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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.

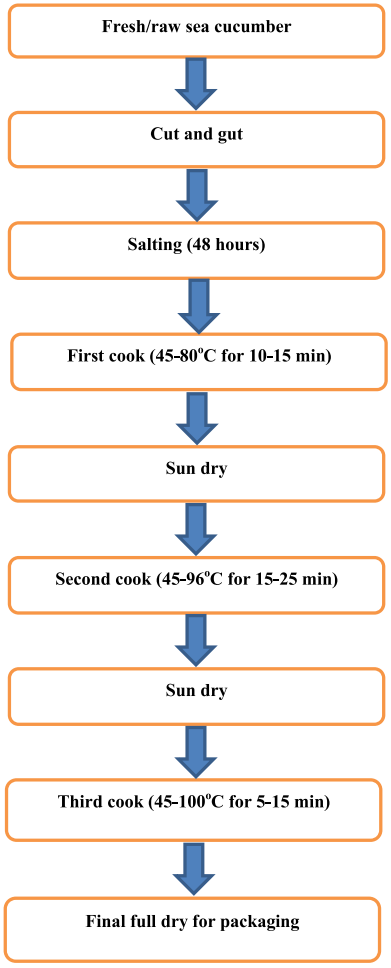

Fig. 1. Steps used by processors in Fiji for production of bêche-de-mer (BDM) from fresh sea cucumbers.

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.