RESEARCH ARTICLE

Artisanal, shell-based handicraft in Papua New Guinea: Challenges and opportunities for livelihoods development

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Abstract A thorough understanding of livelihoods is necessary to ensure development policies are compatible with both resource conservation and the social and economic goals of development. Few studies, however, focus on value-adding activities occurring post-harvest in artisanal fisheries. The transformation of mollusc shells and skeletal remains of other marine taxa into artistic jewellery and decorative items is becoming an increasingly important livelihood activity for rural, coastal communities across the Pacific. We examine the potential challenges facing the shell-based handicraft sector and opportunities for overcoming these challenges using a quantitative study of artisans among the Tigak Islands of Papua New Guinea. The major challenges facing this livelihood sector are perceptions of marine resource declines and a lack of livelihood flexibility, attributed to the specialisation of material assets and skills. Improving market heterogeneity and developing coastal aquaculture may facilitate sustainable development of this livelihood sector.

Keywords Artisanal fisheries · Coastal communities · Mollusc · Rural livelihoods · Tropical aquaculture

INTRODUCTION

Much of the economic development in Melanesia is coordinated by foreign companies that extract primary resources through activities such as logging, mining, and industrial fishing (Filer 2004; Foale and Macintyre 2005; Foale et al. 2016). Only a small portion of the revenue generated by such activities flows back to local landowners through equity agreements or the limited employment opportunities they offer (Macintyre and Foale 2004). Despite foreign investments and resulting cash flow,

promises of services and income opportunities for local communities are often unfulfilled by such industries (Johnson 2012; Banks 2014). As a result, the majority of the population depend on subsistence lifestyles (Kaly et al. 2005; Allen and Bourke 2009a; Foale et al. 2016).

In Papua New Guinea (PNG), there are approximately 4000 coastal communities (Govan 2015) that rely heavily on marine resources for subsistence and income opportunities (Kaly et al. 2005; Cinner and McClanahan 2006; Purdy et al. 2017). While most coastal and island communities in PNG have access to local food resources (Cinner and McClanahan 2006; Allen and Bourke 2009a), there is growing cash dependence for educational, medical, and utility services (Kaly et al. 2005). There is also a strong desire to purchase products that offer lifestyle conveniences (Foale and Macintyre 2005; Kaly et al. 2005), requiring communities to find means of generating sufficient and reliable income. The main income-earning opportunities for coastal and island communities are from market sales of fisheries and agricultural produce (Kaly et al. 2005; Allen and Bourke 2009a; Purdy et al. 2017). For communities on small islands without arable land, however, income opportunities are restricted and rely on marine resources (Macintyre and Foale 2004; Purdy et al. 2017).

Under these constraints, one activity generating income for island communities is the production of shell-based handicrafts (Resture and Resture 2005; Chand et al. 2014). This activity involves the transformation of mollusc shells and skeletal remains of other marine taxa into handicrafts, such as jewellery and decorative items (Chand et al. 2014). Production of ornaments from marine molluscs has been well documented in the archaeological record of PNG (Kinch 2008; Shaw and Langley 2017), and the earliest ethnographical expeditions into PNG discovered shell-

based objects used in personal ornamentation, ceremonies, and numismatics (Finsch 1914). Adaptation of traditional mollusc use to produce handicraft items appealing to Western consumerism (Macintyre and Foale 2004; Stearns 2006) has benefited island communities in other countries (Resture and Resture 2005; Chand et al. 2014).

Artisanal fisheries play a crucial role in poverty reduction (Béné et al. 2007), yet they are often overlooked and undervalued in management and policy (Pauly 2006; Zeller et al. 2007). The extent to which shell-based handicraft production occurs or contributes to rural livelihoods within PNG has not been evaluated. Even at a global scale, little research attention has been given to shell-based handicraft livelihoods despite considerable literature on the economic benefits afforded to local communities through the sale of whole shells (i.e., curios) to international tourists (Gössling et al. 2004; Dias et al. 2011). The participants, resources, markets, and products arising from shell-based handicrafts are rarely the subject of scientific evaluation (e.g., Resture and Resture 2005).

This study evaluated the extent to which shell-based handicraft production occurs and contributes to rural livelihoods among the Tigak Islands within New Ireland Province of PNG. To assess the potential challenges and opportunities for shell-based handicrafts in livelihood development, we described the demographics of artisans, and the socio-economic impacts of this activity, and we identified the most important natural resources utilised in shell-based handicraft production.

MATERIALS AND METHODS

Study area

PNG comprises the eastern part of the island of New Guinea and a number of smaller islands in the western Pacific region. The country is part of the Coral Triangle, the centre of global marine biodiversity. The majority of coastal communities in PNG engage in fishing, and there is increasing pressure on marine resources due to the growing coastal population (Cinner and McClanahan 2006; Purdy et al. 2017). Overexploitation has been particularly problematic for income-generating invertebrate species, such as giant clams (Kinch 2008) and sea cucumber (Barclay et al. 2016).

New Ireland Province is a maritime province of PNG comprising a collection of islands in the Bismark Archipelago with a landmass of around 9600 km². The provincial capital is Kavieng. The province had an estimated population of 194 067 in 2011 (4.5% annual growth) with a Tok Pisin literacy rate of 77.4% and an average life expectancy of 58 years (National Statistical Office 2013).

There are few formal employment opportunities, with paid employment accounting for < 4% of occupations (Kaly et al. 2005). Approximately 3000 inhabitants live among the Tigak Islands (National Statistical Office 2013), northwest of the main landmass (Fig. 1). The majority of the population here relies on sales of seafood as their primary income source (73% of income) and rely on marine resources for subsistence living (Purdy et al. 2017), in part necessitated by limited arable land (Allen and Bourke 2009b).

Data collection

For the purpose of our study, we defined shell-based handicrafts as the transformation of mollusc shells and skeletal remains of other marine taxa into jewellery and decorative items for the purpose of cash sales (Fig. 2). Households solely engaged in the collection and sale of

Fig. 1 Map of the Nusa Islands in New Ireland Province, Papua New Guinea (PNG) where dark shading indicates land and light shading indicates areas with reef development. Hamlets 1–4 occur on Nusalik Island, while hamlet 5 occurs on Nusalavu Island. Top left inset places the Nusa Islands in geographical context within the Tigak Islands region

Fig. 2 Panel figure depicting elements of the discussed post-harvest, shell-based handicraft livelihood activity in rural Papua New Guinea. **a** shells of the mollusc *Chrysostoma paradoxum* are broken into fragments, **b** a man strings drilled shell fragments on a cord for further processing, **c** an example of a final product, here earrings, created by Nusa Islands’ artisans with *C. paradoxum* and nautilus shells. Photos by Nitty Simard

unprocessed whole shells as curios, and households solely engaged in the production of shell products for customary use (e.g., shell money) (Finsch 1914) were excluded from our study.

Artisan households selling shell-based handicrafts at local markets in the province were identified in 2016. To ensure our survey included artisan households not engaging in local markets, known artisans were asked to recommend other artisans for further surveying. This method of snowball sampling (i.e., chain referral) allowed identification of additional artisanal households and is ideal for researching groups of people who are dispersed and difficult to identify (Biernacki and Waldorf 1981). In addition to snowball sampling, retail outlets in Kavieng selling handicraft components and supplies were asked to identify consumers that regularly purchase such products. This was done to overcome potential bias in artisan referrals, where artisans may fail to identify their competition, and to increase the likelihood of sampling all artisan households in the region.

The household member identifying themselves as the primary artisan was asked to participate in an interview on behalf of the household. No artisans refused participation. Between February and March 2017, 38 respondents were interviewed, accounting for all known artisan households engaged in shell-based handicrafts among the Tigak Islands.

Interviews were conducted verbally in either English or Tok Pisin, depending on the preference of the interviewee, and followed a semi-structured format with a questionnaire to guide the interview. Questions were of a variety of formats, including Likert-type scales, multiple-choice, binary, and open-ended response. The questionnaire had four sections relating to (1) artisan demographics, (2)

investment into and income from shell-based handicraft production, (3) the benefits and detriments of engagement in a shell-based handicraft livelihood, and (4) the natural resources of greatest importance to shell-based handicraft production.

Data analysis

Answers to binary-response and multiple-choice questions were treated as categorical data, while answers to Likert-type scale questions were treated as numerical data. Open-ended questions with a numeric response (e.g., those relating to age, household size, household income, etc.) were also treated as numerical data. Answers to open-ended questions with qualitative responses were categorised in an iterative process according to major themes. For example, where artisans indicated community benefits were financial contributions to tangible items for use by the community, such as a water tank, these benefits were categorised as “improvement of community infrastructure”. The assets artisans reported owning for the production of shell-based handicrafts were quantitatively assessed as both the number of unique assets owned and the cumulative value of assets owned. Both metrics were taken as measures of a household’s investment into a shell-based handicraft livelihood. Tool values were based on prices observed at hardware stores in Kavieng during the time-frame of interviews. Product diversity was assessed as the number of unique shell-based handicraft product types produced by an artisan’s household.

Summary statistics describing artisan demographics were generated with the R statistical software and are presented as mean $\pm$ SE. Monetary values are presented as 2017 USD following currency conversion with OANDA

(www.OANDA.com). Kendall's correlation tests, using the *cor.test* function in the R package *stats*, were independently conducted to assess the nature and strength of correlations between weekly incomes from shell-based handicrafts and work effort, experience, unique assets owned, cumulative tool value, household size, and product diversity.

RESULTS

Artisan demographics

A total of 38 households among the Tigak Islands of New Ireland Province produced shell-based handicrafts. All artisans identified themselves as belonging to at least one of nine community groups concentrated in five discrete living areas or hamlets among the Nusa Islands (Fig. 1). Artisans were distributed among these five hamlets as follows: Panacondo (hamlet 1, 36.8%), Kaplaman (hamlet 2, 31.6%), Lamangua (hamlet 3, 23.7%), Walakutung (hamlet 4, 5.3%), and Tugai (hamlet 5, 2.6%). The mean number of occupants per household was 5.08 ± 0.34 (range 1–9). None of the artisans' households had access to public utilities (i.e., electricity, gas, freshwater, and sewerage). Freshwater was sourced from collected rain water (97.4%) and/or a community well (97.4%). Sewage was disposed of in either an earthen pit (60.5%) or by open defecation in the ocean (39.5%). Some households had access to electricity through use of a private generator (39.5%) or solar lighting (18.4%).

The household member that identified as the primary artisan was more often female (81.6%) than male (18.4%; $\chi^2 = 30.32$, $P < 0.001$). Three artisans (7.9%) identified as being physically disabled. The mean age of the primary artisan was 37.63 ± 1.82 (range 22–63) with 7.9% having no education, 36.8% having not completed primary school, and 84.2% having not completed high school.

Artisan experience in producing shell-based handicrafts ranged from 1 to 30 years ($\bar{x} = 10.3 \pm 1.3$; Fig. 3). Two periods of rapid expansion in shell-based handicraft participation were identified. Over a third of surveyed artisans (34.2%) indicated that they began shell-based handicraft production in the 3 years following a resort (named Nusa Island Retreat) commencing business on Nusalik Island in 1997 (Fig. 3). The second period of expansion coincided with the sea cucumber fishery moratorium imposed in 2009 (Barclay et al. 2016). Nearly half (47.4%) of the artisan community began producing shell-based handicrafts during the moratorium. While the moratorium was lifted for a seasonal period of fishing in April 2017, our study was conducted prior to this re-opening of the fishery.

Fig. 3 Cumulative percentage of surveyed artisans engaging in shell-based handicraft production over time. Dashed, vertical line illustrates the opening of Nusa Island Retreat in 1997, and the shaded portion of the graph illustrates the sea cucumber fishery moratorium between 2009 and 2017

Artisans indicated that they sold shell-based handicrafts directly from their homes (76.3% of households), at public produce markets (63.2%), to local hospitality venues (26.3%), and to retail shops in Kavieng (21.0%). Shell-based handicrafts were primarily sold directly to consumers ($78.0 \pm 4.8\%$) with remaining sales to individuals or businesses for resale. Artisans selling their shell-based handicrafts directly to consumers identified most of their customers as women ($80.6 \pm 3.8\%$). Artisans also indicated that the majority of their sales were to locals ($70.6 \pm 5.6\%$) rather than domestic or international tourists.

Investment and income

Investment into shell-based handicraft was represented by the quantity of material assets (3.9 ± 0.3 unique tools) and the cumulative monetary investment into material assets ($\$47.72 \pm 7.52$, range $\$6.19$ – 205.65). The material assets artisans identified as owning for the purpose of shell-based handicraft production are shown in Table 1. In addition to these material assets, artisans indicated a diversity of natural resources could be utilised in place of store-bought assets. For example, river stones could be used in place of stone files and handmade wooden “pump drills” (Finsch 1914) could be used in place of mechanical drills. The majority of artisans (94.7%) desired to make further material investments into their shell-based handicraft livelihood through the purchase of additional tools. Major constraints in committing to further investment included

Table 1 Material assets owned by artisans for the purpose of shell-based handicraft production. The local retail value (USD) and the percentage of artisans owning a given asset are presented

Material assets	Values (\$)	Percentage of artisans
Stone file	3.09	55.3
Cutting pliers	6.18	86.4
Needle files	10.18	15.8
Coping saw	12.36	10.5
Jewellery saw	12.36	34.2
Jewellery plier set	12.36	39.5
Mechanical hand drill	13.90	65.8
Grinding wheel	18.54	50.0
Electric rotary tool	61.80	13.2

lack of available funds (identified by 47.3% of artisans), lack of tool availability when funds were available (34.2% of artisans), and lack of knowledge on how to use the desired tool (18.4% of artisans). The mean effort allocated to shell-based handicraft production was 4.00 ± 0.35 (range 1–7) days per week.

Mean total weekly household income was $\$79.54 \pm 9.14$ (range $\$3.09$ – 239.67) for households engaged in shell-based handicraft production. Income attributed directly to shell-based handicrafts ($\$41.97 \pm 4.18$, range $\$3.09$ – 154.63) accounted for $69.3 \pm 5.2\%$ of the weekly household income, and was the sole income source for 42.1% of households with resident artisans. When asked to rank shell-based handicrafts in relation to other household income-generating activities, 52.6% of artisans ranked shell-based handicrafts as their most important income source, 28.9% ranked it as a secondary income source, and 18.4% ranked it as their third most important source. There were no significant relationships between weekly income from shell-based handicrafts and work effort, household size, artisan experience, number of unique assets owned, cumulative tool value, or product diversity (Table 2).

Table 2 Kendall correlation test results for relationships between reported weekly income from shell-based handicrafts and potential impacting factors

Factors	Weekly income for jewellery		
	τ	z	P
Effort	0.23	1.83	0.07
Value of assets	0.11	0.95	0.34
Years' experience	0.08	0.67	0.51
Product diversity	0.04	0.29	0.78
Household size	0.02	0.19	0.85
Assets owned	− 0.01	− 0.12	0.91

Income satisfaction was also found to be independent of weekly income from shell-based handicrafts ($\tau = 0.16$, $z = 1.16$, $P = 0.25$). Artisans were generally “satisfied” (68.4%) or “very satisfied” (23.7%) with their income from shell-based handicrafts. Only three artisans (7.9%) were less than satisfied with their income: two artisans indicated “neutral” satisfaction, and one artisan indicated that she was “dissatisfied” with her income. Despite a lack of income satisfaction, these three artisans were unwilling to exit shell-based handicraft for an alternative occupation. Across the entire population of artisans, 86.8% indicated they were unwilling to exit a shell-based handicraft livelihood for an alternative occupation. All artisans (100%) were optimistic about future income from shell-based handicrafts (Table 3). When artisans were asked of their willingness to encourage other artisans to engage in a shell-based handicraft livelihood, 89.5% indicated willingness. This willingness to share knowledge was also apparent in artisans' responses to the question of how they learned to produce shell-based handicrafts, with 71.1% identifying other artisans as instructors.

Benefits and detriments

Community benefits of shell-based handicraft production were perceived by 68.4% of the artisans, and they were primarily related to income generation (70.6% of listed benefits, $n = 34$). This included job creation and income for improving community infrastructure, contributions to church, supporting other members of the community, and contributions to customary activities (e.g., mortuary feasts; Table 4). Non-monetary benefits to the community (29.4% of listed benefits) were seen as a greater social engagement of the community (Table 4). No artisan identified detriments of shell-based handicraft livelihoods on their community.

Family benefits from shell-based livelihoods were perceived by 89.5% of the artisans. The family benefits of a shell-based livelihood were primarily related to income generation (94.9% of listed benefits, $n = 78$). This included income for living necessities, extra money for non-essentials, and paying for medical expenses (Table 4). Non-monetary benefits to the family (5.1% of listed benefits)

Table 3 The reasons that artisans perceived their income from shell-based handicrafts will increase in the future

Reasons	Percentage of artisans
More customers in future	34.2
A need to make more money	28.9
Greater effort allocation	21.0
Development of new skills	18.4

Table 4 How artisans perceive shell-based handicrafts benefiting the community and their families. The percentage of artisans is representative of the number of artisans describing the listed benefits in an open-ended question without prompting

Community benefits	Percentage of artisans	Family benefits	Percentage of artisans
Improvement of community infrastructure	21.0	Purchase of food and clothing	81.6
Increased social engagement of community	18.4	Paying for children's school fees	31.6
Financial contribution to church	15.8	Paying for housing improvement	28.9
Job creation	10.5	Having a skilled occupation	10.5
Financial support for others	10.5	Extra money for non-essentials	7.9
Financial contribution to community activities	5.3	Paying for medical expenses	2.6
Uncertain	31.6	Uncertain	10.5

were associated with participation in a culturally important, skilled occupation (Table 4). No artisan identified detriments of shell-based handicraft livelihoods on their family, but artisans did view the physical labour invested in the production of certain product types negatively, at a personal level.

Natural resources

A total of 17 species of marine organisms were identified as the most important natural resources supporting shell-based handicraft production. Nearly all taxa were molluscs, the single exception being cartilage taken from the black-tip reef shark *Carcharhinus melanopterus* (Fig. 4). Two-thirds (65.8%) of artisans identified nautilids, encompassing *Nautilus pompilius* and *Allonautilus scrobiculatus* (Saunders 2010), among the most important organisms for shell-based handicraft production (Fig. 4). This was followed by the gastropod mollusc *Chrysostoma paradoxum* (Fig. 2), important to 57.9% of artisans, and the pearl oyster *Pinctada margaritifera*, important to 44.7% of artisans (Fig. 4). Two other pearl oyster species (Pteriidae) were identified as being among the most important organisms for shell-based handicrafts; *Pteria penguin* (15.8% of artisans) and *Pinctada maxima* (10.5% of artisans; Fig. 4). The IUCN Red List statuses of the identified organisms were “not assessed” for all but *C. melanopterus*, which was listed as “near threatened”. The only taxa listed in CITES was the Nautilidae, which was listed in CITES Appendix II.

Artisans were found to harvest or purchase shells from others. In 41.2% ($n = 114$) of all instances, those species of greatest importance to the artisans were harvested by the artisans in the waters around the Nusa Islands. The number of artisans harvesting a particular organism varied (Fig. 4). All species were harvested alive, except nautilids which artisans harvested as drift shells only. Our study can only account for the harvesting activities of the artisans, and it is unclear how shells sold to artisans were acquired. Where artisans collected species themselves, roughly half (51.1%)

perceived harvesting as being difficult. In an open-ended response to why harvesting was difficult, 70.8% of artisans indicated population declines as a result of competition for resources (Fig. 4), while 29.2% indicated seasonally due to ocean conditions.

In 58.8% ($n = 114$) of instances, artisans purchased the shells from others. Reasons for buying a particular shell were largely a consequence of the mollusc being perceived as absent or in declining abundance around the Nusa Islands (58.2%; Fig. 4). Artisans also indicated a preference to buy shells because harvesting was time consuming (17.9%) or they had a desire to obtain better quality shells, in terms of size or colour, than are locally available (11.9%). A lack of interest in harvesting (7.5%) and being physically unable to harvest (4.5%) were also given as reasons for purchasing shells from others.

DISCUSSION

Shell-based handicraft production was found to contribute to rural livelihoods in PNG. The shell-based handicraft sector of the Tigak Islands was a primary or supplementary income source for approximately 6% of the region's population (National Statistical Office 2013), and the weekly income of artisan households exceeded the regional average (\$43.60) (Purdy et al. 2017) by an additional 78%. Shell-based handicraft offers an opportunity for income generation that does not appear to engender the negative social repercussions attributed to income generation from logging, mining, or other fishing activities in PNG (e.g., Johnson 2012; Banks 2014; Barclay et al. 2016). In contrast to fishery sectors where participation is limited by physical fitness (Barclay et al. 2016) or cultural taboos (Kaly et al. 2005), shell-based handicraft production engaged men, women, the elderly, and disabled persons.

The potential for shell-based handicraft to empower women was identified through the high percentage of female participants and the capacity for women to engage in production and sales from home (Lombardini et al.

Fig. 4 Percentage of artisans identifying a given taxon among the three most important organisms supporting their shell-based handicraft livelihood. This is further broken down into the percentage of artisans harvesting or buying these taxa. The percentage of artisans indicating harvesting has become more difficult as a result of increased competition for resources is indicated by the darkened portion of those harvesting the resource. The percentage of artisans indicating their reason to buy from others was a result of absent or declining stocks is indicated by the darkened portion of those buying the resource. Asterisks denote taxa listed on CITES Appendix II

2017). This aspect of shell-based handicraft allows women to obtain control over productive resources within the household and gain access to income without compromising availability for family responsibilities at home (UN Women 2014; Lombardini et al. 2017). A well-recognised benefit of livelihood sectors providing income-generating opportunities to women is that the income generated by women is typically spent on family and home development, in comparison to the more frivolous expenditures associated with male management of income (Chaaban and Cunningham 2011; UN Women 2014; Barclay et al. 2016). This notion was reflected in our survey where a large number of female artisans identified income generation for aspects of family and home development as a benefit of this livelihood.

Diversity is an important attribute of rural livelihoods in developing countries that reduces the risk of livelihood failure because of fluctuations in resource availability or markets (Ellis 1998, 2000; Allison and Ellis 2001). Our data shows that livelihood diversity was absent among a large portion of households engaged in shell-based handicraft production. Sole reliance on a livelihood dependent on marine resources and a non-essential product niche poses substantial livelihood security risks (Allison and Ellis 2001; Allison and Horemans 2006). We also found that material assets utilised in shell-based handicraft production have limited capacity for diversification. The highly specialised nature of shell-based handicraft assets limits the extent to which they could be applied to alternative livelihood options, primarily market-based fishing and agriculture (Kaly et al. 2005; Allen and Bourke 2009a;

Purdy et al. 2017). While the actual capital tied up in shell-based handicraft assets was not great, generally less than a week's income for most households, the majority of artisans indicated unwillingness to pursue an alternative occupation.

The lack of livelihood diversity, the specialisation of assets, and the unwillingness to pursue alternative occupations demonstrates inflexibility within this livelihood sector. Inflexibility is often attributed to a professionalisation of the occupation due to requirements for specialisation, in terms of material assets and skills (Smith and McKelvey 1996). While professionalisation in the shell-based handicraft sector allows access to higher-value market niches (Chand et al. 2014), the inflexibility associated with professionalisation poses substantial livelihood security risks if resources or market-share access become limiting (Allison and Ellis 2001; Allison and Horemans 2006).

The influx of new entrants to the shell-based handicraft sector in recent years foreshadows challenges in maintaining resource and market-share availability (Allison and Ellis 2001). In many cases, an influx of new entrants into resource-dependent occupations reduces income as available resources and market-share access are further divided (Dalzell et al. 1996; Allison and Ellis 2001). Despite potential for increased competition, the majority of artisans were willing to encourage others to engage in a shell-based handicraft livelihood. Such sentiments were not made with naivety of the implications of increased competition, because numerous artisans indicated that competition had already resulted in local resource declines. Declines in

local resources can be compensated to some extent by increased effort allocation and resource collection from new areas (Anderson et al. 2011), both aspects captured in our survey. A portion of the community anticipated greater effort allocation to shell-based handicraft production and a portion of marine resources were purchased from other areas due to perceptions of absent or declining local stocks. The expanding shell-based handicraft sector is in need of identifying opportunities to overcome resource and market-share access limitations as a result of increased competition.

The existing framework for top-down governmental management of invertebrate fisheries in PNG is unlikely to sufficiently protect marine resources of importance to the shell-based handicraft sector from overexploitation. Attempts to match resource extraction with productivity through a combination of government-imposed output and technical control measures have a high failure rate at community level (Wilson et al. 1994). Within PNG, regulations such as gear restrictions, size restrictions, and harvest bans exist for invertebrates, but are not thoroughly enforced (Barclay et al. 2016). Successful top-down enforcement of fisheries regulations by the government is particularly complicated for shell-based handicraft resources because: (1) there is limited capacity to identify species composition of the final products traded (Fig. 2), which hinders monitoring, (2) most marine resources utilised are not harvested directly by artisans, indicating a dispersal of fishing effort that complicates monitoring and enforcement, (3) local tenure arrangements makes coordinated management of resources difficult (Foale and Manele 2004), (4) a diversity of species are utilised which can make single-species management methods expensive (Militz et al. 2018), and (5) national and provincial governments often lack adequate personnel and funding to monitor catch or enforce regulations (Govan 2015). Therefore, alternatives to top-down government management of resource extraction should be explored to ensure long-term sustainability of the marine resources supporting shell-based handicraft livelihoods.

Perceptions held by many artisans that the marine resources utilised in shell-based handicrafts have declined in abundance may be one avenue to direct resource management. Given existing concerns, linking the benefits of conservation for the purpose of sustaining economically important resources may be well received (Filer 2004; Macintyre and Foale 2004). Community-based resource management in the form of Locally Managed Marine Area models have proven successful in leading to the recovery of degraded mollusc fisheries in some instances (Tawake et al. 2001; Thaman et al. 2017). The geographical concentration of artisans among the Nusa Islands increases the feasibility of implementing community-based resource

management as the islands establish a clear geographical tenure boundary. While a large portion of islands' inhabitants are engaged in shell-based handicraft livelihoods and have a collective interest in resource sustainability, the existence of multiple self-identifying hamlets will inexorably complicate governance (Aswani et al. 2017). A thorough understanding of the Nusa Islands' socio-political and historical dynamism and complexity should be attained (see Aswani et al. 2017) before implementation of a resource management programme.

Further opportunities for improving livelihood security come from the aquaculture sector. Development of regional aquaculture could offer a renewable source of shell resources while simultaneously creating alternative livelihood opportunities. Aquaculture is commercially developed throughout the South Pacific for a number of the species utilised by handicraft artisans in PNG, such as pearl oysters, *Tectus niloticus*, and *Turbo* spp. (Yamaguchi 1991; Southgate et al. 2008). The low technology requirements for community-based collection of pearl oyster species, for example, can provide a sustainable supply of pearl shell and support further product diversification through the culture of pearls (Kishore et al. 2018). The aquaculture development described here has already yielded benefits to communities engaged in shell-based handicraft in Fiji (Kishore et al. 2018) and Tonga (Teitelbaum and Fale 2008), but has yet to be developed in PNG.

Market-share access limitations anticipated from increased competition are likely to be exasperated if current predictions for continued decline of the PNG economy hold true (Fox et al. 2017). When domestic economies suffer, a reduction in consumption of non-essential goods from the domestic market can be expected (Ait-Sahalia et al. 2004). As the shell-based handicraft sector relies heavily on local markets for the majority of sales, a decline in product consumption would negatively impact this sector by restricting the available market. In addition to identifying opportunities for resource sustainability, opportunities for market resilience must also be explored by the expanding shell-based handicraft sector.

Greater market heterogeneity could build resilience against a domestic economic recession. International consumers, whilst in PNG and abroad, represent a market segment likely to be unaffected by domestic economic conditions. The present shell-based handicraft industry, however, only trades products at locations in the immediate vicinity (< 5 km) of production, with sales predominately to local consumers. As shell-based handicrafts are inert goods of high value relative to their weight, they can be transported and sold in more distant markets (Southgate et al. 2008; Chand et al. 2014). This indicates scope for regional marketing of products at international tourism centres (Chand et al. 2014) and global marketing of

products through internet-based marketplaces. Connecting artisan communities with retailers having access to these markets is likely to be more feasible for artisans, given their socio-economic constraints, than encouraging direct participation. The majority of the artisans were village-based women with limited education, and are unlikely to have the financial and business acumen necessary to meet the demands of international markets. Future research should evaluate the nature and extent of PNG shell-based handicraft product demand from international consumers to better guide training and education workshops to develop appropriate products and connect artisans with these markets.

CONCLUSION

This socio-economic assessment provides insights into the potential challenges facing the shell-based handicraft livelihood sector in New Ireland Province, PNG and opportunities for overcoming them. Long-term sustainability of shell-based handicraft production reliant on marine resources is uncertain, suggesting a timely need for coastal aquaculture development in PNG. Training and education workshops focused on improving access to international markets will improve existing market heterogeneity and offer a degree of market resilience. The insights gained from this socio-economic assessment are likely to be of interest and value to shell-based handicraft livelihood development throughout PNG and other developing island nations.

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