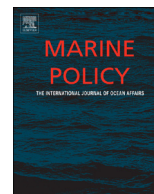




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# The socio-economic context for improving food security through land based aquaculture in Solomon Islands: A peri-urban case study



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## ABSTRACT

Future fish demand-supply scenarios project that investment in aquaculture will be needed to ensure fish for food security in Solomon Islands. In 2010 a study of two peri-urban areas of Solomon Islands analysed the demand and potential for inland aquaculture, and the role of the introduced Mozambique tilapia (*Oreochromis mossambicus*) in household livelihoods and existing value chains. Of 178 households interviewed, marine reef fish were the preferred fish for consumption, although tinned fish was also common. At the study sites, Mozambique tilapia was accessible and contributed to food security, particularly for inland households. Sixty five percent of the people actively fished for tilapia at least monthly; 13% of these fished on almost a daily basis. Fish were consumed by men, women and children and sold by both men and women in local village markets. Mozambique tilapia is considered to perform poorly in aquaculture. While other species like Nile tilapia or milkfish (*Chanos chanos*) are being considered for aquaculture by the Solomon Islands Government, Mozambique tilapia is currently the only cost-effective and widely available alternative for farming fish for household food security. This study lends weight to the premise that peri-urban households that are cash poor are likely to benefit nutritionally from easier access to tilapia or other freshwater fish.

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## 1. Introduction

In the Pacific Islands Countries and Territories (PICTs), coastal capture based fisheries contribute substantially to local subsistence and market economies [1,2], while the offshore tuna fisheries are particularly valuable national assets [1,3]. Marine capture fisheries typically dominate the fisheries of PICTs [4] although production in recent decades has seen a gradual decline, similar to global fishery trends [5–7]. The industrialisation of fisheries since the 1950s has led to the well documented overexploitation of marine resources with a number of fisheries collapsing [8–15]. There is overwhelming evidence that human activities are profoundly altering marine ecosystems on a global scale [16–18]. Of particular concern are the environmental changes that human activity is causing to the functioning of coral reef ecosystems that support fisheries upon which millions of people, including all of the PICTs, depend [19].

One of the responses to declining capture fisheries has been a dramatic rise in aquaculture production. With a global reduction in wild capture of more than 0.5 million tonnes per year from 2004 to 2010, aquaculture has been increasing in production at approximately 2.5 million tonnes per year over the same period [20]. Globally, aquaculture contributed 63.6 million tonnes of the total 154 million tonnes of fish produced in 2011 [20]. Aquaculture is currently the fastest growing food production system for developing, low income and food deficit countries (LIFDCs), which boast the highest annual aquaculture growth rate (10% per year) since the 1970s, compared to the 3.7% per year rate for developed countries [21,22]. There are marked geographical differences in aquaculture production, however, and PICTs have experienced significantly slower growth rates than most other areas [23–25]. Sustainable aquaculture as a tool for development, incorporating environmental, economic, nutritional and social considerations, is increasingly considered to have great potential to help meet the global requirements of fish for the future, and contribute to future food and nutrition security [25–27].

While improved management of coastal fisheries in the coral reef ecosystems of the Pacific is widely recognised as being essential to secure the benefits of capture fisheries [1,4,28], it has also been recognised that increased production from

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aquaculture will be necessary to meet the fish food needs of the region in the future [1,28]. Demand for fish from aquaculture will increase as supplies from capture fisheries, particularly from inshore reefs, become increasingly unreliable, as seen, for example, in recent fish-supply demand scenarios in Solomon Islands [28].

Imbalances between supply and demand for fish in many PICTs are expected to be exacerbated by the external drivers, such as fuel prices and climate change, to which these nations are particularly vulnerable [29]. Solomon Islands is one of the PICTs where future shortfalls in food fish production are projected, with contributing factors including population growth and development, degrading coral reef fisheries, long travel times to and from fishing grounds and fishing access rights [1]. Recent calculations suggest coastal fisheries will not supply the fish required for future food security, with all projected shortfalls, greater than 4000 t per annum by 2030 [1,28], raising critical questions about the future supplies of the most significant animal food source.

The Solomon Islands Government, through the Ministry of Fisheries and Marine Resources (MFMR), is responding to predictions of shortfalls in fish to meet food security needs through three principal policy endeavours: (1) improved coastal resource management; (2) increased tuna allocation to the domestic market, and (3) development of aquaculture opportunities [30,31].

In 2009 and 2010, a study was undertaken by WorldFish, MFMR and the Secretariat of the Pacific Community (SPC) to analyse the demand and potential for development of inland aquaculture in two provinces [32]. The study comprised three main components (1) understand the role of tilapia and other freshwater fish in household livelihoods and existing value chains; (2) assess scaling options for land based aquaculture and (3) use GIS based tools to assess and map suitable land based aquaculture areas. Component one is reported on here. While recognising the widespread rural demand for household food security throughout the country, this initial study was confined to two peri-urban areas on the premise that poor urban households are primarily being impacted by high urban fish prices, and that for an aquaculture industry to develop it will require sufficient local market demand to be economically viable. Empirical data were collected through household surveys and key informant discussions and findings are mentioned in the context of opportunities and constraints for land based aquaculture to contribute to improved food security in Solomon Islands.

## 2. Solomon Islands

Non-fish animal-source foods are rare in the diet of Solomon Islanders and fish make up about 90% of the animal-source food intake [33]. Although around half the rural population of women, and 90% of men, engage in fishing, the Solomon Islands inshore subsistence fishery is poorly quantified. The subsistence fishery was estimated at about 15,000 t in 2006 [34] and it has been described as meeting more than 60% of the nation's annual fish consumption [1]. The inshore subsistence fisheries are integral to nutrition, employment, cultural practices, cash trade and recreation [1].

The offshore fishery in Solomon Islands waters is part of the Asia-Pacific region, the most heavily exploited region in the world [35]. In 2007 121,642 t of fish were taken from offshore Solomon Islands waters, primarily consisting of yellow fin (*Thunnus albacares*) and skipjack (*Katsuwonis pelamis*) tunas [36]. Foreign fleets dominate commercial deep-sea fishing, with catches primarily targeted for export. With approximately 94% of fresh tuna transported to Asian markets, the opportunity to utilise this source for local food security is compromised [28]. The remaining 6% of tuna

sold in Solomon Islands comprises the old, small or low quality tuna, deemed unfit for Asian markets.

The 515,000 people [33] currently living in Solomon Islands are distributed throughout the country's 990 islands, and distances between them are substantial. According to the 2009 census, 80% of the population is considered rural [33], although the population of the capital Honiara is increasing, and the town experienced an annual growth rate of 2.7% between the 1999 and the 2009 census [37]. An increasing number of informal settlements in Honiara are unplanned with a lack of basic services. Poverty and unemployment are often higher in the informal settlements, as most residents are dependent on gardening and informal economic activities such as street vending for their livelihoods [37]. For urban areas (including the capital Honiara), small scale artisanal fisheries contribute to meeting fresh fish demand. However, supplies of reef fish to the capital's fish market are increasingly drawn from more distant provincial waters [16]. Fish remains the major source of animal protein and micronutrients for the population [38]. Income from fish and other marine products sold primarily in local markets also provide indirect benefits, generating revenues to purchase other foods, goods and services [39]. However, there is growing evidence of over-exploitation of coral reef fisheries due to localised intensification of fishing [16,40], which has been positively correlated with proximity to urban markets [34,40]. Prices of reef fish in the capital Honiara have increased dramatically in recent years [40], anecdotally making it more difficult for many of the burgeoning urban dwellers to regularly afford fresh fish.

A fledgling aquaculture industry began in Solomon Islands in the late 1980s and 1990s. Production, made up primarily of invertebrates (clams, corals and prawns), and targeting export markets, peaked in 2000–2001 at approximately 15 metric tonnes (excluding seaweed production, which peaked in 2005 at 320 metric tonnes) [20]. In the late 1990s, civil unrest effectively terminated local aquaculture production. Investors across sectors abandoned their businesses due to extensive loss of infrastructure, and by 2002 the government was insolvent [41]. Revival of the aquaculture industry has been slow but by 2010, 8000 t of farmed marine production, composed primarily of seaweed (*Eucheuma* sp.), was exported from Solomon Islands [20]. Apart from suffering such a setback at the start of this century, Solomon Islands has no tradition of aquaculture and little domestic production from aquaculture is formally recognised. Traditionally, people have been able to rely on reef fishing, there has been lack of aquaculture education or extension and attempts to start large scale commercial aquaculture enterprises have suffered from political instability, traditional land rights deterring private investment, lack of infrastructure and lack of government policy prior to 2000 at which time an Aquaculture Department was first established [31,42].

As a country that is rich in water resources and has substantive populations of forest and farm dwelling people with limited day-to-day access to coasts, freshwater or inland aquaculture<sup>1</sup> potential is now codified in a national Aquaculture Development Plan [31]. The plan outlines goals for future inshore and freshwater aquaculture development, the resources and expertise required to attain these goals and backgrounds on viable species for aquaculture.

Within rural communities, interest in aquaculture is also high. In records kept by WorldFish and MFMR between 2012 and 2013, more than 160 enquiries were recorded of farmers looking for advice and information about starting inland aquaculture. A desire to farm fish in the absence of any extension or information

<sup>1</sup> We define inland aquaculture as the farming of aquatic animals and plants in ponds or water-bodies, regardless of proximity to the coast.

services had led interested farmers to construct poorly designed backyard ponds and adopt basic farming practices. The farming systems were primarily for the introduced Mozambique tilapia (*Oreochromis mossambicus*) although rural people reported that they had occasionally captured and attempted to rear native marine species such as milkfish *Chanos chanos* and rabbit fish (*Siganus* spp.).

Mozambique tilapia is the only species of tilapia in Solomon Islands [31,43], where it was introduced by the Solomon Islands Government in the 1950s and 1960s [43,44]. Familiarity with Mozambique tilapia as well as other freshwater fish (e.g. eels and various mullet species) traditionally targeted by people living inland [34] has resulted in a level of cultural acceptance and market demand for freshwater fish. However, in Solomon Islands, as elsewhere in the Pacific [43], most tilapia farming efforts have been *ad hoc*, based on species and strains that perform poorly, and progress towards viable inland aquaculture systems and industries is limited. The variety of Mozambique tilapia in Solomon Islands is one that was widely stocked in waterways throughout the Pacific in the 1950s and 1960s for the purpose of creating new freshwater fishery resources. It has a very low ranking for use in aquaculture [43], owing to its slow growing and early maturing characteristics. In the Pacific Mozambique tilapia has received attention largely for its invasive characteristics [43].

Nevertheless, the role of Mozambique tilapia in fish supply may be under-estimated, particularly for populations that do not have easy access to fish from inshore reef resources. Mozambique tilapia is providing a significant food source to inland lake dwellers in Lake Tengano on Rennell and Lees Lake on Guadalcanal (Fig. 1) [34,45]. Yet, its current and potential role in wider national food security has largely been ignored. In Solomon Islands, the larger questions of how and where inland aquaculture can best contribute to food security and the adaptation of fish production systems in the face of climate change, at household and national level, have not been adequately addressed, let alone answered.

### 3. Methods

#### 3.1. Key informants

A focus group discussion of key informants was held at a stakeholder consultation workshop in Honiara on the 17th and 18th May 2010. The group was composed of six people from in or near Honiara who had previously expressed interest, to one of the implementing organisations, in backyard pond aquaculture; three

Ministry of Fisheries and Marine Resources staff and 11 representatives from the private sector, NGOs, civil society and regional organisations. The key questions asked of the group were: (i) what is known about the current geographical extent of inland aquaculture in the country and what species are household farmers targeting and (ii) what is your perception of inland aquaculture in Solomon Islands?

#### 3.2. Household surveys

Household surveys were conducted in the peri-urban area within 6 km of Auki (capital of Malaita Province) and within 47 km of the national capital Honiara (Guadalcanal Province) (Fig. 1). Surveys aimed to address the extent to which people in the peri-urban settlements of Auki and Honiara had access to tilapia; what contribution it made to their diet and whether this was ameliorated by ease of access to other sources of fish and meat and/or household income.

Within each province surveys were stratified by three classes of accessibility to the nearest urban centre (i) within town boundaries; (ii) can access town daily; (iii) access town less than daily and by proximity to the sea; (i) coastal (settlement borders the sea) and (ii) inland (settlement does not have direct access to the sea). None of the inland communities was further than 3.5 km from the sea. Settlements were selected based on fisheries officers' knowledge of places that fished tilapia from local waterways. This resulted in a design that was balanced in terms of location (inland/coastal) and island, but there were no settlements in the Auki group 'access town less than daily' (Table 1).

Survey questions sought information on the general demographic circumstance of households, livelihood strategies (on-farm and off-farm activities), household income, consumer preference and level of consumption and affordability of meat and fish, familiarity with, access to and perception of tilapia, and familiarity with and perception of fish farming. Questionnaires were conducted by WorldFish-Solomon Islands staff, MFMR staff and Malaita Provincial Government fisheries officers. The questionnaire was written in English then tested and modified by local researchers fluent in English and Pidgin to clarify any ambiguities. Interviews were conducted in Pidgin. If necessary, translation to local language was assisted by a village volunteer. Trained project staff completed the fieldwork between 28 June and 21 July 2010.

One hundred and seventy eight households participated in the survey, representing on average (for those settlements where census population estimates are available) 23% and 36% of households in the target settlements near Honiara and Auki,

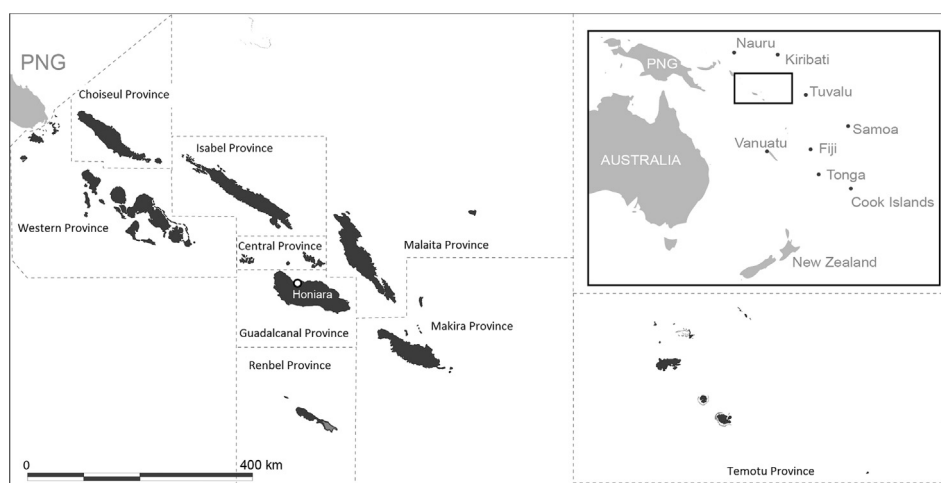


Fig. 1. Map showing location of Solomon Islands and provinces mentioned in the text.

**Table 1**  
Number of respondents within each category in Honiara, Guadalcanal and Auki, Malaita that were analysed (M= male, F=female).

Guadalcanal: Honiara						Malaita: Auki					
Within town boundaries		Can access town daily		Cannot access town daily		Within town boundaries		Can access town daily		Cannot access town daily	
Coastal	Inland	Coastal	Inland	Coastal	Inland	Coastal	Inland	Coastal	Inland	Coastal	Inland
M-12	M-23	M-5	M-7	M-5	M-5	M-11	M-11	M-13	M-12	0	0
F-8	F-16	F-5	F-3	F-5	F-5	F-9	F-8	F-7	F-8		

respectively. Households were selected based on the community leaders' knowledge of which people had, or had at any time in the past, a household pond, and/or fished tilapia from local waterways. If community leaders indicated that this applied to most people then a subset of 10 households was selected. In each selected household, the male household head or his wife was interviewed or, if both were absent, the eldest member of the household present was involved. Effort was made to interview a similar number of men and women (Table 1). Interviews were conducted during the day or night to fit with the community's livelihood activities and typically took from 30 to 50 min to complete.

### 3.3. Data analysis

Data collected from questionnaires were categorised and entered into Microsoft Excel for graphing. Data on household consumption patterns of fish and meat products were analysed using SigmaStat V. 3.5 ([www.systat.com](http://www.systat.com)). None of the variables was normally distributed and only income was able to be transformed to normality (as  $\ln(\text{income} + 1)$ ). A non-parametric Mann–Whitney Rank Sum test was used for two-factor analyses (by province or by proximity to the coast); ANOVA by ranks was used for three-factor analyses (access to town). Rank correlation was used to examine the effects of income on selection of sources of fish and meat. For examination of patterns related to household consumption, data were not separated by gender as the responses to those questions were given for the household, rather than individuals.

## 4. Results

### 4.1. Focus group discussions

The focus group discussion elucidated that the participants were aware that tilapia are widely spread in ponds and lakes throughout the country although the distribution has not been mapped and the study relied on anecdotal reports for many places. Although tilapia is not ubiquitously present in the few rivers that have been surveyed [46], it is also important to note that the freshwater fauna of many Solomon Islands' freshwater systems remains poorly documented.

Tilapia farmers in the group described how in the late 1990s early 2000s they had started trial backyard ponds for tilapia through personal interest. Some had also attended fish farming workshops held by local NGO, the Solomon Islands Development Trust (SIDT). The farmers had made from three to nine ponds on their own land, in or near Honiara, of varying sizes and constructed of various materials (earth, concrete) and had mixed success using different home-made foods. One of the farmers had originally brought Mozambique tilapia across from Malaita to Guadalcanal to stock his pond and subsequently had caught additional fish from within Lungga River and nearby ponds, near Honiara, for re-stocking. No-one reported having a harvesting regime for selling fish. Backyard ponds were identified as a good

source of fish for poorer households in Honiara, who were only eating salt-fish (salt preserved tuna discards from the commercial purse seiners) and for schools where food supply is a challenge. Challenges that were identified for land based farming were unreliable water supplies, lack of equipment, lack of knowledge and no commercially available feed. Perceptions of the focus group were that there is a demand for farmed fish in some parts of Solomon Islands, especially the peri-urban areas of Auki and Honiara. Farmer participants felt that individual backyard ponds are good; while Mozambique tilapia may not be the best species for aquaculture, it was believed to be the only fish species currently easily available for aquaculture. Government participants noted that the MFMR Tilapia Plan [31] considers introducing a strain of Nile tilapia, while scientists in the audience noted that introduction of any new species requires caution as the current fresh water fauna of Solomon Islands is poorly known.

The focus group participants could not identify any known data on the number of people with backyard ponds who are farming tilapia, or the frequency of people eating tilapia, although they stated that tilapia is widely eaten from waterways near Honiara settlements, Lake Tengano and Auki Lake.

### 4.2. Household surveys: demography, livelihood strategies and economics

Respondents ranged from 17 to 83 years old ( $n=178$ ). Sixty percent of primary respondents in each household were men and 40% were women (Table 1). Household size ranged from two to 22 people per household, with an average of seven people per house. Estimated monthly household income ranged from SBD \$55 to \$46,100 per month (SBD \$1.00 approximately = \$7.00 USD) with a median of \$1910 per month, but this varied considerably within and between villages. On average, 17% of respondents were without formal education. Of the remainder, 5% had completed tertiary or vocational (trade school, teaching college) education.

The majority of households (96%) were engaged in two or more livelihood activities, with the most common being gardening, off-farm employment and selling produce at market (Table 2). Seventy six percent of respondents were involved in gardening, off-farm employment or selling produce at market as their primary livelihood.

### 4.3. Household surveys: sources of fish or meat and consumer preference

Animal protein sources were dominated by fish, supplemented by tinned meat, chicken and occasionally other fresh meat (Fig. 2). Tinned fish (canned tuna) was the most commonly consumed animal food source, eaten on average 15 days per month, followed by fresh reef fish and fresh tuna. Salt-fish, tilapia and other freshwater fish were each consumed on 2–4 days a month, on average. Over both islands consumption patterns were similar (Fig. 2), with no statistically significant differences in the frequency of consumption of different types of fish and meat between the households near Auki and those near Honiara. When



comparing coastal and inland settlements, in Malaita the people on the coast ate significantly more reef fish than the inland people ( $P < 0.001$ ) and in Guadalcanal the people in the inland

communities ate significantly more tilapia than those in the coastal communities ( $P = 0.006$ ).

Fifty three percent of all respondents actively fished for tilapia at least occasionally (Fig. 3); 13% of these fished on a daily basis. Catches from fishing trips averaged between 50 and 100 fish (usually between 10 and 20 cm long; authors' personal observations).

Households that were directly engaged in tilapia fishing consumed, on average, 84% of fish they caught. Sixteen percent of fishers reported that they also sold some of their catch in local markets (formal and informal) at SBD \$5–\$20 for approximately 5–10 fishes. The frequency of tilapia consumption by individual households was poorly correlated with the number of households engaged in fishing. Only 16% of the people consuming tilapia were also tilapia fishers, suggesting that the majority either bought the fish or were given the fish by their neighbours.

Approximately equal numbers of men and women marketed their catch. The majority of respondents (88%) said that they had consumed tilapia before and of these 95% said that in their household men, women and children all ate tilapia.

**Table 2**

Primary and secondary livelihoods for adult (over 15 years old) men and women (% of respondents).

Livelihood	Primary		Secondary	
	Men	Women	Men	Women
Gardening	26	17	11	11
Employment <sup>a</sup>	9	13	10	6
Selling fresh products or cooked food at market	6	5	14	11
Cocoa	4	2	2	2
Fishing	3	2	6	4
Livestock	1	1	2	3
Teaching	1	2	0	0
Trades <sup>b</sup>	1	1	1	1
Small business <sup>c</sup>	3	1	7	4
Copra	1	0	4	1

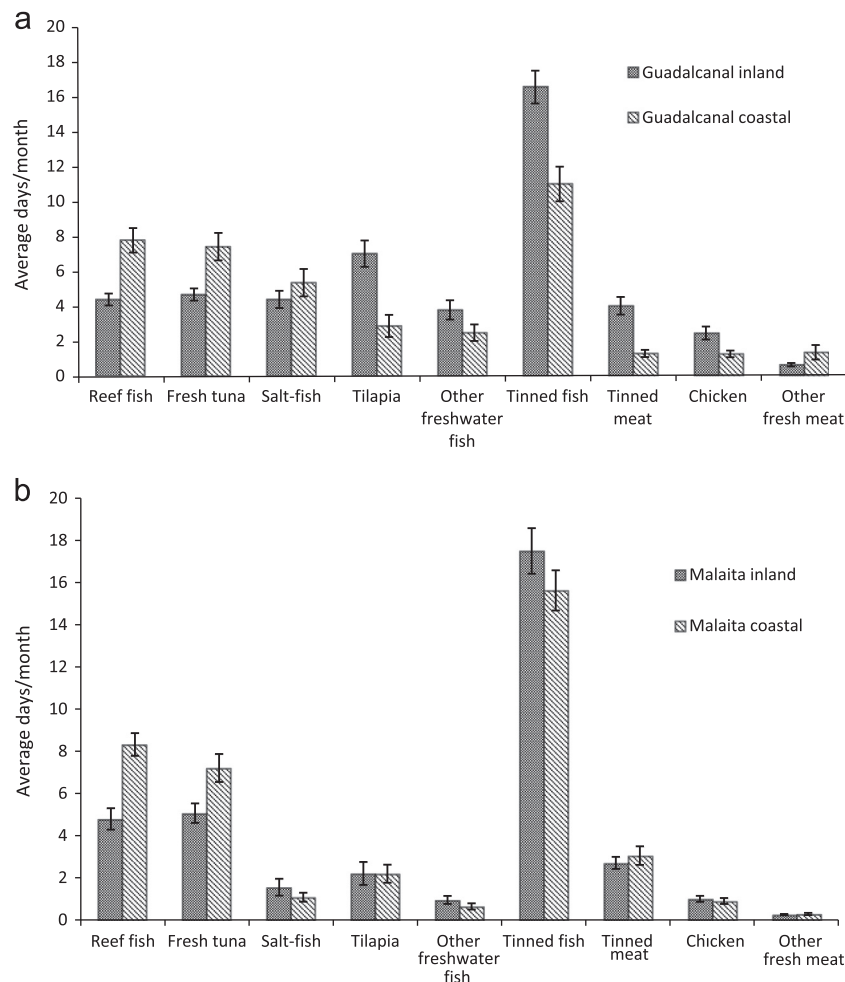
<sup>a</sup> Employment includes taxi driving, security work and working in the food industry (baking, cooking etc.)

<sup>b</sup> Trades includes carpentry and plumbing.

<sup>c</sup> Small business includes shell money, farming, craft making, rental property, remittance and milling timber. Numbers indicate percentage of respondents ( $n = 178$  primary,  $n = 170$  secondary).

4.4. Household surveys: income

Household consumption patterns were investigated in relation to (ln transformed) household income in the province and proximity to the coast and to town. On average, the geometric mean income for study households on Guadalcanal (SBD\$1900, 95%



**Fig. 2.** Average days per month each major source of fish or meat was consumed for inland and coastal communities on Malaita (A) and Guadalcanal (B). Error bars represent standard error of the mean.

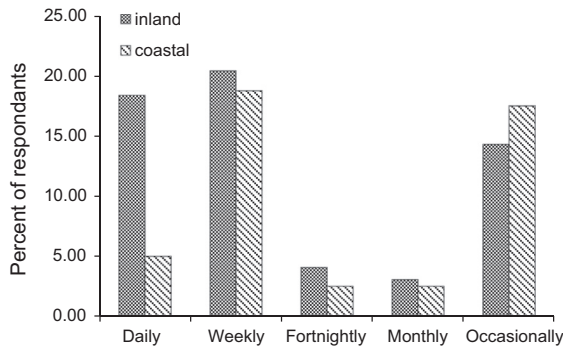


Fig. 3. Frequency of people fishing for tilapia (% of respondents) in inland and coastal communities across both provinces.

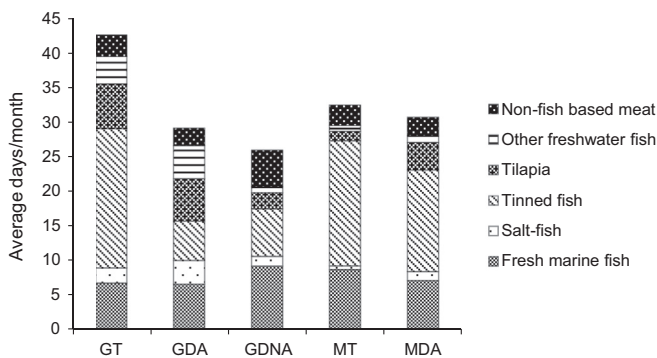


Fig. 4. Average number of days in a month that various protein sources were consumed. Fresh marine fish includes reef fish and fresh tuna/bonito, preserved fish includes tinned fish and salt-fish, non-fish based meat includes chicken, tinned meat, pork and other fresh meat. GT—Guadalcanal town ( $n=59$ ), GDA—Guadalcanal daily access to town ( $n=20$ ), GDNA—Guadalcanal villages not able to access town daily, ( $n=20$ ), MT—Malaita town ( $n=49$ ), and MDA—Malaita daily access to town ( $n=30$ ). Average distance from town market (km) GT-4.59, GDA-8.17, GDNA-47.03, MT-0.65, and MDA-5.70

confidence limits \$1472–\$2450) were higher than those on Malaita (SBD\$1260, 95% confidence limits \$938–\$1693). There was no significant relationship between income and location (inland or coastal) in either Province. Although people living in Auki town had slightly higher incomes than those from out of town, the data were highly variable and the difference was not statistically significant ( $P > 0.05$ ).

Households on Guadalcanal consumed both salt-fish ( $P=0.001$ ) and tilapia ( $P=0.04$ ) more frequently than the households on Malaita, but otherwise the consumption of different types of fish and meat was similar (Fig. 4). Households in town, in both provinces, ate more tinned fish; however the reasons for this are not easily explained by the data. Although tinned fish are associated with affluence (Table 3), as described above, these households did not show up as being significantly more affluent than those further from town. On Guadalcanal, the consumption of tinned fish for households in town was significantly higher than either households with daily or with non-daily access to town ( $P < 0.001$ ) (Fig. 4), but daily access and non-daily access were not significantly different from each other. In Malaita, where it was only possible to compare within town and daily access, the households in town consumed tinned fish significantly more frequently than those with daily access ( $P < 0.001$ ) and they consumed tilapia significantly less frequently ( $P=0.015$ ).

In order to examine whether income affected the choice of fish or meat, the data were examined separately for each province and then pooled to examine the patterns across both provinces using rank correlation. Overall, in both provinces, income was

Table 3  
Correlation matrix (by ranks) of pooled data from both provinces. Correlation coefficient and  $P$  value are shown. Values that are significant  $P < 0.05$  are in bold.

	Marine	Salt-fish	Tinned	Tilapia	FW other	Meat
Income	0.173 <b>0.034</b>	-0.034 0.673	0.227 <b>0.005</b>	0.036 0.654	0.091 0.267	0.238 <b>0.003</b>
Marine		0.032 0.671	0.199 <b>0.007</b>	-0.003 0.959	0.063 0.400	0.343 <b>0.000</b>
Salt-fish			0.049 0.509	0.306 <b>0.000</b>	0.221 <b>0.003</b>	0.001 0.981
Tinned				0.137 0.068	0.194 <b>0.009</b>	0.343 <b>0.000</b>
Tilapia					0.364 <b>0.000</b>	0.007 0.922
FW other						0.118 0.117

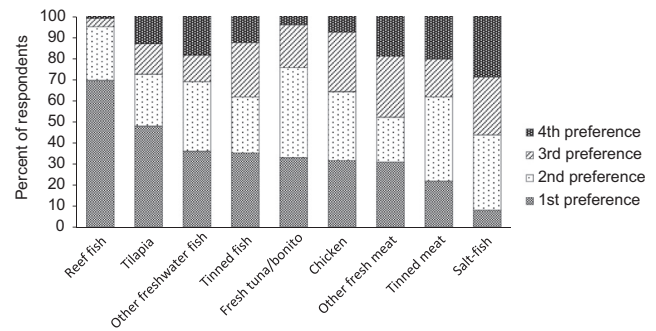


Fig. 5. The percentage of respondents ( $n=150$ ) that ranked fish or chicken from 1st preference (most preferred) to 4th preference (least preferred) without considering price as a factor.

significantly positively correlated with marine fish ( $P=0.035$ ), tinned fish ( $P=0.005$ ) and meat ( $P=0.003$ ) (Table 3).

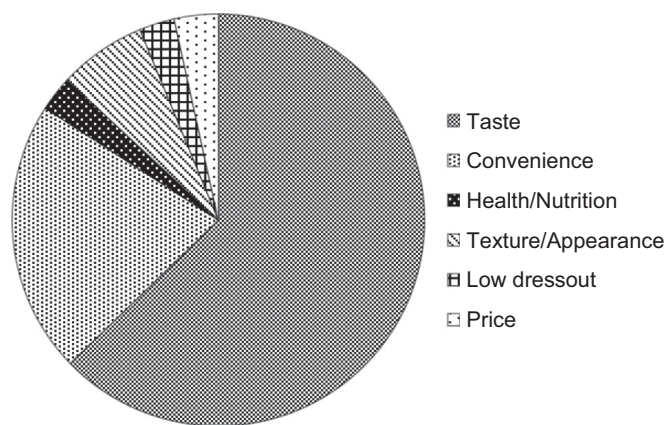
When examined by province, this pattern also held for Guadalcanal (marine fish,  $P=0.047$ ; tinned fish,  $P=0.05$  and meat,  $P=0.042$ ). On Malaita, there were strong positive correlations with income and meat ( $P=0.013$ ) and tinned fish ( $P=0.011$ ), but the correlation with marine fish was not significant. Instead, low income on Malaita correlated with high consumption of salt-fish ( $P=0.004$ ).

Respondents were asked to rank the fish and meat products that they ate at least occasionally, starting from a rank of '1' as their most preferred to their least preferred '4'. They were asked to exclude price in this instance but to consider any other aspect, such as taste. As few people were consuming non-fish products other than chicken, the analysis of preference was restricted to the top four preferences for fish and chicken, a rank higher than '4' was omitted. A number of respondents ranked more than one item equally and so the findings are weighted by this factor.

Although tinned fish was the most commonly consumed fish (Fig. 2), reef fish was the number one preference for more than 70% of respondents (Fig. 5). Chicken ranked similarly to tinned fish and in the study households. A higher proportion of people preferred tilapia over fresh tuna, tinned fish and chicken, although fresh tuna ranked as the second preference for twice as many people as tilapia. Only five people ranked 'salt-fish' as their most preferred fish.

#### 4.5. Perception of tilapia

The overall perception of tilapia was positive, with 98.3% of people surveyed familiar with the fish. Tilapia was described as a 'good fish' by 85% of respondents, with the majority saying this was because of its "good greasy taste" (Fig. 6).



**Fig. 6.** Primary and secondary reasons ( $n=148$ ) of the 130 respondents who said they thought tilapia was a 'good' fish. Low dress-out includes responses such as tilapia "has more meat", "is fleshy". The texture/appearance category reflects comments such as "it has a soft white flesh".

#### 4.6. Household surveys: familiarity with and perception of fish farming.

At the time of the survey, with the exception of some small water storage areas, rudimentary backyard ponds and old drums, no tilapia was being farmed; all tilapia was being caught from nearby waterways (lakes, rivers and streams). Fourteen percent of respondents said that they had tried or had seen fish farming; in all cases this referred to tilapia, with the exception of one respondent who had experience in farming giant clams. Those who had tried growing tilapia in ponds reported a large range in pond size; on average approximately  $4 \times 4 \text{ m}^2$  in area and 1–1.5 m in depth. Ponds were described as highly variable and opportunistic in design, taking advantage of natural depressions, large water drums or small creeks. Some people did not feed their fish. For those that did, feeds were composed of white ants, kitchen scraps, coconut scrapings, rice, earthworms or mill run flour (in decreasing order of frequency mentioned).

Ninety two percent of respondents, including men and women, expressed an interest in knowing more about, or undertaking, fish farming, primarily for household consumption. Sixteen percent ( $n=25$ ) of respondents indicated that they were interested in watching the fish grow as a pastime, while two people indicated an interest in commercial production. One respondent noted the value of farming tilapia for mosquito control purposes.

When people who had previously attempted to grow fish were asked why they had not continued with their ponds, they implied that they did not have sufficient knowledge to overcome any problems that they met, responding that they had found out about farming from friends and family that had very little knowledge or experience on fish farming. Some respondents had experienced their fish having being stolen. The lack of knowledge about husbandry practices, feeding and pond maintenance meant that farmers struggled to develop a productive farm and had become discouraged.

## 5. Discussion

The present study has provided insight into the fish and meat consumption patterns of peri-urban settlements in the vicinity of Auki and Honiara that have access to 'wild' sources of Mozambique tilapia to supplement their diets. The primary livelihood of the majority of the respondents in peri-urban settlements was gardening, but they were also engaged in the cash economy through a variety of channels including the sale of their garden produce.

Expenditure on fish (both caught and purchased) comprises around 20% of the total expenditure on food in poorer households in Honiara and other urban areas [47]. According to the 2005/6 household income and expenditure survey (HIES), the highest proportion of expenditure on fish in urban areas is on low-grade taiyo (canned tuna) and fresh tuna/bonito. The highest proportion of expenditure in rural areas is a category called 'other fresh fish' [47]. Our study finding is consistent with the findings for urban households in terms of the amount of fish consumed. However, the present study categorised the fish eaten into more groups and also showed that for those households that had access to wild tilapia, this fish ranked similarly to fresh tuna and tinned fish in terms of preference, after reef fish.

The HIES has been widely used to estimate the amount of fish that people consume in Solomon Islands [1,28]. There is no evidence of national surveys to date having asked about the consumption of tilapia, although for consumption (but not necessarily expenditure) surveys, it is expected that this would be captured in the category "other fish". For urban households (particularly those not immediately adjacent to the coast) that have access to wild tilapia, and fish it themselves at no cost, this is not reflected in household expenditure surveys. Qualitative assessments have previously identified higher levels of consumption, especially of reef and 'other' fish, than is apparent from the national HIES data [28].

When price was not considered, marine reef fish were the preferred fish or animal source protein for the respondents in this survey. However, tinned fish was most commonly consumed. Income was one factor that influenced fish and meat consumption, although this was not always a straightforward relationship. For example, those with a greater cash income more frequently consumed marine fish, tinned fish and meat than freshwater fish or tuna. However, despite reef fish easily being the most preferred fish overall, people who lived in town, who generally had higher cash incomes, consumed more tinned fish. Even though none of the communities in this study were more than 3.5 km from the sea, and in Malaita all could access Auki market daily if they wished to, reef fish was consumed more frequently by the coastal people of Malaita (who have direct access to the sea for fishing for their household) than inland settlements. Consumption of tilapia and other freshwater fish was higher for the Guadalcanal inland people than the coastal people.

Accurate estimates of household income are acknowledged to be difficult to obtain in Solomon Islands [48] and only limited emphasis therefore is placed on this factor here. Nevertheless it illustrates the fact that many influences, including patterns over a relatively small geographical scale, determine the strategy of household food choices that do not get recorded by national surveys. This observation is consistent with observations elsewhere that the contribution of fish to food and nutrition security at household level depends upon availability, access and cultural and personal preferences, access being largely determined by location, seasonality and price [49]. At the individual level, it also depends upon a person's physiological and health status and how fish are processed, cooked and shared among household members [49]. The study indicates that for some, Mozambique tilapia is accessible, appears to be culturally and personally accepted, and indeed available, fulfilling some attributes of a food item that contributes to food security, particularly for those inland households. Where it was fished regularly, it appeared to be both consumed within the household and traded and sold for cash. Less is known about how tilapia are processed, cooked or shared within households, and thus its influence on household members, including women and children, although the study suggested that all members of the family eat tilapia. A recent review [38] has indicated the importance of addressing under-nutrition among



young children in Solomon Islands, suggesting further research around intra-household behaviour and consumption of tilapia should be considered.

The propensity for salt-fish, the cheapest fish option on sale in the Honiara market, to cause symptoms similar to dysentery [50] has resulted in it being described as a health hazard by various commentators in the local media. In nearby Papua New Guinea, Madang's provincial government deemed salt fish unfit for human consumption and banned it from the fish market in the town centre [50]. Similar to Honiara however, despite health concerns, salt-fish remains widely available at unregulated markets, in part because it provides a relatively low-cost source of animal protein [50]. In this study, the least preferred 'salt-fish' (Fig. 5) was consumed by the households with the smallest cash income.

This study lends weight to the premise that peri-urban households that are cash poor would likely benefit nutritionally from easier access to tilapia. Like other fish, tilapia are nutritionally rich and are a good source of protein, fats and micro-nutrients such as vitamin B12, calcium and potassium [51]. Other locations that are likely to benefit are inland rural areas where households have limited access to coastal fish resources [45].

The study shows that despite the perception among the Pacific aquaculture community that it is a poorly performing farmed fish [43], Mozambique tilapia appears to have achieved a high degree of acceptance and utilisation among some peri-urban households in Malaita and Guadalcanal, though with supply from feral wild-caught fish, rather than farmed sources. This is likely a consequence of its widespread establishment and accessibility in water bodies within these regions, not aquaculture. The status of aquaculture supply appears to be very limited, with low productivity in the small number of existing household ponds.

What of the future? There is growing awareness of the emerging gap between fish supply and demand in several Pacific island nations [1,28], with inland aquaculture considered one of three options to fill this gap, and with tilapia receiving particular attention [31]. Such analyses have to date been largely macro-level, with limited attention to other factors determining food and nutrition security; for example the differences between inland and coastal populations explored in this study, or intra-household distribution, a key factor in addressing under-nutrition in children [38]. The research indicates that Mozambique tilapia has a high degree of acceptability, but is there a role for a farmed supply?

Mozambique tilapia farming systems in Solomon Islands are low in productivity, supplying few fish, although there may be opportunities for improvement. Whilst Mozambique tilapia is widely considered in Asia and the Pacific as a poorly performing aquaculture fish due to its slow growth rate and early sexual maturity [43,52] small fish *per se* are clearly not a constraint for consumers in Solomon Islands, and there may be opportunities for productive culture of small fish. Such systems have become important sources of fish for the poor elsewhere. In Sri Lanka for example, it is still prized [53] and whilst the species does not grow to a large size, it can be productive, with sizes that are accessible to poor consumers, at low cost.

Fish for food security calculations [1,28] suggest that Solomon Islands may require between 6000 and 20,000 t from aquaculture by 2030. Such supply volumes, though, are unlikely to be achieved by backyard pond farming of Mozambique tilapia. Coupled with a slow growth rate, Mozambique tilapia productivity is one of the lowest of all tilapia species [50]. With an optimistic annual productivity of 5 t/ha, typical, 100 m<sup>2</sup> backyards ponds would produce, under optimal management, perhaps 50 kg of fish per year. Whilst significant for a household of five persons, more than 120,000 such ponds would be required to produce 6000 t of fish, which seems unlikely. Increasing urban populations will also restrict opportunities for homestead fish farming among many households, leading to a conclusion that a

combination of homestead and more commercial enterprises would likely be required to supply future demand. The interactions and combination of these two types requires further research.

Commercial farming is probably not feasible with Mozambique tilapia, as the species is unlikely to attract commercial investment, due to poor farming characteristics [42,52]. Introduction of new strains remains a possibility. Nile tilapia is being considered for introduction by government and would conceivably be a better candidate species. The species has been widely introduced into the Pacific islands, with backyard and commercial operations existing in Fiji, Vanuatu, Papua New Guinea, Guam, American Samoa, Samoa, and Commonwealth of Northern Marianas Islands, amongst others [42,51]. Farming of milkfish (*Chanos chanos*) is an indigenous candidate worthy of further research and the Solomon Islands National Aquaculture Development Strategy (2009–2014) identifies farming of both tilapia and milkfish as options for future supply of domestic fish markets. Providing fish for food security through aquaculture will require a change in the planning priorities of most national fisheries agencies in the Pacific region [1] and the development of skills in public and private sector for planning and management. In Solomon Islands, given constraints within government agencies, it will also likely need new forms of research and development partnerships that enable the innate capacity of communities to develop the institutional arrangements and innovation systems necessary for an indigenous aquaculture industry to emerge.

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