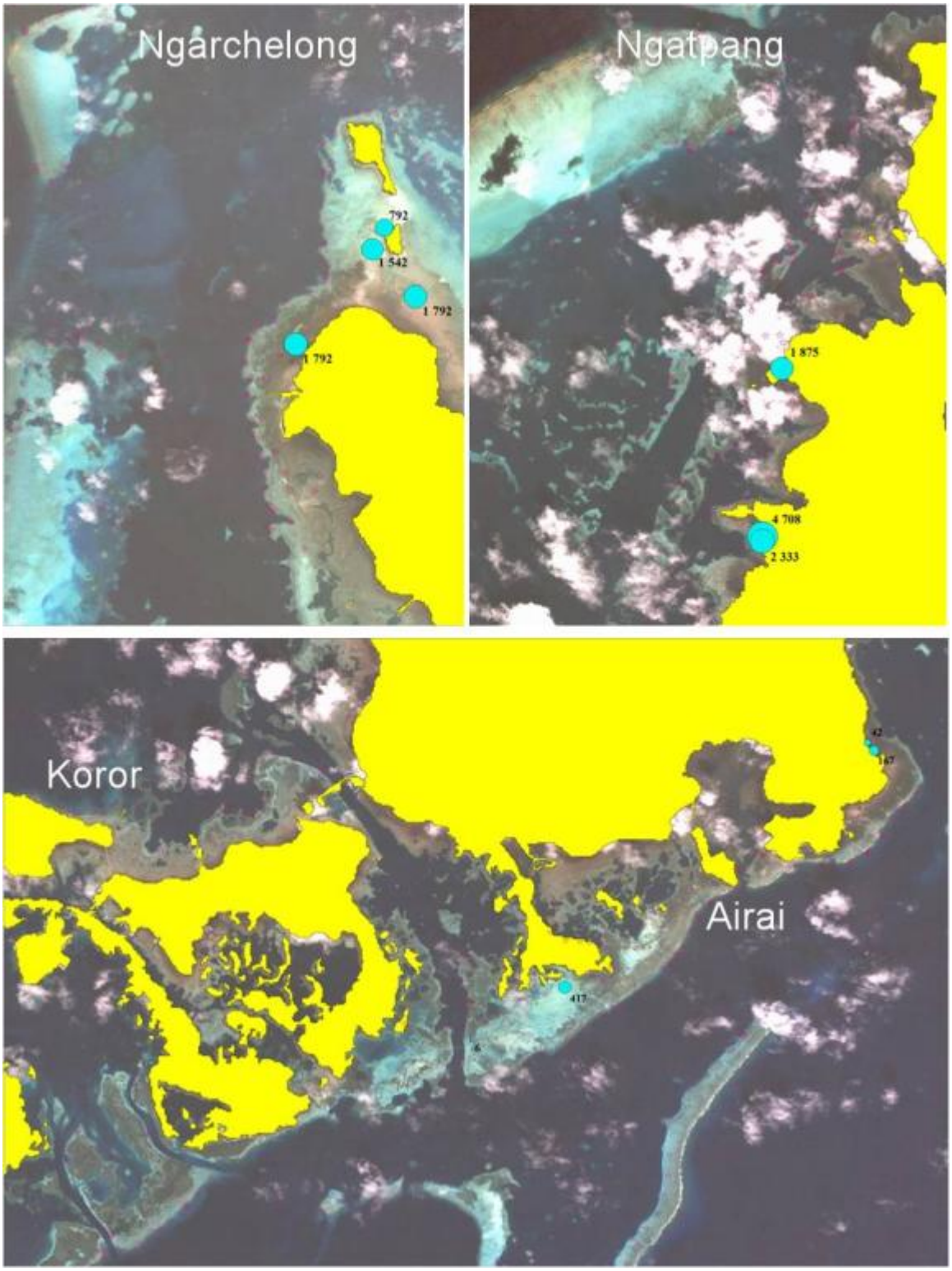


Figure 13: *Holothuria scabra* density distribution (specimens per hectare) at the four Palau sites.

5.3 Size distribution of species

5.3.1 Holothuria scabra

The sandfish *H. scabra* was recorded in three sites surveyed other than Koror where it was absent. Average size was 16–17 cm ranging from 8–23 cm (length) (Table 7; Fig. 14). This average size is contrasted with other sites in the Pacific. In the Papua New Guinea site of Tsoilung, (where fishing of sandfish occurs regularly), the mean size was 17.5 cm ± 0.7SE was recorded. In New Caledonia, two sandfish size structures were recorded at an open access area) and a community-managed area. Smaller average sizes (13.5 cm ± 0.1SE in length and ranging from 2.5–18 cm) in open access area and while significantly larger specimens (averaging 21.9 cm ± 0.8SE in length and ranging from 13.4–30.2 cm) were recorded in the traditionally protected part of the same site (Fig. 14). Furthermore, at a site in Vanuatu (in the Maskelyne Island) where sandfish was protected by the local community, a full range of sizes were present, from 5–32 cm in length (Friedman et al. 2008).

Results from other sites showed that sandfish can grow to a larger size of 25-30 cm if they are allowed to reach full maturity size. The stock in Palau which range from 8–23 cm sizes are of medium size *H. scabra* class which corresponds well with the size structure of the sandfish population recorded in the open access and actively fished sites in the region as shown in Table 6.

These results indicate that the impact of continuous fishing on *Holothuria scabra* by domestic subsistence fishers (for local market sales and for export for home consumption to relatives abroad) is having a greater impact on the sandfish stocks.

Table 6: Mean size comparison for *Holothuria scabra*.

Location	Density range per ha	Mean density ±SE per ha*	Size range length (cm)	Mean size
Ngatpang, Palau	1,875–4,700	2,972 ± 878SE	10–23	16.2 cm ± 0.2SE
Ngachelong, Palau	792–1,792	1,479 ± 237SE	8–23	16.5 cm ± 0.3SE
Airai, Palau	42–417	208 ± 110SE	14–22	16.8 cm ± 0.6SE
Tsoilung, PNG	42–458	134 ± 51SE	12–28	17.5 cm ± 0.7SE
Maskelynes, Vanuatu	125–5,333	1,713 ± 578SE	6–32	19.3 cm ± 0.3SE
Ouenjo, New Caledonia (all)	42–3,416	1,166 ± 375SE	2.5–30.0	14.4 cm ± 0.2SE
Oundjo (outside community-based MPA)	42–3,416	2,292 ± 503SE	2.5–18.0	13.5 cm ± 0.1SE
Oundjo (within MPA)	42–500	202 ± 70SE	13.5–30.2	21.9 cm ± 0.8SE

* = Mean density only from stations where species was present.

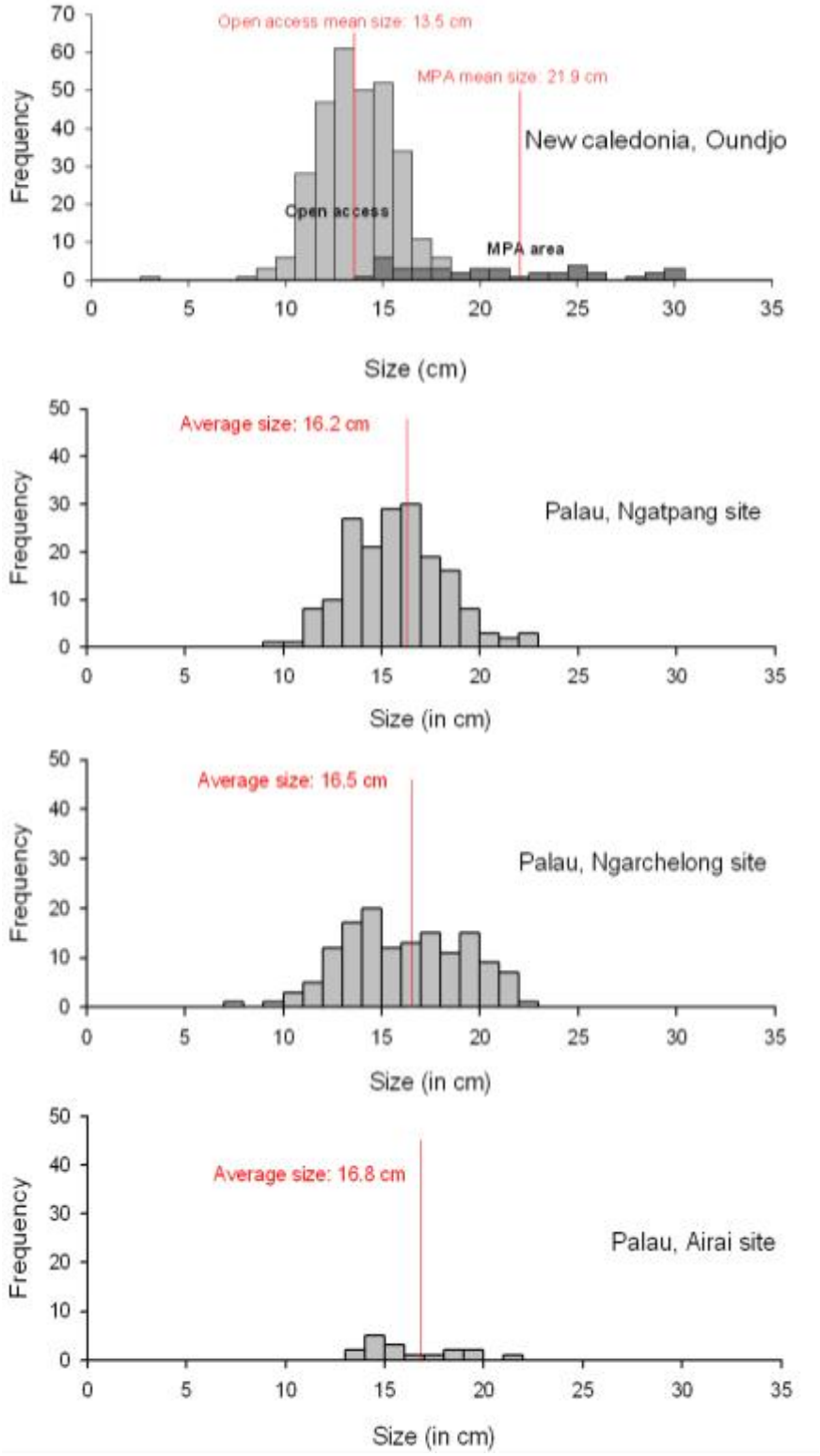
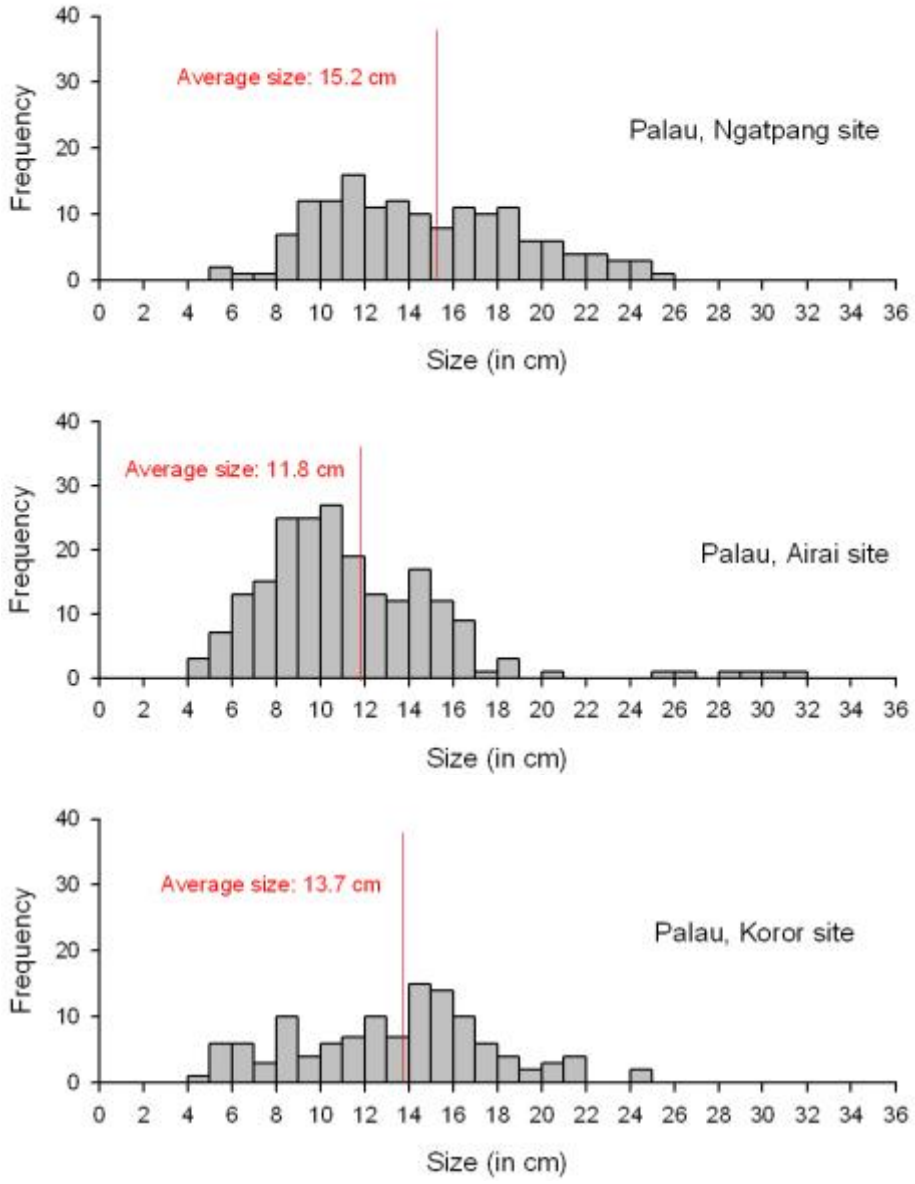


Figure 14: Comparison of size distribution for *Holothuria scabra* in Palau and New Caledonia.

5.3.2 Stichopus vastus

The mean sizes and density of *S. vastus* contrasted sharply with those of similar areas in the Pacific. For instance, in Palau there were very high densities of smaller sized specimens compared with only a few large specimens usually seen elsewhere, whereas in other Pacific Island countries, juveniles are very rare and adults are not commonly seen. The highly skewed size distribution seen in Palau (favoring smaller size classes) (Fig. 15) suggests that: 1) due to over-crowded conditions, animals have become stunted in growth, hence many juveniles could well be adults; and 2) the species may not be *S. vastus* at all but a different species of the genus *Stichopus*. A slight decline in the distribution of larger animals (18+ cm) in both Koror and Airai may indicate fishing pressure in these two populated and intensely fished areas. Larger animals are normally preferred for their larger amount of viscera.



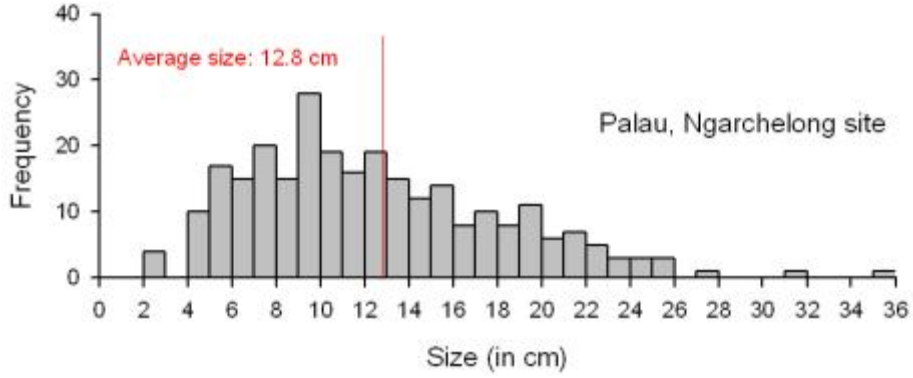
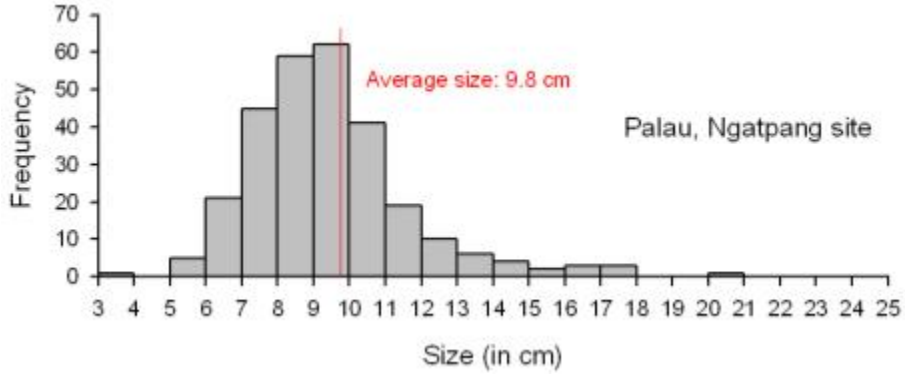


Figure 15: Size distribution graphs for *Stichopus vastus* (ngimes).

5.3.3 Actinopyga sp. (ceremrum)

Actinopyga sp. is commonly found on seagrass beds in the mid to inner lagoon areas between 0.5–.5 m where they are protected from strong wave action. In Palau, seagrass beds found within the afore-mentioned zones are dominated by two seagrass species — *Enhalus acoroides* and *Thalassea hemprichi* — which *Actinopyga* sp. tends to closely associate with. In Ngatpang, the species is observed to hide under patches of the algae *Padina* sp. Palau has extensive areas of suitable habitats, which explains why *Actinopyga* sp. is commonly found. *Actinopyga* sp. ranges in size from 4–22 cm, with a modal size class of 9–10 cm (Fig. 16). In addition, three color morphs exist as shown in Figure 2 (i.e. pale-gray, light-brown with a black barred pattern of varying intensity, and dark brown). Brownish with a black barred pattern and pale-gray are the two most common morphs in Palau. The northernmost site of Ngachelong had larger animals (15+ cm) than all of the other sites, possibly indicating fishing impact on larger animals.



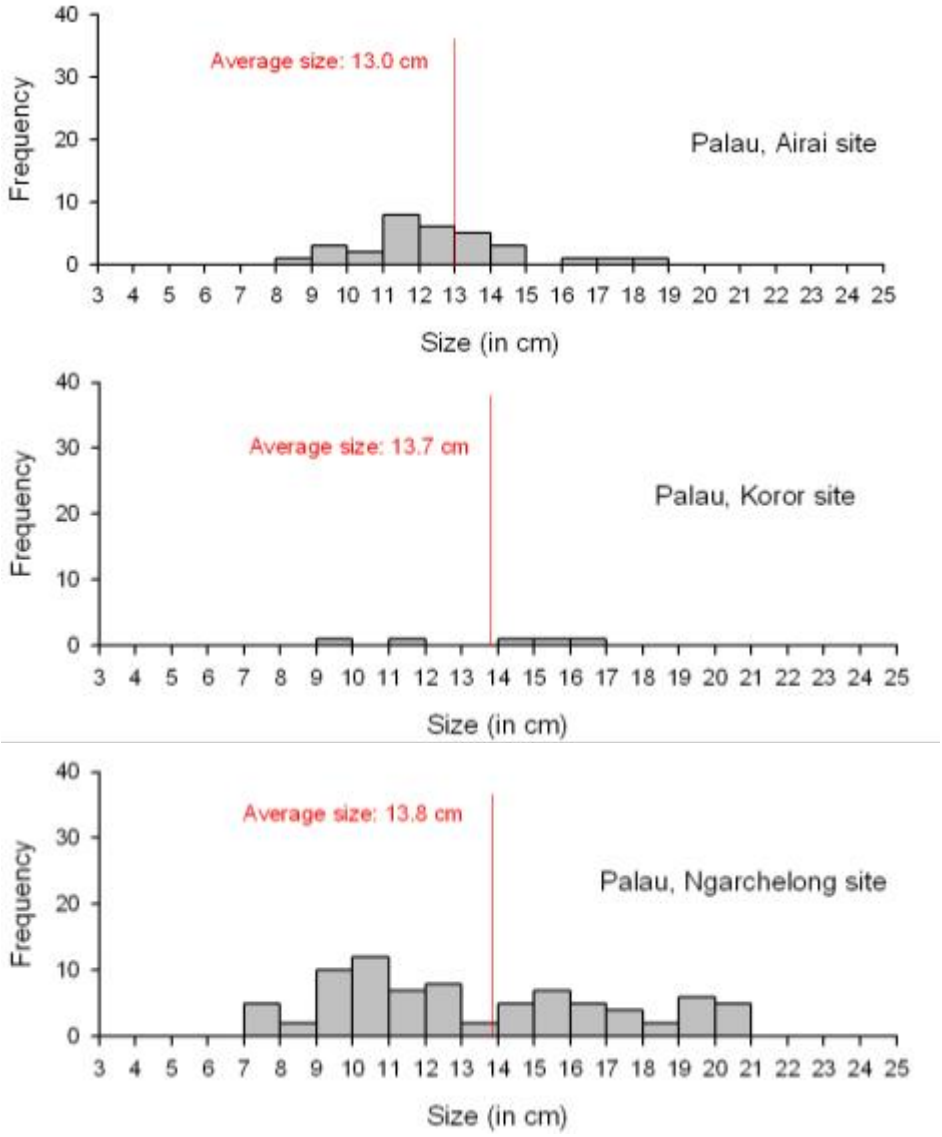


Figure 16: Size distribution graphs for *Actinopyga* sp.

6 Discussion and recommendations

Identification: We can now confirm for now that the two sea cucumbers that were previously misidentified in Palau belong to the family Stichopodidae (*Stichopus vastus*) and Holothuriidae (*Actinopyga* sp.). In the near future, *Actinopyga* sp. will finally be officially identified to its species level. As for *S. vastus*, the name might change in future but until this happens, its current naming remains.

Processing techniques: Sea cucumbers have been a significant part of Palau's subsistence fishery for centuries. The importance of sea cucumbers in the diet of Palauan people demonstrates the importance of traditional knowledge in using available resources. Processing knowledge and skills of different species learned over many years demonstrates

the unique knowledge that Palauans have for their resources and the environment that supports those resources. Fishers know the relevant parts of the animal and the processing techniques to turn them into an edible form. This knowledge is based on a long history of resource use. Harvesting *S. vastus* during morning low tides and in previously fished areas — in order to collect the viscera from previously gutted animals — is a form of management in itself in that animals in other areas that were not previously used are left undisturbed. Morning low tide harvests means the animals are found in shallow water, are easily accessible to the women, and the intestines are free of sand. Harvesting *S. vastus* is done twice a month, separated by a 10-day "rest period" to allow animals to regenerate their internal organs. Such knowledge and practices have positive implications with regard to resource sustainability.

Production: Known throughout the Pacific Islands as the most sustainable means of resource use, the region's subsistence fisheries are today evolving into commercial enterprises through market forces and increased demands from human population. Marketing raw sea cucumbers in Palau represents an evolving subsistence fishery. Fishers are intensifying their activities in order to supply demands from urban populations in Koror and to overseas-based Palauans. An almost equal proportion of sea cucumber landings were sold for domestic household consumption from 1989–1998 (Palau Conservation Society 2000). Recent production figures are not available, but responsible officers from Palau's Bureau of Marine Resources believe that production for export has increased. Such information should be quantified to accurately monitor the fishery.

The socioeconomic surveys of PROCFish in 2007 showed higher production rates for the two northern states of Ngatpang and Ngarchelong than the two central sites of Airai and Koror. This trend was revealed in the results of the resource surveys where the northern sites of Ngatpang and Ngarchlong seem to have better status of sea cucumber resources. *Actinopyga* sp is widespread in all the four Palau sites while H. impatiens was present only in Ngarchelong.

H. scabra is t preferred by fishers (Kitalong 2008; Harvey Renguul and Lora Demei, Palau Bureau of Marine Resource, pers. comm. 2008) for its guts and meat, which are consumed or sold. *H. scabra* is overexploited in Airai but is in relatively good abundance in Ngachelong and Ngatpang. Studies in Airai (Kitalong 2008) also document an 80% decline in harvest rates for this species between 1991–2008. While densities at Ngatpang and Ngachelong were good (>1,200 ±SE/ha) the animals were smaller with none of the specimens larger than 230 mm with mean size of 160–170 mm and ranged from 80–230 mm. This size range reflects other heavily fished H. scabra populations in Papua New Guinea and New Caledonia. In contrast, the mean size of *H. scabra* in a well protected fishery in Vanuatu and New Caledonia was 20 cm with a maximum size of 31 cm. In these two countries, there are no subsistence fishery for sandfish and local managed practices are relatively good.

The *H. scabra* stocks in Palau are not being allowed to reach larger or sexually mature sizes as a result of continuous fishing by subsistence fishers. Even in the MPA, the animals were smaller which indicate fishing may have been active also in the MPA which contributed to the removal of of larger animals. Larger sandfish have thicker meat and the larger volume of viscera that are preferred by fishers over smaller specimens. In addition *H. scabra* is preferred over others for its ease of processing.

The common view that subsistence fishing of *H. scabra* is modest and cannot deplete the resource as in Palau and as well in Fiji is no longer a valid view. As revealed here the increasing use of *H. scabra* by the subsistence fishery can have a similar devastating impact on its sustainability as the traditional commercial bech-de-mer export activity. Management regulations must therefore be readjusted to fit new resource utilization patterns and subsistence used must be treated in a uniform manner as other uses.

Stichopus vastus is the most densely populated resource in Palau with wider distribution. Generally resource stocks in all four sites were in relatively good condition although there may be increasing pressure for larger animals in Koror and Airai. This can be attributed to the fact that the animal is not killed in order to harvest its guts but returned to the sea to regenerate which help to keep the population stable. In addition, preferential fishing of stocks is a sustainable practice as certain stocks are harvested over and over again while the rest are left alone. Guts from previously fished sea cucumbers taste better than guts from unfished ones (Kitalong 2008).
However, cutting animal into more than two pieces can result in high mortality due to infection and stress which may be explained in the results of Airai and Koror. Women in Airai have been cutting *S. vastus* in to 2 or 3 pieces (Kitalong 2008) which may have resulted in the low population of larger animals in this results.

Actinopyga **sp.** is the third most abundant resource with wider distribution as S. vastus. The species is of moderate to high value in the commercial dried beche-de-mer fishery. Stocks in Koror and Airai are depleted. Fishers from Airai are now moving to access resources in other Stats such as Ngatpang where the resource is still stable. The presence of larger animals in Ngarchelong (> 14 cm length) indicates modest activities in the area. The highest population in the study was recorded in Ngatpang but again lack of larger animals may highlight existing pressure due to fishing. Larger animals are more fleshier than smaller ones.

Mariculture: The mariculture of *S. vastus* and *Actinopyga* sp. by cutting the animals into pieces is not a recommended technique for 'farming' these species. Cutting of sea cucumbers leads to higher rates of mortality caused by stress and infection. In addition, any form of fattening of animals or speeding of their growth rate is not the standard aquaculture practice and should be discouraged. And advisory note on sea cucumber farming in the region put together by SPC and World Fish Centre is provided in Appendix however for further advice can be sought from the Aquaculture Section of SPC.

Palau's national commitment to save its sea cucumber resources is bearing positive results, and is a lesson to be learned by other Pacific Island countries that are only recently moving to control their sea cucumber fisheries from overfishing. But in a country whose people have used sea cucumber as one of their important resource for food security and where the fishery has evolved into a strong semi-commercial operation, tighter management may have to be considered to ensure sustainability of the resources.

6.1 Management recommendations

1. Sandfish harvesting in Ngachelong was modest, which explains why numbers of *H. scabra* remain in 'open access' areas. Ngachelong State should consider protecting an area around the island of Ngerkeklau and the adjacent mainland where *H. scabra* stocks were present for conservation purposes.

2. The marine protected area at Ngatpang has been effective at conserving *H. scabra.* However, lack of bigger animals suggest poaching may have been occurring within the protected area. Ngatpang State should look at strengthening its monitoring activites in the area.

3. Airai's *H. scabra* resources are depleted and cannot support more fishing effort. Protection should now be a priority to conserve remaining breeding stocks. At least one or some of the remaining populations in the east, south and west need to be included within a marine protected area.

4. The existing ban on *H. scabra* that only controls export should be reviewed to also cover subsistence harvest and therefore fully protect the use of this resource.

5. The *Actinopyga* sp. resource in Koror and Airai States are overexploited. Both of these sites should look into setting up at least one marine protected area to protect breeding populations.

6. Generally, *Stichpus vastus* stocks in all four sites in Palau are in relatively good condition, although signs of fishing pressure on larger animals are evident within Koror and Airai. The resource seems to sustain exploitation over many years, which may be attributed to the animals' strong capacity to regenerate after their guts are harvested. Fishers of S. vastus should be encouraged to cut the animal into 2 only pieces and not 3 or more.

7. Lack of landing data, especially from 2000 to the present, is a problem. Collection of export data at the airport needs to be complemented with data from the local commercial industry (agents and sale outlets in Palau) .

8. A new policy to limit the quantities of sea cucumber products to be taken out per traveler should be considered as a control measure. Quota allocation per traveler (eg. 5kg/traveler) is a common practice that could be adopted.

9. The practice of cutting animals into pieces as a form of mariculture is not a recommended option and should be discouraged. Palau has learned from the negative impacts of such activities and should allowed a repeat of this experience. Any sea cucumbers mariculture development activity should be done through a hatchery breeding and seeding programme. Any advice on this should be directed to SPC Aquaculture Section in Noumea.

10. Monitoring surveys by the Bureau of Marine resources are encouraged to provide up to date understanding of the resources status and which allow good data collection which can help in asking for assistance in future management activities..

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Appendix

Advice on the hatchery production of sea cucumber

Use of hatcheries to increase production of sea cucumbers- caution required!
Secretariat of the Pacific Community and The WorldFish Center

High demand for sea cucumbers in Hong Kong, Singapore and mainland China has resulted in widespread overfishing of these valuable resources throughout the Pacific.
As stocks dwindle, investors and traders from Asia are looking for other ways to maintain supply. Based on the success of culturing one species of sea cucumber in the cooler waters of China, private companies are approaching countries and territories in the Pacific with proposals to construct hatcheries for sea cucumbers. Although this may appear to be a practical way of restoring and maintaining productivity, much caution is needed in assessing these proposals. Hatcheries can only be used to produce one species of tropical sea cucumber reliably at the present time and therefore have potential for very few locations.
Poorly planned hatchery operations run the severe risk of raising expectations that cannot be met, leaving participating communities disillusioned.
The purpose of this short briefing paper is to inform policy-makers in the Pacific about:

1. The main objectives and potential benefits of producing sea cucumbers in hatcheries.
2. The normal management measures that should be used to restore and maintain sustainable harvests of sea cucumbers
3. The limits of technology for restocking and sea ranching tropical sea cucumbers
4. Conditions to be met by investors when construction of a hatchery is deemed to be in the national interest.

The main objectives and potential benefits of producing sea cucumbers in hatcheries
Before managers consider whether investment in a sea cucumber hatchery may provide a benefit to their country, they need to have a clear understanding of the status of their sea cucumber fishery. They should apply the approach outlined in the recently published sea cucumber fisheries manager's toolbox [1] to determine this status.
In theory, hatcheries provide managers with: 1) an option for restoring severely depleted fisheries for sea cucumbers through 'restocking' programmes, and 2) a way of increasing production through 'sea ranching' projects.

'Restocking' is defined as the release of cultured juveniles into wild population(s) to restore severely depleted spawning biomass to a level where it can once again provide regular, substantial yields.

'Sea ranching' is defined as the release of cultured juveniles into unenclosed marine and environments for harvest at a larger size in 'put, grow and take' operations.
However, restocking represents just one of many options available to managers for rebuilding an over-exploited fishery (see below). Sea ranching is a possible way of producing more sea cucumbers, but many conditions need to be fulfilled for it to be successful (see below).

Other management measures to restore and maintain sustainable harvests of sea cucumbers

The sea cucumber manager's toolbox [1] provides an easy guide to help managers identify the status of their sea cucumber fishery, and the various measures that should be used to restore production and then maintain sustainable harvests. These management measures include:

- **Declare no-take zones** in areas where sea cucumbers are known to spawn to protect adequate numbers of adults. If permanent no-take zones are difficult to establish, use temporary or rotational fishing closures for periods of 5-10 years instead. The larvae produced in no-take zones will replenish nearby fishing grounds.
- **Apply minimum size limits** to sea cucumbers outside no-take zones so that they can reproduce before they are harvested. Size limits also help fishers earn more for each sea cucumber they catch. Size limits should be applied to processed (dried) at export gateways but fishers should also be provided with corresponding size limits for live animals so that they know which ones to retain.
- **Inspect all exports of bêche-de-mer** to check that they comply with size limits. Impose heavy penalties (including loss of export licence) on exporters who break the rules. Limit the number of enterprises licensed to export to make it easier to inspect all bêche-de-mer leaving the country.
- **Restrict fishing methods** for sea cucumbers. Ban the use of compressed air (SCUBA and hookah), weighted spears ('bombs'), small dredge nets and the use of lights at night. These gear restrictions will help maintain the natural 'refuges' of species created by their distribution and behaviour. Permit only a mask and snorkel to be used for collecting sea cucumbers

(**NB.** See the sea cucumber manager's toolbox for a more complete list of the management actions needed)
Only when a sea cucumber species has been fished so heavily that the animals are too far apart to reproduce, should restocking be considered. Even then, it will usually be a lot easier and less expensive to place enough of the remaining individuals in 'no take zones' to create an effective spawning aggregations, and to manage those remaining outside the no take zones using the measures outlined above. Afterall, creating effective spawning aggregations is the ultimate aim of a restocking program. More details about how to use the remaining wild sea cucumbers to form effective spawning aggregations to help rebuild depleted sea cucumber fisheries are available in a recent publication called 'Restoring small-scale fisheries for tropical sea cucumbers [2].

The limits of technology for restocking and sea ranching tropical sea cucumbers

In recent years, China has developed a large industry based on pond farming and 'sea ranching' of one species of sea cucumber, *Apostichopus japonicas*. Indeed, China now produces more sea cucumbers from hatchery-based operations than the rest of the world harvests from the wild. However, this technology cannot simply be transferred to the species of sea cucumber s that live in the tropical Pacific.
Such transfer takes a long time and much investment to accomplish successfully. So far, the transfer of technology to the Pacific has been limited to just one species of tropical sea cucumber, the 'sandfish' (*Holothuria scabra*) . The WorldFish Center has spent almost 10 years developing the basic technology to produce this species in hatcheries at modest scales [3].
Therefore, ***hatcheries for sea cucumbers in the Pacific can only be expected to produce one species*** until further research and development is undertaken.

Astute and responsible investors will understand that a hatchery for sea cucumbers in the Pacific only has potential mainly for sea ranching, and only for sandfish.

Conditions to be met by investors when construction of a hatchery is deemed to be in the national interest

If and when an investor proposes to construct a hatchery for the purposes of sea ranching sandfish, and careful analysis by independent experts shows that this may have net benefits for the country, managers need to be sure that the following conditions will be fulfilled.

1. ***Under no circumstances should investors in a hatchery for sea cucumbers be permitted to engage in fishing for sea cucumbers in the wild.*** There have been proposals in the region by private companies to negotiate access to wild stocks on the promise that the overall abundance of the resource will be increased through the release of hatchery-reared juveniles. However, the juveniles were not reared to a size large enough to survive well in the wild, and no evidence was provided that they contributed to the wild stock. A grave concern is that a proposal to release hatchery-reared juveniles in the wild is simply a façade to gain access to sea cucumber resources at the expense of local fishing communities.

2. There must be a robust partnership with local resource owners, who agree to provide access to suitable habitat for the grow-out of sandfish to market size in sea ranching projects, in return for acceptable and agreed benefits. The partner community needs to have sole authority to grant access to the area, and the risk of poaching by those not involved in the project needs to be very low.

3. The investor must have sufficient capital, and must employ qualified hatchery staff, to produce the numbers of juvenile sandfish needed to make sea ranching operations profitable. Note that the juveniles need to be grown to a size of about 3-5 g before they are released. Even then, high levels of mortality >80% can be expected before the animals reach market size.

4. Hatchery-reared animals must be able to be distinguished from wild sandfish to ensure that the harvesting operations of the sea ranching project do not collect wild sandfish outside the designated area for sea ranching.

5. Harvest size should exceed the minimum size at first maturity so that the released animals also contribute to the replenishment of the wild stock.

6. Hatchery operations should be environmentally responsible, viz.
    a. Broodstock for use in the hatchery should be collected from area where the juveniles are to be released to prevent ‘genetic pollution’ of stocks.
    b. Broodstock or juvenile sea cucumbers must not be imported from overseas. This will minimize the risk of introducing diseases to hatcheries, which can later spread to infect wild stocks.

c. The hatchery should be located where effluents will not contaminate the environment.

7. Investors should bear the cost of demonstrating that their proposal to construct a hatchery and operate a sea ranching project for sandfish is socially and commercially viable, and environmentally responsible. The proposal should be assessed by independent experts.

8. In the event that an investor proposes to construct a hatchery for other species of sea cucumbers, they should provide evidence that they have the capital and commitment to do the research and development required to produce a commercially viable technology for the mass production of juveniles that are large enough to survive at high rates when released in the wild. Any such proposal should be limited to species of sea cucumber that occur naturally in the country. The conditions outlined under 6) above should also be applied.

For further information contact…..

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