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Recovery rates for eight commercial sea cucumber species from the Fiji Islands

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HIGHLIGHTS

- We determined recovery rates for eight sea cucumber species during processing in Fiji.
- Length and weight-based recovery rates were species-specific.
- Results provide a basis for species-specific harvest sizes for sea cucumbers in Fiji.
- Results allow estimation of fresh weight from processed product and vice versa.
- Results have broad application in fishery stock assessment and monitoring.

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ABSTRACT

Determination of the original weight and length of sea cucumbers processed and dried to become bêche-de-mer (BDM), is an important tool in sea cucumber fishery management. The only management mechanism for the sea cucumber fishery in the Fiji Islands is a minimum length prescribed for BDM for export. However, different commercial species have different shrinkage rates during processing and previous studies have suggested modification of fisheries management for sea cucumbers to include species-specific minimum harvest size limits This study determined weight-based and length-based recovery rates (i.e. the length/weight of BDM recovered after processing from the initial length/weight of fresh sea cucumber), for eight commercial sea cucumber species following processing to BDM; White Teatfish (*Holothuria fuscogilva*), Black Teatfish (*Holothuria whitmaei*), Tigerfish (*Bohadschia argus*), Surf Redfish (*Actinopyga mauritiana*), Hairy Blackfish (*Actinopyga miliaris*), Stonefish (*Actinopyga lecanora*), Prickly Redfish (*Thelenota ananas*) and Sandfish (*Holothuria scabra*). Length and weight recovery rates varied between species and ranged from the highest recovery values of 54.9% for length and 11% for weight in Black Teatfish, to the lowest recovery values of 32.6% for length and 3.0% for weight in Sandfish and Tigerfish, respectively. Length-based and weight-based relationships were generated for each species through the various stages of processing from fresh to dried (BDM) allowing estimation of initial fresh weight/length from partially or fully processed BDM and *vice versa*. Information generated in this study provides a basis for developing more species-specific harvest size restrictions for sea cucumbers in the Fiji Islands, and has application in stock assessment studies, estimation of harvest data, monitoring of harvest size limits and standardizing catch data.

1. Introduction

Sea cucumber fisheries are an important source of income for coastal communities in the Pacific (Conand, 1990). Sea cucumber are usually processed into a dried product called bêche-de-mer (*iriko* in Japanese, *hai—som* in Chinese or *trepang* in Indonesian) (McElroy, 1990; Bumrasarinpai, 2006; Ferdouse, 1999) that is consumed as a delicacy and for perceived medicinal benefits (Bordbar et al., 2011; Esmat et al., 2013). The major markets for bêche-de-mer (BDM) are China, Hong Kong Taiwan, Singapore and Malaysia (Ferdouse, 2004), and around 58 species of sea cucumber are commercially exploited as BDM in Asian markets

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(Li, 2001; McElroy, 1990; Conand, 1990). The majority of these belong to the genera *Actinopyga*, *Bohadschia*, *Holothuria*, *Stichopus* and *Thelenota*, with Asian buyers particularly targeting species from the genus *Holothuria* (Li, 2001). The Sandfish, *Holothuria scabra*, White Teatfish, *H. (Microthele) fuscogilva* and Black Teatfish, *H. (Microthele) whitmaei* are among the highest value species (Holland, 1994) and well-dried 'A' grade product may command a price of $US 70–190 per kg depending on size and quality (McElroy, 1990; Purcell et al., 2012). Papua New Guinea (PNG), the Solomon Islands, Australia and the Fiji Islands were the leading suppliers of BDM to Asian markets from the Pacific (Ferdouse, 2004) but a moratorium on the fishery has prevented supply from PNG since 2009 (Carleton et al., 2013; Hair et al., 2016). Fiji currently exports around 243 tonnes of BDM per year (Carleton et al., 2012; Ram et al., 2016) composed of at least 27 species ranging from very high to low value species.

BDM processing entails an uncomplicated sequence of actions (Fig. 1) resulting in a product that is non-perishable if stored in dry, dark conditions. The BDM processing method currently used in the Fiji Islands was developed in the 1800s and has changed little since. Post-harvest steps include first boiling, slitting and gutting, second boiling, smoking and finally sun-drying (Ram et al., 2014a; Purcell, 2014a). Each step in this process contributes to the resulting quality of the final product which determines the suitability of processed products for Asian markets (SPC, 1994; Sachithananthan et al., 1985; Purcell, 2014b; Conand, 1990) and their value (Ram et al., 2014b). Although these steps are uncomplicated, it requires continuous attention to obtain a high quality dry product of consistent quality. Failure to do so can result in reduced quality and value of the final product (SPC, 1994; Sachithananthan et al., 1985). Nevertheless, because of a general lack of equipment required to optimize BDM quality (e.g. kerosene burners, smoking sheds and drying amenities), BDM production in Fiji uses simple customary methods described above (Seeto, 1999; SPC, 1994; Ram et al., 2014a). Processing BDM may also involve a 'salting' step where a saline solution or coarse salt is used to draw water from sea cucumber tissues (Lavitra et al., 2008) to facilitate dehydration and shrinking of the tissue.

About 60% of the sea cucumber body wall is composed of water (SPC, 1994) and most of this is lost during processing. The remainder is composed primarily of protein that accounts for the high protein content of BDM (Dong et al., 2011). Much of the protein content of the body wall of sea cucumbers, and resulting BDM, is composed of collagens; structural proteins that provide sea cucumbers with their body shape and form and assist during feeding, respiration, burrowing and in defense (Yamada et al., 2010). If BDM processing includes salting, salt soluble proteins are generally leached from the tissues during this process, but salt also enters the tissues and binds to the triple-helix collagen structure (Gómez-Guillén et al., 2011; Duerr and Dyer, 1952) where it contributes to the weight of the final BDM product (Bao et al., 2010; Dong et al., 2008, 2011), helps minimize weight and length loss during processing (Lavitra et al., 2008), protects from spoilage and prolongs shelf life.

Yield of BDM is generally expressed as a 'recovery rate' that determines the relationship (usually percentage) between fresh weight of sea cucumbers and the dry weight of resulting BDM (Skewes et al., 2004). Recovery rates vary between species and this has implications for fisheries management. The Fijian sea cucumber fishery for example, is in decline (Pakoa et al., 2013) and there is a push towards stricter management (Ram et al., 2016). Fiji's only management mechanism for this fishery is a minimum length of 7.63 cm (or 3 in.) prescribed for BDM for export (Pakoa et al., 2013; Ram et al., 2016; Carleton et al., 2012), regardless of species. Because different commercial sea cucumber species have different shrinkage rates during processing, previous studies have suggested modification of fisheries management for sea cucumbers in Fiji to include species-specific minimum harvest size limits (Vuki and Viala, 1989; Seeto, 1999; Skewes et al., 2004; Purcell et al., 2009). However, the data on which such species-specific management protocols for sea cucumbers in the Pacific could be based are limited to a small number of reports in regional bulletins and unpublished sources (Shelley, 1981; Vuki and Viala, 1989; Ngaluafe and Lee, 2013; Purcell et al., 2009) and information in the primary literature on recovery rates for the highest value commercial species from the Pacific (Sandfish *Holothuria scabra*) is limited to studies in Papua New Guinea (Shelley, 1985) and northern Australia (Skewes et al., 2004). Reported recovery rates for *H. scabra* in both studies are based on mass, not length, providing limited application in Fiji where the major criterion defining the suitability of BDM for export is minimum length.

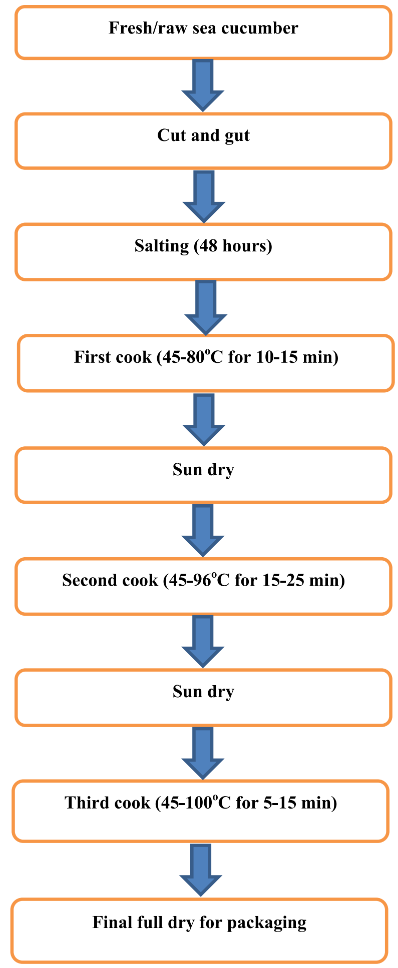

Fig. 1. Steps used by processors in Fiji for production of bêche-de-mer (BDM) from fresh sea cucumbers.

There is therefore an immediate need for research into the processing yield of the major species of sea cucumbers utilized for BDM production in Fiji. The data generated would provide a basis for developing more focused fishery management protocols where, for example, species-specific minimum harvest sizes could be determined to ensure that resulting BDM is of an appropriate length for export. Such data would assist responsible fisheries agencies in obtaining more accurate estimates of the fresh weight of sea cucumbers processed by fishers and exporters (Skewes et al., 2004), and facilitate enforcement of size limits for harvest. The aim of this study was to determine both mass-based and length-based recovery rates for eight high-value to medium-value commercial species from Fiji's sea cucumber fishery.

2. Materials and methods

This study was carried out with a commercial seafood processor in the Fiji Islands and live sea cucumbers were supplied to the processor by local fishermen. The recovery rates of eight sea cucumber species; Surf Redfish (*Actinopyga mauritiana*, $n = 77$), Hairy Blackfish (*Actinopyga miliaris*, $n = 28$), Stonefish (*Actinopyga lecanora*, $n = 73$), Tigerfish (*Bohadschia argus*, $n = 117$), White Teatfish (*Holothuria fuscogilva*, $n = 10$), Sandfish (*Holothuria scabra*, $n = 51$), Black Teatfish (*Holothuria whitmaei*, $n = 46$) and Prickly Redfish (*Thelenota ananas*, $n = 19$), were determined in this study. These species represent the most important commercial species harvested for BDM export in Fiji. Mean length and weight of each species prior to processing is shown in Table 1.

Sea cucumbers were processing using the method normally used by BDM processors in Fiji as outlined by Purcell (2014a) and represented in Fig. 1. Briefly, sea cucumbers were laid on a table for approximately five minutes to allow them to relax before the length and weight of each was determined to the nearest 10 g. Individual sea cucumbers were then gutted and the viscera removed before length and weight were determined for a second time. The sea cucumbers were then cooked for 10–15 min. (at 45 °C rising to 80 °C) and cooled before being salted using a coarse 'grade 11' solar salt for 48 h. After salting the sea cucumbers were again measured and weighed before being cooked for the second time for 15–25 min. (at 45 °C rising to 96 °C) and then solar dried for 2–3 weeks. A third cook for 5–15 min. (at 45 °C rising to boiling) was then followed by shape correction (straitening and closure of the body cut) to assist market acceptability, before the product was finally dried using solar and oven drying, then weighed.

Recovery rate for length (RRL) and recovery rate for weight (RRW) were calculated for each individual as:

RRL = *Length after processing / fresh length* × 100.

RRW = *Weight after processing / fresh weight* × 100.

Means were then calculated for each species.

3. Results

Changes in the mean lengths and weights of the eight species of sea cucumbers after each of the main processing stages (fresh, gutted, salted and fully dried) are shown in Table 1, and RRL and RRW for dried product from all species are shown in Fig. 2. Weight recovery after gutting was around 95% for all species, while length recovery ranged from 94.4% for Prickly Redfish to 99.3% for Tigerfish at the same stage. Weight recovery after salting ranged from 20.7% for Hairy Blackfish to 73.7% for Sandfish, while length recovery after salting ranged from 58.9% for Hairy Blackfish to 99.4% for Tigerfish (Table 1). RRL of fully dried BDM ranged from 32.6% for Sandfish to 54.9% for Black Teatfish while RRW ranged from 3.0% for Tigerfish to 11.0% for Black Teatfish (Fig. 2). Biometric relationships between length and weight of the eight species at different points in the processing sequence are shown in Table 2.

4. Discussion

This study determined mass-based and length-based recovery rates of eight high-value to medium-value species from Fiji's sea cucumber fishery after processing to BDM. Our results show that recovery rates varied between the eight species and were species-specific. Table 3 shows the recovery rates reported in this study and compares them with those of prior relevant studies for the same target species.

The most valuable species from the Fijian sea cucumber fishery is Sandfish which has a broad Indo-Pacific range and is the focus of research to develop commercial scale mariculture enterprises in east Africa, Vietnam, Philippines, Papua New Guinea and the

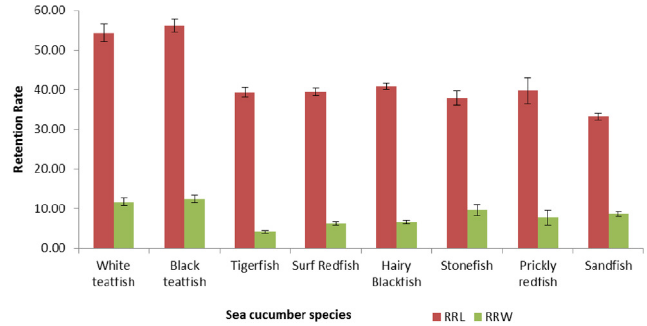

Fig. 2. Mean retention rates (%) for length (RRL) and weight (RRW) of eight species of sea cucumber processed into BDM.

Pacific islands (Hair et al., 2012). Given the importance of this high value species it is surprising that RRL has not been reported prior to this study. The RRW for Sandfish in this study was 8.1% and this is higher than previously reported values of 5.0% (Conand, 1979) and 5.1% (Skewes et al., 2004). BDM processed from Sandfish earns around $US115-1668 per kg in S.E. Asian markets (Purcell et al., 2012). This high value has resulted in over-exploitation by the Fijian sea cucumber fishery and, in 1989 the Fijian Government imposed a complete ban on the export of this species that is still in place. The ban applies to both fresh and dried products (Ram et al., 2016).

The second most valuable sea cucumber species in Fiji, White Teafish, had a RRL of 54.1% in this study which is slightly higher than that of 53% reported by Vuki and Viala (1989) and 51% reported by Shelley (1981). Weight recovery for this species was 10.6% after processing in this study which is again slightly more than the values previously reported for this species of 9.8% (Vuki and Viala, 1989) and 7.6% (Shelley, 1981) (Table 3). Given the high value of White Teatfish, and the export moratorium for Sandfish, the former is now preferentially targeted by the Fijian sea cucumber fishery (Ram et al., 2016).

Black Teatfish is a relatively high value species that has been the subject of a number of prior studies to determine recovery rates. Our results show that the RRL of Black Teatfish was 54.9% and this is similar to the RRL values reported for this species in prior studies that range from 55% to 44% (Shelley, 1985; Vuki and Viala, 1989) (Table 3). The RRW of Black Teatfish in this study was 11.0% and this is also similar to the value of 11.6% reported for this species by Purcell et al. (2009), but less than values of 8.1%–9.8% reported in some prior studies (Shelley, 1985; Vuki and Viala, 1989).

Prickly Redfish lost 93.5% of its fresh weight during processing with a RRW of only 6.5% after final drying. Similarly, length was reduced by 62.9% during processing resulting in a RRL of only 37.1% and this value compares well to those of 38% and 36% reported for this species by Shelley (1981) and Vuki and Viala (1989). Prior studies have also reported low RRW values for Prickly Redfish of 3.0% (Harriott, 1984), 4.6% (Shelley, 1981), 5.6% (Vuki and Viala, 1989), 8.0% (Parrish 1978; cited in Conand, 1990), 6.7% (Skewes et al., 2004) and 5.1% (Purcell et al., 2009) (Table 3).

The Surf Redfish had RRL of 38.5% and RRW of 5.7% in this study. Our results for RRL are slightly less than those reported in prior studies of 46% (Vuki and Viala, 1989) and 44% (Zoutendyk, 1989) and possibly result from differences in the processing methods between studies. The RRW of Surf Redfish in the current study (5.7%) was slightly higher than that of 4.9% reported by Vuki and Viala (1989), but lower than that of 6.7% reported by Zoutendyk (1989) (Table 3). Surf Redfish has a skin thickness of around 6 mm that renders this species susceptible to significant moisture loss during processing.

When comparing the results of this and prior studies, some noticeable differences are apparent between our values for RRW

Table 1
Mean (± SD) length (L, cm) and weight (W, g) of eight commercial sea cucumber species after each of the main stages (Fresh, Gutted, Salted, Fully Dried) of processing to bêche-de-mer (BDM) in Fiji.

Species	Length (L) and weight (W)				
		Fresh	Gutted	Salted	Fully dried
Actinopyga lecanora (Stonefish)	L	24.55 ± 4.85	24.18 ± 4.51	15.93 ± 2.81	9.09 ± 3.35
	W	709.45 ± 181.42	673.98 ± 172.35	224.04 ± 74.08	67.17 ± 74.97
Actinopyga mauritiana (Surf Redfish)	L	25.12 ± 4.61	24.12 ± 4.25	16.08 ± 1.95	9.68 ± 1.69
	W	635.39 ± 205.24	603.62 ± 194.98	254.16 ± 74.30	36.05 ± 18.03
Actinopyga miliaris (Hairy Blackfish)	L	29.29 ± 3.03	28.18 ± 2.95	17.25 ± 2.82	11.86 ± 0.76
	W	1079.00 ± 287.35	1025.05 ± 272.98	223.46 ± 131.22	67.89 ± 22.29
Bohadschia argus (Tigerfish)	L	30.85 ± 5.38	30.63 ± 5.20	30.66 ± 8.51	11.81 ± 3.45
	W	1016.57 ± 569.89	965.74 ± 541.40	435.64 ± 250.07	30.49 ± 21.69
Holothuria fuscogilva (White Teatfish)	L	36.40 ± 2.42	35.40 ± 2.80	21.75 ± 4.37	19.70 ± 2.04
	W	1532.00 ± 763.67	1455.40 ± 25.49	694.70 ± 235.37	162.12 ± 40.33
Holothuria scabra (Sandfish)	L	18.60 ± 3.03	18.22 ± 2.94	12.18 ± 1.36	6.06 ± 0.82
	W	128.95 ± 45.29	122.50 ± 43.02	95.02 ± 28.99	10.40 ± 5.13
Holothuria whitmaei (Black Teatfish)	L	27.93 ± 4.74	27.17 ± 4.51	23.35 ± 4.24	15.34 ± 1.99
	W	1084.24 ± 367.18	1030.03 ± 48.82	570.67 ± 150.37	119.06 ± 36.24
Thelenota ananas (Prickly Redfish)	L	50.68 ± 12.22	47.84 ± 10.51	45.74 ± 8.03	18.80 ± 3.59
	W	2145.53 ± 737.43	2038.25 ± 700.56	1136.32 ± 275.79	139.87 ± 121.81

Table 2
Biometric relationships for eight species of fresh and processed of sea cucumbers from Fiji where FL = length of fresh sea cucumber (cm), FW = weight of fresh sea cucumber (g), GW = gutted weight of sea cucumber (g), DL = length of dried sea cucumber (cm) and DW = weight of dried sea cucumber (g).

Species	X	Y	R^2	Equation
Actinopyga lecanora	FL	FW	0.3557	$Y = 0.0159x + 13.246$
	FL	GW	0.3557	$Y = 21.214x + 153.21$
	FL	DW	0.0159	$Y = 1.9527x + 19.231$
	FL	DL	0.0572	$Y = 0.1652x + 5.0356$
	DL	DW	0.8415	$Y = 0.041x + 6.3399$
Actinopyga mauritiana	FL	FW	0.1165	$Y = 0.0077x + 20.241$
	FL	GW	0.1165	$Y = 14.419x + 241.45$
	FL	DW	0.0721	$Y = 1.0493x + 9.6904$
	FL	DL	0.1192	$Y = 0.1268x + 6.4982$
	DL	DW	0.7621	$Y = 0.0821x + 6.7252$
Actinopyga miliaris	FL	FW	0.3478	$Y = 0.0062x + 22.567$
	FL	GW	0.3478	$Y = 53.067x - 529.06$
	FL	DW	0.2021	$Y = 3.3029x - 28.843$
	FL	DL	0.0459	$Y = 0.0539x + 10.286$
	DL	DW	0.4024	$Y = 0.0217x + 10.391$
Bohadschia argus	FL	FW	0.4037	$Y = 0.006x + 24.757$
	FL	GW	0.4037	$Y = 63.939x - 1007.1$
	FL	DW	0.0084	$Y = 0.3692x + 19.098$
	FL	DL	0.0088	$Y = 0.0602x + 9.9564$
	DL	DW	0.4988	$Y = 0.1125x + 8.3856$
Holothuria fuscogilva	FL	FW	0.2332	$Y = 0.0015x + 34.059$
	FL	GW	0.2332	$Y = 144.97x - 3821.6$
	FL	DW	0.0003	$Y = 0.2675x + 152.38$
	FL	DL	0.0007	$Y = -0.0223x + 20.51$
	DL	DW	0.2037	$Y = 0.0228x + 15.999$
Holothuria scabra	FL	FW	0.3016	$Y = 0.0368x + 13.859$
	FL	GW	0.3016	$Y = 7.7969x - 22.502$
	FL	DW	0.0758	$Y = 0.4658x + 1.7355$
	FL	DL	0.0335	$Y = 0.0494x + 5.1452$
	DL	DW	0.7695	$Y = 0.1401x + 4.6079$
Holothuria whitmaei	FL	FW	0.0678	$Y = -0.0034x + 31.582$
	FL	GW	0.0678	$Y = -19.153x + 1565.1$
	FL	DW	0.1514	$Y = 2.973x + 36.009$
	FL	DL	0.0809	$Y = 0.1194x + 12.005$
	DL	DW	0.4404	$Y = 0.0364x + 11$
Thelenota ananas	FL	FW	0.4438	$Y = 0.011x + 27.004$
	FL	GW	0.4438	$Y = 38.199x + 102.17$
	FL	DW	0.0047	$Y = -0.6816x + 174.42$
	FL	DL	0.0172	$Y = -0.0386x + 20.755$
	DL	DW	0.6043	$Y = 0.0229x + 15.595$

Table 3
Recovery rates based on weight (RRW) and length (RRL) for tropical sea cucumbers from the Fiji Islands from this study and from previous studies targeting the same species.

Species	Common name	RRW (%)	RRL (%)	Author(s)
Actinopyga lecanora	Stonefish	17.2	–	Ngaluafe and Lee (2013)
Actinopyga lecanora	Stonefish	9.5	37	This study
Actinopyga mauritiana	Surf Redfish	6.7	44	Zoutendyk (1989)
Actinopyga mauritiana	Surf Redfish	4.9	46	Vuki and Viala (1989)
Actinopyga mauritiana	Surf Redfish	5.7	38.5	This study
Actinopyga miliaris	Hairy Blackfish	5.6	–	Harriott (1984)
Actinopyga miliaris	Hairy Blackfish	9.7	52	Vuki and Viala (1989)
Actinopyga miliaris	Hairy Blackfish	11.5	–	Skewes et al. (2004)
Actinopyga miliaris	Hairy Blackfish	6.3	40.5	This study
Bohadschia argus	Tigerfish	14.3	–	Ngaluafe and Lee (2013)
Bohadschia argus	Tigerfish	3.0	38.3	This study
Holothuria fuscogilva	White Teatfish	7.6	51	Shelley (1981)
Holothuria fuscogilva	White Teatfish	9.8	53	Vuki and Viala (1989)
Holothuria fuscogilva	White Teatfish	18.6	–	Ngaluafe and Lee (2013)
Holothuria fuscogilva	White Teatfish	10.6	54.1	This study
Holothuria scabra	Sandfish	5.0	–	Conand (1979)
Holothuria scabra	Sandfish	5.1	–	Skewes et al. (2004)
Holothuria scabra	Sandfish	8.1	32.6	This study
Holothuria whitmaei	Black Teatfish	8.7	–	Harriott (1984)
Holothuria whitmaei	Black Teatfish	9.8	44	Shelley (1981)
Holothuria whitmaei	Black Teatfish	8.1	55	Vuki and Viala (1989)
Holothuria whitmaei	Black Teatfish	11.6	–	Purcell et al. (2009)
Holothuria whitmaei	Black Teatfish	11.0	54.9	This study
Thelenota ananas	Prickly Redfish	3.0	–	Harriott (1984)
Thelenota ananas	Prickly Redfish	4.6	38	Shelley (1981)
Thelenota ananas	Prickly Redfish	5.6	36	Vuki and Viala (1989)
Thelenota ananas	Prickly Redfish	8.0	–	Conand (1990)
Thelenota ananas	Prickly Redfish	6.7	–	Skewes et al. (2004)
Thelenota ananas	Prickly Redfish	5.1	–	Purcell et al. (2009)
Thelenota ananas	Prickly Redfish	6.5	37.1	This study

for Stonefish and Tigerfish and those of others. Ngaluafe and Lee (2013) reported RRW values for Stonefish and Tigerfish of 17.2% and 14.3%, respectively, while equivalent values in the current study were 9.5% and 3.0%, respectively. The reason for these differences is unclear but they are likely to be influenced by factors including differences in initial sea cucumber size, variations in processing techniques (e.g. method and duration of drying), when measurements were taken, ambient conditions and the degree of BDM dryness (Skewes et al., 2004; Purcell et al., 2009). In this particular case, Ngaluafe and Lee (2013) mentioned that some of the fresh sea cucumbers used in their study, including Stonefish, had already eviscerated prior to the start of the study and so accurate determination of initial fresh weight was not possible under these circumstances.

Fiji's only management mechanisms for the sea cumber fishery is a minimum length of 7.63 cm prescribed for BDM for export (Pakoa et al., 2013; Ram et al., 2016; Carleton et al., 2012), regardless of species, and a moratorium on the export of Sandfish. Regulations relating to BDM export have not been revised in the past 25 years despite a number of studies suggesting a need for further research that would provide a basis for such revision. A key issue in this regard is improved knowledge of the reproductive biology of target species (i.e. knowledge of minimum reproductive size), to provide a basis for replacing the current 'catch-all' export size limit with species-specific minimum harvest sizes that account for size at maturity (Ram et al., 2016). Another key research issue is improved knowledge of the recovery rates of target species following processing to BDM (Carleton et al., 2013; Pakoa et al., 2013; Ram et al., 2014a,b,c; Skewes et al., 2004), and this is addressed in the current study.

This study reports on the length-based and weight-based recovery rates of eight key species from the Fijian sea cucumber fishery for the first time. The data generated provide a crucial source of information for sea cucumber fishery management in Fiji and for developing policy relating to quality control for BDM exports. We report length-based and weight-based relationships through the various stages of processing from fresh sea cucumbers to dried BDM. These relationships allow conversion between processing stages and estimation of initial fresh weight/length from partially of fully processed BDM or estimation of BDM yields from fresh weight measurements. These data will have application in stock assessment studies, estimation of harvest data, monitoring of harvest size limits and standardizing catch data, and they provide a basis for developing more species-specific harvest size restrictions for sea cucumbers in the Fiji Islands.

The Sea Cucumber Fishery Act in Fiji has not been revised since it was implemented in 1984 and, in contrast to some other South Pacific countries, the Fijian sea cucumber fishery has not been closed, even temporarily, in response to over-harvesting (Ram et al., 2016). However, the Fijian government is currently drafting the Fiji Sea Cucumber Management Plan (Mangubhai et al., 2016) that should be completed in 2017. The Plan will outline future management strategies for the sea cucumber fishery in Fiji that will hopefully incorporate recommendations from prior reviews of the fishery (e.g. Carleton et al., 2012; Pakoa et al., 2013; Ram et al., 2016), and utilize the data generated in this study as a basis for developing species-specific management strategies supporting sustainability in the future fishery.

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