Variation in postharvest processing of sea cucumbers by fishers and commercial processors among three Pacific Island countries

Steven W. Purcell[1], Poasi Ngaluafe[2], Karibanang T. Aram[3], Watisoni Lalavanua[4]

Abstract

The value of beche-de-mer exported from small-scale sea cucumber fisheries throughout the world depends partly on the postharvest processing methods used by fishers or commercial processors. Development programmes to help fishers in value adding need to understand current processing practices. We used questionnaire data to evaluate postharvest processing of sea cucumbers, and compared methods between fishers and commercial processors in Fiji, Kiribati and Tonga. Most fishers in Kiribati, and a minority of Fijian and Tongan fishers, process their sea cucumbers. Few fishers had received training or information on processing methods. The placement of the cut to gut sea cucumbers varied widely, especially among fishers. I-Kiribati fishers salted sea cucumbers for the least number of days. Coconut husks were mostly used in Kiribati as the fuel to heat water for cooking sea cucumbers, whereas wood was mostly used in Fiji and Tonga. Fishers practiced a second cooking less frequently than commercial processors. Smoke curing was not practiced in Tonga, owing to traditional practices, but was done frequently in Kiribati and Fiji. Fijian fishers invested the least amount of time in processing. We found few women fishers in Kiribati but they were often involved in processing. In both Fiji and Kiribati, other family members were frequently engaged in processing. We show that poor processing methods were often used by fishers. Our study reveals that postharvest processing cannot be generalised among countries, and a holistic view of the role of women and children in fisheries should examine more than just their involvement in fishing.

Introduction

Processing sea cucumbers in the Pacific Islands region

A market for beche-de-mer (dried sea cucumber) from Pacific Island countries has existed since the early 1800s (Conand 1990; Kinch et al. 2008). Nowadays, sea cucumbers from more than 20 species are caught by small-scale Pacific Island fishers (Purcell et al. 2012). Traditionally, the animals were gutted, boiled then dried in the sun or over a smouldering fire by artisanal fishers. Gutting and cooking methods used by fishers sometimes reflect those that they use for preparing sea cucumbers for subsistence consumption, such as in Tonga where several species are commonly eaten locally. After cooking and drying, beche-de-mer are then stockpiled until they can be sold to middlemen or export agents. Prices paid to fishers for beche-de-mer vary greatly, depending on the species, size and quality of postharvest processing (Kinch et al. 2008; Lavitra et al. 2008; Ram et al. 2014). Postharvest processing methods have been outlined in a few documents but few data have ever been published on methods used by fishers or commercial processors.

Conand (1990) briefly described previous methods used in New Caledonia to process sea cucumbers: one for sandfish and golden sandfish, and another for other species. She concluded that the main processing problems by fishers were an incorrect cut, outer damage to the body wall of the animals, and inadequate cleaning and cooking times. Two other reports provide information about processing methods employed in the Indian Ocean but contain no quantitative data comparing methods used by fishers (James 1994; Lavitra et al. 2008).

Ram (2008) was the first researcher to compare the general processing steps used by professional processors and fishers. His questionnaires and inspection of products in Fiji showed that fishers still used traditional methods to process sea cucumbers and incorrect methods were commonly used. In a later publication of that study (Ram et al. 2014), he concluded that poor processing resulted in spoilage of products, poor product quality for export, and diminished sale prices for fishers. Apart from that study from Fiji, little is known about the processing methods used by fishers and how those methods might vary geographically. This knowledge gap constitutes a weak foundation on which to identify

[1] National Marine Science Centre, Southern Cross University, PO Box 4321, Coffs Harbour NSW 2450, Australia
[2] Ministry of Agriculture & Food, Forests and Fisheries, PO Box 871, Nuku'alofa, Tonga
[3] Ministry of Fisheries & Marine Resources Development, PO Box 64, Bairiki, Tarawa, Kiribati
[4] Partners in Community Development Fiji, 8 Denison Rd, Suva, Fiji Islands
* Author for correspondence: steven.w.purcell@gmail.com

needs for capacity-building programmes to improve product quality and livelihoods in fisheries.

Methods involved in processing sea cucumbers into beche-de-mer

The Secretariat of the Pacific Community (SPC) included small sections on postharvest processing of sea cucumbers in its field ID cards (4 pages; SPC 2004) and a, now outdated, identification guidebook of sea cucumbers in the tropical Pacific (7 pages; SPC 1994). However, neither information source explains processing methods in detail. More recently, research by the Australian Centre for International Agricultural Research determined the current best-practice methods used by successful commercial processors and outlined these methods in a training manual (Purcell 2014a). The methods also confer with "correct" product characteristics (e.g. cut, shape, colour) indicated by retail and wholesalers in China (Purcell 2014b). The following is a summary of the various processing steps given in that manual.

Different species groups require different processing methods due to differences in the thickness and softness of their body wall, and the extent of water retention after cooking. Slight variations in methods among commercial processors, according to their own beliefs and experiences, do not necessarily result in different product quality.

The cut made on sea cucumbers (to remove guts and aid drying) should be in different locations on the body for different species. Both black teatfish (*Holothuria whitmaei*) and white teatfish (*H. fuscogilva*) should be cut on the dorsal side, while other species that attain large sizes (i.e. *H. fuscopunctata*, *Thelenota ananas* and *T. anax*), should be cut on the ventral side. In both instances, the cut should stop short of the anus and mouth. For most other species, the general practice among processors is to make a small longitudinal cut (i.e. 2–3 cm) on the ventral surface at the anus. Certain species develop a better product shape if they are cut and gutted after the first cooking.

Generally, sea cucumbers are cooked first, starting in warm sea water that is brought to around 90°C, then salted for 1–5 days. Other species, especially those in the genus *Bohadschia*, are best salted first for 1–2 days and then cooked. Salt curing has several benefits to the products: 1) water is removed; 2) the flesh is cured, making it less prone to bacteria; and 3) salt adds weight to the product, which is later sold by weight.

After salting, sea cucumbers are cooked again in hot water, then smoked for 1–2 days and dried for 3–7 days. Smoke curing is also advantageous for processing sea cucumbers, although Chinese consumers do not want a strong smoky odour (Purcell 2014b). Drying by commercial processors is often done in drying rooms with dehumidifiers and heaters, whereas fishers simply dry the products in the sun.

Purpose and significance of this study

Poor processing practices result in beche-de-mer that have some or all of the following characteristics: physical damaged, bad odor, unattractive colour, poor shape, and/or insufficiently dried. These problems translate to lower prices in the marketplace (Purcell 2014b) and lower prices given by buyers to fishers. Poor processing also wastes the potential value of the resource and potential national revenue from export levies (Purcell 2010; Purcell et al. 2009).

Improving postharvest processing should be coupled closely with improved management and governance of sea cucumber fisheries. Training in processing could be presented as a "trade off" for reduced access to the resource (e.g. by shorter fishing seasons). In order to help fishers improve their processing methods, it is important to first determine which methods they use, and identify any unsuitable practices. Assessing who is doing the processing, and to what quality, is also advised when diagnosing a fishery before forming a management plan (Purcell 2010).

The trade in and market value of beche-de-mer from these Pacific Islands has already been reported (Purcell 2014b) and the value of the products to fishers will be the subject of other reports (Purcell et al. unpubl. data). Here, we examine variations in postharvest processing of sea cucumbers by fishers and commercial processors in Kiribati, Tonga and Fiji using questionnaire-based interviews. At the time of data collection, these three countries were among the few in the Pacific Islands region not having harvesting bans (moratoriums) in place. Our intention is to simply present the differences among countries, and provide comparative results for species groups. An understanding of such differences is crucial for identifying countries with the greatest need for training and processing steps that are most incorrectly done by fishers. Such information could also reveal deeper insights into the involvement of Pacific Islanders in seafood postharvest processing.

Materials and methods

Within Fiji, Kiribati and Tonga, we conducted the questionnaire-based interviews at multiple islands or island groups within each country to enable broad representation. The study island groups were as follows: Fiji – Ra, Kadavu, Bua, Cakaudrove,

Taveuni, Yasawa, Lau (south), and Vanua Balavu; Kiribati – Tarawa, Butaritari, Abemama, Onotoa, Kiritimati; Tonga – Tongatapu, Ha'apai, Vava'u, Niuatoputapu. Within the islands and island groups, we generally collected data from five to eight fishers in each of several villages. We chose study locations and villages depending on advice from fishery management institutions about where sea cucumber fishing was active, and we sought to disperse our locations and villages within locations. At each village, we consulted the village elders and fishers to get the residences of sea cucumber fishers and then visited those residences.

Interviews were held in 2011 in Kiribati and Tonga, and in 2014 in Fiji. We interviewed fishers and processors and asked them questions from the questionnaires in a standardised fashion among respondents. The questionnaires primarily used closed questions, as described by Purcell et al. (2009) and Kronen et al. (2007). We also solicited additional (open-ended question) information. Human ethics approvals for interviews were given by an accredited ethic committee of Southern Cross University[5] and by the Fiji Ministry of Education[6]. Approvals for the research in Tonga and Kiribati were given by national fisheries ministries.

The project team conducted interviews with 84 sea cucumber fishers and 21 processors in Kiribati, 134 sea cucumber fishers and 13 processors in Tonga, and 235 fishers and 17 processors in Fiji. Our sampling was gender inclusive by interviewing women preferentially when possible. We used key informants to identify sea cucumber fishers to interview, and relied on the "snowball" effect to find other sea cucumber fishers in villages.

Local names for sea cucumber species were used in interviews along with species identification sheets to confirm each species with respondents. Responses from questions were entered as nominal data (e.g. "D" if sea cucumbers were cut on their dorsal side), continuous data (e.g. number of minutes to cook different sea cucumbers), or binomial data (e.g. "1" for yes and "0" for no in response to yes-or-no questions).

Cross-checks of data across respondents and exploratory graphs were made to ensure data accuracy. We use standard deviation as the error measure to indicate variation in responses within samples rather than the precision of the mean estimates. For this article, we pooled data across villages and locations for cross-tabulations of each country for fishers and commercial processors.

Results

Frequency of processing and training

In Kiribati, 76% of fishers process their sea cucumbers. Only 33% of fishers in Fiji and 18% of fishers in Tonga do their own processing of sea cucumbers. The majority of fishers sell their catch fresh to processors.

In Tonga, national fishery regulations prohibited fishers from doing their own processing due to concerns that fishers would damage the products. Since the distribution of training manuals and workshops on processing methods, however, that regulation has been removed from the country's Sea Cucumber Fishery Management Plan 2014 so that fishers can again process their catch.

The majority of fishers and processors in Kiribati were trained informally by a foreign export agent but they had never seen or received information on postharvest processing (Table 1). This contrasts with Fijian fishers, most of whom had not been trained by foreign export agents.

In Tonga, many fishers and processors had received or seen some published material on processing sea cucumbers, especially the the ID cards produced by SPC. Half of the processors interviewed in Fiji had seen processing methods in published media, particularly in the ID cards prepared by SPC (SPC 2004), but very few fishers had ever seen any published information on processing.

Cutting methods

There was considerable variation in the placement of the cut for different species, both among processors and fishers (Table 2). Cutting white teatfish and black teatfish on their dorsal sides is practiced by the vast majority of commercial processors although many fishers in each country incorrectly cut them.

Some processors in Tonga and Kiribati were not cutting *Thelenota* species (*T. ananas* and *T. anax*) in the correct place (ventral side), and many fishers in each of the three countries were also not cutting species of *Thelenota* correctly (Table 2).

As a general rule, species in the genera *Actinopyga*, *Bohadschia*, and *Holothuria* should receive a small, longitudinal cut at the anus on the ventral surface, but a small cut at the mouth is acceptable. Cuts on these species were usually made correctly by Tongan fishers, but appreciable proportions of Fijian and I-Kiribati fishers did not cut correctly.

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Table 1. Training and information on processing for fishers doing their own processing.

Location	% trained by foreign exporting agent	% never received printed information on processing methods
Kiribati		
Processors	89	68
Fishers	83	98
Tonga		
Processors	18	36
Fishers	55	55
Fiji		
Processors	18	82
Fishers	8	96

Table 2. Percentage of fishers and processors in each country who cut sea cucumbers in the preferred location. Values are percentages of respondents.

Location	% cutting teatfish dorsally	% cutting *Actinopyga* species at anus or mouth	% cutting *Bohadschia* species at anus or mouth	% cutting *Stichopus* species at anus or mouth	% cutting *Thelenota* species ventrally	% cutting *Holothuria* species at anus or mouth
Kiribati						
Processors	88	56	50	46	87	92
Fishers	66	50	82	78	86	96
Tonga						
Processors	100	82	73	82	64	91
Fishers	88	65	100	100	54	100
Fiji						
Processors	100	81	93	69	94	86
Fishers	66	87	93	77	47	95

Salt curing

While most processors practiced salt curing (Fig. 1), many fishers in Kiribati and Fiji did not (Table 3). In Fiji, processors salt the product after the first boil for most species. In contrast, 36% of processors in Tonga and 100% of processors in Kiribati salt the animals after gutting them, and before the first cooking for most species.

Processors and fishers in Tonga salt the animals for more days than those in Kiribati or Fiji (Table 3). In Kiribati, processors and fishers use salt curing far less frequently than in other countries. Only one-third of I-Kiribati fishers salt sea cucumbers, and they do so for the least amount of time of any group we studied.

Figure 1. White teatfish (*Holothuria fuscogilva*) being salted in a salting box by a commercial processor in Fiji.

Table 3. Salting methods. Values are averages with standard deviations in parentheses.

Location	% using salting	Days salting teatfish (± SD)	Days salting *Actinopyga* (± SD)	Days salting *Bohadschia* (± SD)	Days salting *Stichopus* (± SD)	Days salting *Thelenota* (± SD)
Kiribati						
Processors	71	2.5 (1.6)	2.6 (2.5)	2.6 (2.5)	1.0 (0)	2.1 (1.8)
Fishers	32	2.4 (3.4)	1.2 (1.1)	1.2 (0.9)	0.7 (0.6)	1.6 (1.7)
Tonga						
Processors	100	4.5 (2.0)	3.5 (2.1)	3.8 (2.3)	3.7 (1.5)	5.1 (1.6)
Fishers	78	3.6 (1.7)	3.7 (1.7)	3.8 (1.7)	4.5 (0.7)	3.6 (1.4)
Fiji						
Processors	100	3.1 (1.5)	3.0 (1.5)	2.7 (1.5)	2.4 (1.0)	3.3 (1.6)
Fishers	58	3.1 (1.4)	2.6 (1.3)	2.4 (1.1)	2.3 (1.2)	2.7 (1.3)

Table 4. Cooking methods (in hot or boiling water). Values are averages with standard deviations in parentheses.

Location	Temp. of water (1st boil) (°C)	Minutes 1st cook teatfish	% practicing 2nd cook for some species	Minutes 2nd cook teatfish	Minutes 1st cook *Actinopyga* species	Minutes 1st cook *Bohadschia* species
Kiribati						
Processors	94 (12)	53 (39)	63	41 (44)	47 (25)	43 (22)
Fishers		56 (36)	42	25 (23)	47 (37)	47 (39)
Tonga						
Processors	79 (17)	38 (19)	82	33 (18)	39 (19)	43 (24)
Fishers		25 (21)	42	43 (19)	29 (19)	29 (21)
Fiji						
Processors	53* (18)	12 (10)	100	23 (10)	18 (13)	19 (11)
Fishers		15 (12)	66	21 (21)	19 (13)	21 (21)

* Many processors put sea cucumbers in cool water or at 40°C, and then slowly bring the water to 90°C or boiling.

Cooking methods

Several Fijian processors seemed to be the best of all the processors we interviewed in the three countries; they were more experienced, displayed more knowledge about optimal methods for each species, took more care to process the animals to a higher standard, and attained the highest export prices. On average, Fijian processors cooked the animals for a shorter time (especially for the first cook) and practiced a second cooking for each species more commonly than processors in Kiribati or Tonga (Table 4). Many processors in Fiji put the animals in warm water (~40°C), then bring to the boil and cook for a relatively short period.

The majority of processors and fishers in Kiribati used coconut husks as the fuel to heat water for cooking sea cucumbers, and fishers who camped out at distant fishing sites tended to use wood (Fig. 2). In Tonga, the copra industry was inactive so the few fishers processing their catch mostly used wood. Likewise, 100% of Fijian fishers who processed sea cucumbers used wood as the fuel to heat water (Fig. 3).

While the majority of processors in both Kiribati and Tonga practice a second cooking of sea cucumbers, less than half of the fishers in those countries cook sea cucumbers more than once (Table 4). There were large variations (i.e. standard deviations) in the average cooking times for different species by processors and fishers, revealing inconsistent cooking methods.

Through unstructured questions, we found that many I-Kiribati fishers were using fresh water to cook sea cucumbers, which is not ideal because the skin can be damaged. This seems to be a problem and some processors told them that saltwater should be used.

Figure 2. An I-Kiribati fisher and his family cooking lollyfish (*Holothuria atra*) on Kiritimati Island, Line Islands Group, Kiribati.

Figure 3. Fijian female fishers cooking sea cucumbers in cut 44-gallon drums using bamboo and wood.

Figure 4. A smoke house on Tarawa, Kiribati, for smoking sea cucumbers. The sea cucumbers are placed on mesh trays that slide into the oven and sit well above a smouldering fire.

Figure 5. A basket of brown sandfish (*Bohadschia vitiensis*) that have been burned by a fisher in Kiribati by placing the rack too close to the fire.

Smoke curing and drying methods

Smoke curing, by treating sea cucumbers over a smouldering fire, is practiced by most fishers and processors in Fiji and Kiribati, and is sometimes done on a mesh table over a smouldering fire or in a purpose-built smoke house (Fig. 4). In Fiji and Kiribati, this is favourable for fishers because they do not have sophisticated drying ovens and often do not use salt curing, so the smoking stage helps to cure the sea cucumber flesh. Fishers sometimes smoked sea cucumbers too close to the fire, which was often too hot, resulting in burned products that would fetch much lower prices or be discarded (Fig. 5). In stark contrast, none of the processors in Tonga used smoke curing or dry sea cucumbers over a fire.

In the boom years in the early 1980s, Tongan fishers processed sea cucumbers using similar methods for processing locally eaten seafood, which does not involve smoke curing. This cultural difference from Pacific Island cultures that commonly practice smoke curing, such as in Kiribati, could explain why sea cucumbers were not smoke cured by Tongan fishers. The influence of cultural practices should be expected, especially where fishers have not been formally taught other processing methods specific to export commodities.

Figure 6.
A Fijian fisher with a mixture of sea cucumbers drying on a sheet of corrugated iron in the Lau Group, Fiji.

Sun drying was the most common method used to dry sea cucumbers (Fig. 6). Around one-third of processors in Tonga and most in Fiji used some form of drying oven to dry sea cucumbers (Table 5). The drying ovens used by commercial processors either use electric heaters and dehumidifiers in a closed room, or use the heat (not smoke) from a wood burner to create dry and hot conditions in a concrete drying house. Except for the few fishers processing sea cucumbers in Tonga, fishers generally do not use a drying oven, and those that do use a small and simple oven relying on heat and smoke from a smouldering fire. In Tonga, copra was dried in makeshift ovens when that industry was active, so oven drying was a familiar method.

Table 5. Drying methods.

Location and respondent group	% drying also over a fire	% drying also in an oven	% using smoking
Kiribati			
Processors	76	12	82
Fishers	95	0	85
Tonga			
Processors	0	36	0
Fishers	0	28	0
Fiji			
Processors	24	41	65
Fishers	3	7	91

Processing as a livelihood activity

Tongan fishers spent more time processing one day's catch of sea cucumbers than fishers in Fiji or Kiribati (Table 6), although processing times differed considerably among fishers (s.d. = 1.9 h). This investment in time is substantial, and compares closely to the time fishers spend in the water fishing for the sea cucumbers. Fijian fishers spend the least amount of time processing their catch, and the time investment corresponds to roughly half of the time, on average, that they spend in the water fishing for sea cucumbers (c.f. Purcell et al. in review).

Involvement of family members and other people in the processing of sea cucumbers was quite variable among fishers and among the three countries (Table 6). In many cases, the fishers themselves did the processing or were involved in it. In Kiribati, almost all of the fishers we interviewed were men and two-thirds of their spouses helped in postharvest processing. I-Kiribati tend to consider fishing by diving as a man's job. Women, however, joined

Table 6. Processing effort by fishers. Standard deviations of average processing time are superscripted.

Location	Average time to process one day's catch (h ± s.d.)	Who is involved in cooking and drying of sea cucumbers? (% of respondents)			
		themselves	spouse	children	other
Kiribati	2.5 $^{(1.2)}$	65	66	15	25
Tonga	3.9 $^{(1.9)}$	33	0	0	67
Fiji	1.9 $^{(1.1)}$	42	43	23	11

the sea cucumber harvesting when buyers began purchasing the low-value lollyfish (*Holothuria atra*), which they can collect on shallow sand flats where women usually glean for shellfish.

In Fiji, spouses also often help in processing, and children and other people often contribute to the processing work (i.e. family members often play a role in processing). This contrasts with the situation in Tonga, where only the fisher or another person processed the sea cucumbers.

Discussion

A main finding of our study was that fishers often do not process sea cucumbers in the same way as commercial processors. This resulted in the beche-de-mer by fishers often being improperly cut, physically damaged, poorly preserved and incompletely dried for export. These shortcomings can decrease prices in the marketplace, especially physical damage to the products (Purcell 2014b) that occurs through poor handling at sea prior to processing, over-cooking or drying too quickly. In the same way, Ram et al (2014) found that Fijian fishers often had problems in processing sea cucumbers to a good quality and rushed some steps to save time. Poor processing by fishers was also reported by processors in New Caledonia (Purcell et al. 2009). Poor processing no doubt has a significant bearing on the prices that traders can offer to fishers.

Cutting of most species appeared to be *ad hoc* and varied greatly among fishers. Essentially, there was often a lack of understanding of proper cutting methods to gut the animals. Salting time by I-Kiribati fishers was too short for most species compared with times used by successful processors. Most processors used a second cooking, and even a third, while a majority of fishers only cooked the sea cucumbers once. The lack of repeated cooking can prevent the product from drying thoroughly or taking a desired straight shape.

Some processors argued that a processing manual and training of fishers were not required because they visit fishers and train them. Our data refute this line of argument; a high proportion of fishers had not been formally trained in postharvest processing. In addition, although some basic information about processing had been previously distributed in the Pacific (SPC 1994, 2004), few fishers were aware of these. That the beche-de-mer produced by fishers was often damaged gives further rationale for a need for information sources and training of fishers. Training in postharvest processing has also been identified as a critical shortcoming in other fisheries (Eriksson et al. 2010, Ochiewo et al. 2010). The recent manual (Purcell 2014a), training videos (see below) and village-based workshops funded by the Australian Centre for International Agricultural Research seek to fill this gap in information. Our data showed that although women do not collect sea cucumbers, they should be given manuals and invited to workshops if they are involved in processing.

Improving postharvest processing will not be a "one-size-fits-all" solution because current processing methods (e.g. smoking) and resources (e.g. coconut husks for fuel) differ greatly among countries. In addition, species frequently caught by fishers differ among the three countries (Purcell et al. in review), so workshops should focus on locally common species. We also recognise other successful variations of the processing methods, which fishers or processors may prefer. For example, some processors in Fiji salted *T. anax* for several days, which seemed to avoid splitting of the body wall during the first cook. Further research could to be conducted to determine whether variations in processing methods affect the weight and the appearance of the animal, because these two factors will largely determine the price offered by buyers.

Postharvest processing can be viewed as a livelihood activity because it is sometimes a voluntary activity to earn more money from the resource through value adding. In Fiji, much of the family are involved in the processing. Although we interviewed few I-Kiribati women who harvest sea cucumbers, they are involved in processing the sea cucumbers of their spouses in a majority of cases. Therefore, diagnosis of gender in fisheries should also examine the roles of men and women (and children) in postharvest processing, in addition to their roles in fishing to fully understand their involvement in the industry.

This study has demonstrated a high degree of variation in seafood processing among island countries. Discussion about value adding in coastal fisheries must be underpinned by some understanding of this variation and the external factors underlying the methods and time investments of fishers.

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Resources: training videos

Downloadable postharvest processing training videos: http://scu.edu.au/environment-science-engineering/index.php/125

Online training videos: All language versions of the training video are available on Youtube with a root title of "Processing sea cucumbers into Beche-de-mer"

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