Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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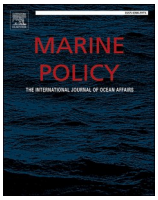

Local practices and production confer resilience to rural Pacific food systems during the COVID-19 pandemic

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ABSTRACT

Resilience of food systems is key to ensuring food security through crisis. The COVID-19 pandemic presents an unprecedented shock that reveals varying levels of resilience of increasingly interconnected food systems across the globe. We contribute to the ongoing debate about whether increased connectivity reduces or enhances resilience in the context of rural Pacific food systems, while examining how communities have adapted to the global shocks associated with the pandemic to ensure food security. We conducted 609 interviews across 199 coastal villages from May to October 2020 in Federated States of Micronesia, Fiji, Palau, Papua New Guinea, Solomon Islands, Tonga, and Tuvalu to understand community-level impacts and adaptations during the first 5–10 months of the COVID-19 crisis. We found that local food production practices and food sharing conferred resilience, and that imported foods could aid or inhibit resilience. Communities in countries more reliant on imports were almost twice as likely to report food insecurity compared to those least reliant. However, in places dealing with a concurrent cyclone, local food systems were impaired, and imported foods proved critical. Our findings suggest that policy in the Pacific should bolster sustainable local food production and practices. Pacific states should avoid becoming overly reliant on food imports, while having measures in place to support food

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security after disasters, supplementing locally produced and preserved foods with imported foods when necessary. Developing policies that promote resilient food systems can help prepare communities for future shocks, including those anticipated with climate change.

1. Introduction

The COVID-19 pandemic has created a global health and economic crisis that has highlighted the fragility of globalized food systems to external shocks ([13,56,62,101]). In the context of fisheries, border closures and social distancing measures led to the closure of ports and the vast reduction of shipping and air freight [69], as well as reduced access to urban markets [13]. Restricted air travel has decimated tourism, with tourism-dependent communities facing higher imported food costs and reduced income from fisheries [51,63]. Governments are grappling with uncertainties regarding the short- and long-term impacts of COVID-19 on food supply and demand, while trying to put in place measures to avoid a health and a food crisis. Even before the pandemic, 135 million people were food insecure and undernourished [36], and a doubling in food insecurity worldwide has been predicted due to the global pandemic ([37,94]).

Pacific states have been caught up in these global disruptions. Since the mid-1990 s, the region has become increasingly connected to global food trade with a doubling of food net-imports, paired with a 30% drop in domestic crop production during the 1980 s, which has not recovered [34]. Against this backdrop it might be expected that Pacific states and particularly those communities most dependent on food imports would be vulnerable to the food systems shocks produced by COVID-19. In 2020, national food systems experienced strain to varying degrees depending on factors such as access to arable land, social capital, urban-rural gradients, disruption to cash-flow, other simultaneous shocks, and changes in food producing practices, including fishing (e.g., [32,53,57,63,81]). But so far, there has been no regional synthesis of primary data from across the Pacific region to understand nuances of these patterns and the resilience of rural coastal food systems.

Understanding the factors that contribute to resilience of local food systems is essential to design strategies that ensure food security and the long-term sustainability of human populations [79]. The concepts of food security, resilience, and food systems are used across many fields and in sometimes conflicting ways. Here, we use the Food and Agriculture Organization of the United Nation's (FAO) definition of 'food security' as "a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" [35]. We use the definition of 'resilience' provided by Folke [43] as, "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, and feedbacks, and therefore identity." Finally, we use the term 'food systems' to refer to the social-ecological systems that comprise food production, processing, distribution, and consumption [30], encompassing social, economic, political, institutional, and environmental processes and dimensions [83].

Walker [90] identified modularity – that is, not being over- or under-connected to global networks – as a central attribute of resilient systems, arguing, "overconnected systems are vulnerable to rapid spread of diseases (coronavirus), cascading failures (like the global financial crisis), faulty ways of doing things, bad ideas, etc." Though a growing proportion of global food consumption is obtained through international trade [29], whether increased reliance on trade benefits or hinders food security is an ongoing debate [46], specifically with respect to the resilience of global food systems in the face of shocks [64]. While international trade provides a buffer against local shocks, trade also exposes communities to external shocks [72], and increased connectivity can increase systemic risk because, in a connected system, shocks propagate more easily [88]. The COVID-19 pandemic represents an enormous and unprecedented shock to globalized food systems and thus an opportunity to investigate the role of connectivity in contributing to resilience.

In coastal communities, resilience to external shocks relies on adaptive capacity, defined as the "latent ability to implement effective responses to changes by minimizing, coping with, or recovering from the potential impacts of a stressor" [84], and the ability to turn surprises into opportunities to evolve, renew, learn, and increase adaptive capacity [43]. Resilience in small island communities relies on adaptive capacities that include flexibility and diversity in livelihood strategies, multilevel governance systems that are participatory, and adaptive local knowledge systems ([1,6,14]). In the context of Pacific Island nations, adaptive capacity has been linked to factors including community cohesion, good leadership, and religious participation (e.g., [78]). Levels of resilience and adaptive capacity thus vary across the Pacific [6,19,58], and previous shocks produced by massive disturbances reveal levels of system resilience and conditions that result in some small island communities being more able to adapt than others [1,6,33,41].

In this paper, we ask: (1) how the global shock from the COVID-19 pandemic has impacted food availability in rural communities in the Pacific; (2) how impacts have varied across islands and between men and women; and (3) how communities have adapted to address food security challenges. We examine how connectivity to global food systems shapes resiliency and identify pathways to build resilience to food systems shocks in the future in order to ensure food security.

2. Methodology

2.1. Pacific Islands context

The Pacific region is made up of twenty-two countries and territories that are diverse in land mass size, number of islands, size of exclusive economic zones, geography and island topography, population, economy, and culture (Fig. 1). Characteristics of the seven Pacific Island countries (PICs) included in this study (Federated States of Micronesia (FSM), Fiji, Palau, Papua New Guinea (PNG), Tuvalu, Tonga, and Solomon Islands) are summarized in Table 1.

Fisheries are important for food security and economic wellbeing at both household and individual levels [20], with fish consumption providing an estimated 50–90% of animal protein in rural areas and 40–80% in urban areas [48]. Coastal fishery resources across the region are managed locally and traditionally by nearby communities and resource owners, as well as through legislation and policy at the local, state, and national scale [75]. However, population growth and the associated increase in demand for seafood, coupled with poor coastal fisheries management practices, has raised concerns that PICs might no longer be fish protein secure by 2030 [9]. Furthermore, diets across the Pacific region have shifted from being high in locally grown fresh fruits and vegetables, seeds and nuts, lean meat and seafood, to diets high in processed and often imported foods [87] and low in diversity [4]. Consequently, Pacific communities suffer from high rates of chronic diseases including diabetes [98], which are correlated with increased COVID-19 severity [61].

Following the announcement of the COVID-19 pandemic by the World Health Organization (WHO) on 11 March 2020, PICs responded swiftly by closing their international borders and implementing a variety of national measures to protect their citizens from the virus (Table 1; Fig. 2). At the national level, measures taken by governments included declarations of states of emergency, school closures, periods of lockdowns and curfews, social distancing measures, and migration from

urban to rural areas. As of the last interview conducted in each country, COVID-19 cases and deaths were low in our case study countries (34 cases, 0 deaths) compared to other regions globally [96]. Eleven PICs have had no COVID-19 cases at the date of writing (1 April 2021), including four (i.e., FSM, Palau, Tonga, and Tuvalu) of our seven study countries [96].

In addition to addressing the health threats posed by the COVID-19 crisis, PICs experienced a number of natural disasters during our study period, which caused additional disturbances to communities and food systems: Category 3 Tropical Cyclone Tino hit Tuvalu in January 2020; and Tonga, Fiji, and Solomon Islands were hit by severe Tropical Cyclone Harold in April 2020.

2.2. Data collection

In order to understand the early response and resiliency of rural Pacific food systems to the shocks associated with the COVID-19 pandemic, we conducted a rapid assessment of 609 individuals in 199 coastal villages in seven PICs with varying levels of connectivity to global food systems. We examined how communities were meeting their food and income needs and the associated impacts on local seafood markets during the first shockwave of the global pandemic, from May to October 2020. For this assessment, two methods were used: structured key informant interviews were deployed in all countries, and a nationwide survey was additionally conducted in Palau.

2.2.1. Structured key informant interviews

The structured key informant interview protocol was initially developed by WorldFish for use in Solomon Islands [32]. The protocol was then modified by the Locally Managed Marine Area (LMMA) Network and partners [89] and deployed in communities with an established relationship to the LMMA Network (Table 1) in FSM (n = 56), Fiji (n = 76), PNG (n = 46), Solomon Islands (n = 106), as well as in Tonga (n = 20) and Tuvalu (n = 20). In Palau, a subset of questions from the LMMA protocol were asked of key informants (n = 10) in one rural village. The interview protocol included quantitative and qualitative questions on major events that may have affected the whole village recently and the consequences of those events, such as: changes in village population, changes in food availability, changes in local food production and food sharing, prices and sales of fresh fish, and fishing effort. Interviews were conducted in locally appropriate languages and lasted 10–15 min. Due to various government COVID-19 restrictions to protect its citizens, most interviews were conducted over the phone, with in-person interviews conducted only where safe and possible. Organizations undertaking this work with communities were bound by the LMMA Network's Social Contract, which includes guidelines for upholding free, prior, and informed consent from Indigenous communities.

A total of 334 key informants (190 men, 144 women) were selected and interviewed among those engaged with the LMMA network. A small number of highly knowledgeable respondents were selected based on their participation in relevant committees or their being highly active and/or knowledgeable in local fishing and food production practices.

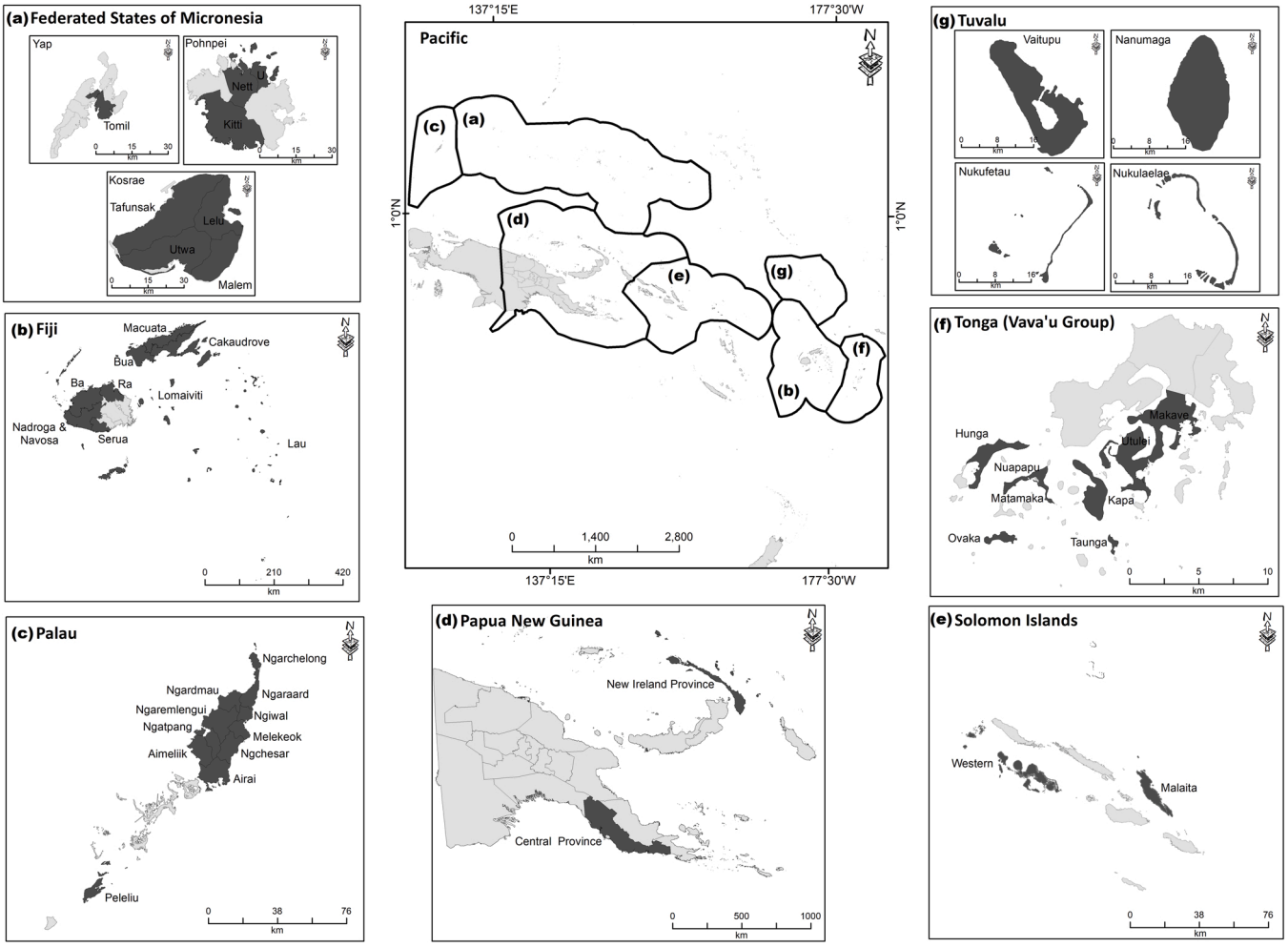

Fig. 1. Map of the seven Pacific Island countries (PICs) included in this study (Federated States of Micronesia, Fiji, Palau, Papua New Guinea, Tuvalu, Tonga, and Solomon Islands). Study areas are shown in dark grey.

Table 1
Summary of interviews conducted across seven Pacific Island countries, number (N) of female (F) and male (M) respondents, COVID-19 cases and deaths, and the national restrictions put in place in each country. The number of COVID-19 cases and deaths are the numbers recorded up to the last interview date for individual countries.

Country	Pop Total[1]	Coastal Pop[1]	GDP per capita[2]	Visitors[3]	Survey dates	Study sites[4] (villages)	N	F	M	Cases[5]	Deaths[6]	Restrictions
Fiji	894,961	244,635	6152	968,926	13 May–13 Jul	9 (59)	76	32	44	26	0	First case recorded 19 March 2020. Borders closed 19 March 2020; lockdowns for towns with COVID-19 cases; night curfews; inter-island travel stopped from 3 to 26 April; and social distancing measures in place including controls on the size of gatherings. Fishing was only prohibited in towns during lockdowns. Permits required for fishing during curfew hours.
Palau	17,930	16,786	15,673	94,115	1 Jun – 10 Aug	11 (70)	10 (276 surveys)	5 (116 surveys	5 (160 surveys)	0	0	Borders closed March 2020. Curfew, school closures, and restrictions on large gatherings.
PNG	8934,475	729,840	2854	210,980	21 May – 6 Jun	2 (14)	46	21	25	8	0	First case recorded 20 March 2020. State of Emergency (SOE) declared, borders closed, domestic air travel suspended, travel between provinces limited to cargo, medical, and security personnel. Schools closed.
Solomon Islands	712,071	473,663	2295	30,821	25 Apr – 6 Jun	2 (24)	106	53	53	0	0	SOE declared, international borders closed, street side and suburban marketing banned and the informal work sector encouraged to move out of the capital Honiara. Schools closed.
Tonga	99,780	83,886	5081	93,972	27 May – 2 Oct	5 (7)	20	11	9	0	0	SOE declared, international borders closed, night curfew, social gathering restrictions, and social distancing measures in place.
FSM	105,503	93,635	3830	19,207	19 May – 28 Jul	9 (27)	50	14	27	0	0	International borders closed then lifted with quarantine measures required, travel banned to and from Hubei Province in China, interisland travel restricted, schools closed.
Kosrae					19 May–5 Jun	5 (5)	21	6	15	0	0	
Yap					3–6 Jun	1 (10)	20	8	12	0	0	
Pohnpei					25 Jun–28 Jul	3 (12)	9	–	9	0	0	
Tuvalu	10,580		4223	3611	4–11 Jun	4 (5)	20	9	11	0	0	State of Public Health Emergency declared, quarantine requirements on returning citizens, restrictions on movement to and from the capital Funafuti and citizens encouraged to return to home villages, government control of imported food stocks, and closed schools.

[1] Population (Pop Total) and opulation living within 1 km of the coast (Coastal Pop) data based on the most recent census (Source: https://sdd.spc.int/)
[2] GDP per capita in USD (Source: https://sdd.spc.int/)
[3] 2019 visitors (Source: https://stats.pacificdata.org/)
[4] Study sites show the number of provinces/states and (villages) included in this study.
[5] As of last interview in-country
[6] As of last interview in-country
Source:Source: World Health Organization.

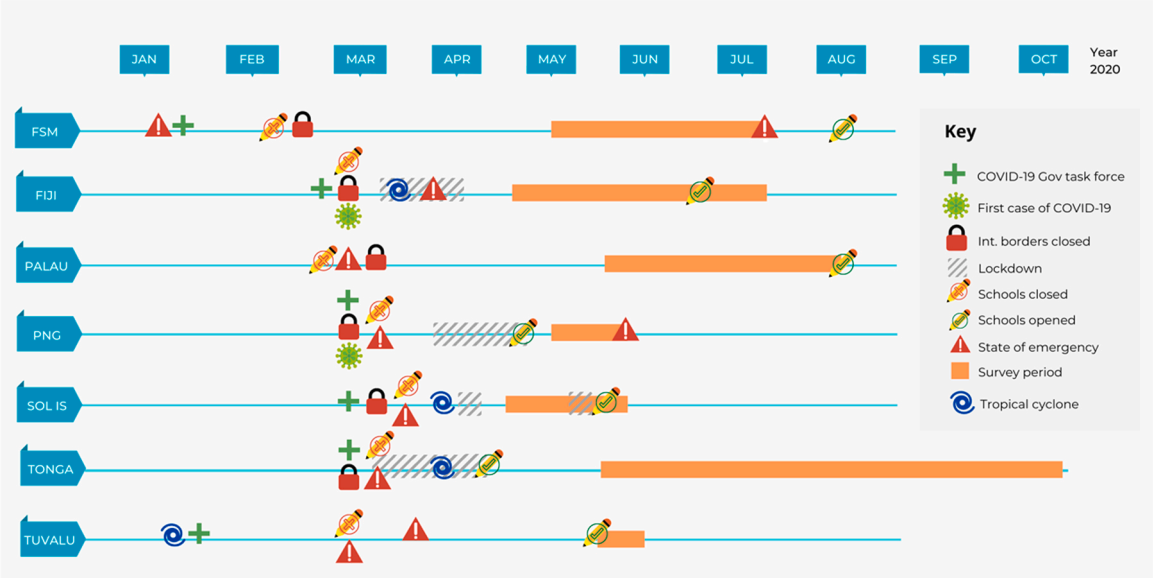

Fig. 2. Timeline of countries' response to the virus and our study period in each site.

Key informants were asked to respond with their knowledge of the whole village, rather than their individual experiences; thus, some experiences may not have been adequately captured. It should also be noted that perceptions of quality of life have been shown to vary both within and between communities and countries, a limitation of comparisons across sites [3,65]. Across the Pacific, men and women use their coastal resources in different ways and have developed specialized knowledge and skills relating to them, often fishing for and harvesting different species using diverse methods and equipment [95]. For this reason, we attempted to interview similar numbers of men and women in each village in order to understand gendered responses to the pandemic.

2.2.2. *Nationwide survey*

In Palau, local authors conducted a nationwide survey from May to August 2020 employing random sampling, stratified by gender, that included questions on the impacts of COVID-19 that overlapped with WorldFish and LMMA interview questions. For the purpose of this analysis, we included only respondents from rural communities ($n = 275$). In-person structured key informant interviews ($n = 10$) were subsequently conducted in September 2020 in one rural village using a subset of additional questions from the LMMA protocol to provide qualitative insights and align the method with that used in other study countries.

2.3. *Data analysis*

Datasets from each PIC were compiled and analyzed in Excel. Data from FSM were analyzed at the state scale (Kosrae, Pohnpei and Yap) due to the large size of the country; the significant cultural, political, and economic diversity between islands; and the importance of state governance. To test for significance among variables, we performed Pearson chi-square tests for independence, with significance level set at $p < .05$.

To understand country-level differences in how connectivity through trade and tourism impacted food availability, fishing pressure, and seafood markets, we used the publicly available social and economic vulnerability indicators dataset from the Pacific Community (SPC).[1] Specifically, to assess how trade balance shaped these variables, we bucketed countries according to the latest available data (2018) on trade balance as percentage of gross domestic product (GDP) into three buckets: less than −35%, −35 to −30%, and more than −30%. To assess how tourism shaped these variables, we bucketed countries according to the latest available data (2018) on gross tourism receipts as percentage of GDP into three buckets: 0−15%, 16−30%, and more than 30%. We then compared how respondents in countries within each of these buckets answered the questions of interest. To test for significance, we used Pearson chi-square tests for independence, with significance level set at $p < .05$.

We coded qualitative data inductively and iteratively to identify emergent themes and provide a more in-depth understanding of quantitative results, consistent with Saldaña [77]. We conducted qualitative coding in three phases. In the first phase, we assigned codes, or themes, to each response in an Excel database. In the second phase, we tallied the number of times each code appeared in each state. Finally, in the third phase, we reviewed all codes to consolidate redundancies. Examples of codes for food sharing analysis included, "tradition of sharing continues", "COVID-19 restrictions reduced food sharing", and "food shortages led to reduced sharing". All codes were reviewed by the three lead authors to ensure reliability and validity.

3. Results

3.1. *Impact on food availability*

Overall, the majority (63%) of respondents reported that there was "enough" or "more than enough" food available to feed their communities, compared to the same time in past years (Fig. 3). However, there was high variability between countries. Between 11 and 68% of respondents in each country reported "not enough" food, with the largest fractions in PNG (65%) and Tuvalu (68%) and lowest in Kosrae (14%) and Pohnpei (11%). Greater fractions of women reported food insecurity at all sites, with the exception of PNG, where more men reported food shortage, and Pohnpei, where we did not interview any women; however, these gender differences were not statistically significant (Fig. 3). In communities struggling to obtain enough food, reasons varied between sites and included: shortages of imported foods at local stores (e.g., Tuvalu, Pohnpei); physical damage to local food systems (e.g., Fiji); disruptions to markets for buying and selling fish (e.g., PNG); and in-migration to the village placing additional strain on existing food

[1] https://sdd.spc.int/disasters-data/covid-19; Table provided in Supplementary Materials

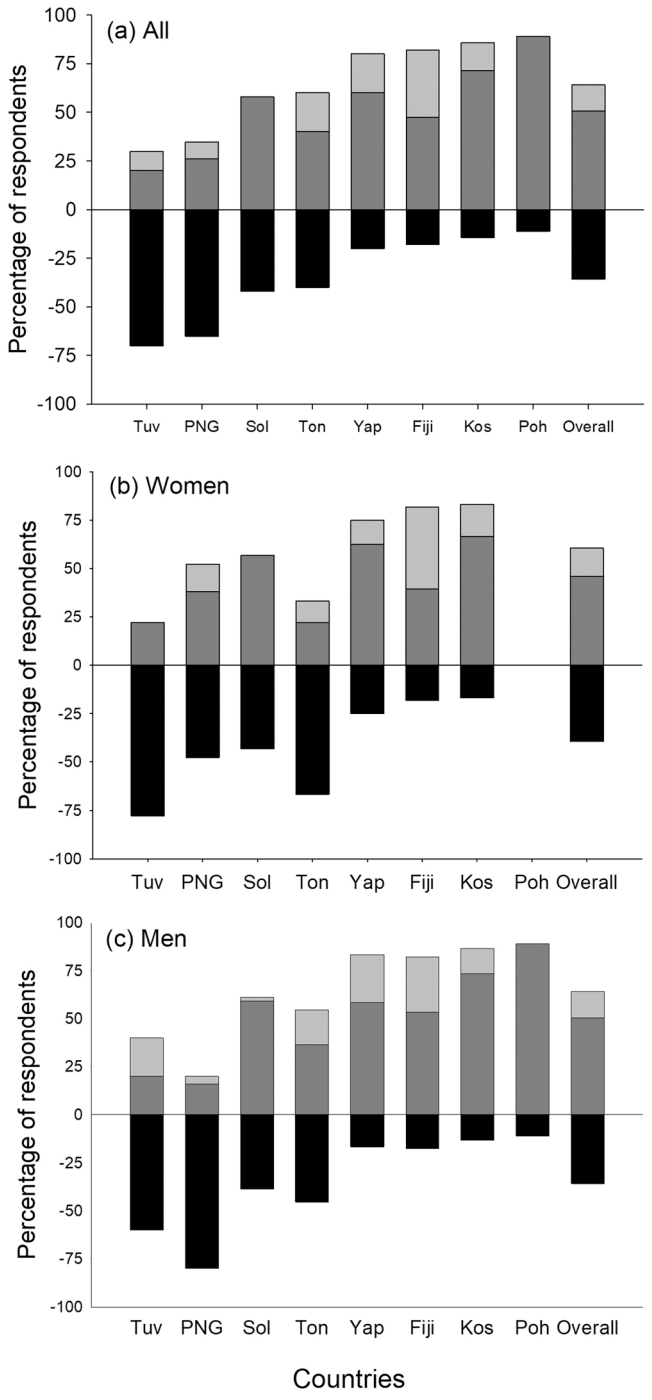

Fig. 3. Impact of COVID-19 on food availability. Responses by (a) all, (b) women, and (c) men to the question "Do you think there is enough food in the village for everyone, compared to normal, for this time of the year?" Black=not enough, dark grey=enough, light grey=more than enough. Three states in the Federated States of Micronesia (Kos=Kosrae (n = 21), Yap (n = 20), Poh=Pohnpei (n = 9)) are presented separately. Fiji (n = 78), Ton=Tonga (n = 10), Tuv=Tuvalu (n = 20), PNG=Papua New Guinea (n = 46), Sol-=Solomon Islands (n = 50). Note: no women were interviewed in Pohnpei. Number of women and men available in Table 1.

resources (e.g., Tuvalu).

Migration from cities to rural villages was widely reported and even incentivized or mandated by some governments early in the pandemic. Region-wide, just under half of respondents (48%) reported migration into their village since the beginning of the pandemic. Consistent with the findings reported above, we found that people in villages dealing with in-migration were significantly more likely to report food insecurity (42% in villages with in-migration compared to 33% in villages with no change in population or out-migration), X^2 (2, n = 271) = 9.9, p = .007.

People in the most import-dependent countries were nearly twice as likely to report food insecurity compared to those in the least import-dependent countries (62% in the most import-dependent countries compared to 35% in less import-dependent countries), X^2 (4, n = 313) = 37.7, p < .0001. Meanwhile, respondents in countries with a high dependence on tourism were four times less likely to report insufficient food (12% in the most tourism-dependent countries compared to 53% in countries with lower tourism dependence) and also more than twice as likely to report more than enough food (61% compared to 23%), X^2 (4, n = 313) = 59.58, p < .0001.

3.2. Community-level food security adaptations

Local food production and food sharing are central to ensuring food availability. Maintaining or increasing these practices were the main adaptations deployed to ensure food availability. While these responses were widespread across the region, they were constrained in some instances because of movement restrictions associated with COVID-19 safety measures and with impacts on natural resources from extreme events.

3.2.1. Food sharing

When asked, "Are you seeing changes in how people are sharing food?" most respondents referred to the maintenance of strong traditions of food sharing, and the majority (59%) noted no changes in food sharing in their village. Food is primarily shared within villages through kinship obligations to support those in need of assistance [73]. A man in Tonga explained, "It is still our tradition to share food with the community," echoing sentiments expressed by villagers in every country in our study. Region-wide, 9% of respondents noted increases in food sharing, owing to increases in food production or changes in seafood markets (e.g., Palau).

Yet 32% of respondents noted reductions in food sharing, attributed to concerns about the spread of COVID-19 in Fiji and FSM, food shortages in PNG, and economic hardships in Solomon Islands and Tuvalu. An *iTaukei* (Indigenous) woman in Fiji explained, "We are not sharing food as much as before [COVID-19] because of current movement restrictions. Most of us are just confining ourselves to our own homes and trying to adhere to the government directive of social restrictions." Overall, communities that faced increased food insecurity were sharing less food than before the pandemic, with those reporting not enough food significantly more likely to report changes in food sharing, X^2 (1, n = 237) = 15.19, p < .001. Qualitative analysis revealed that these changes were primarily reductions.

3.2.2. Local food production

People in communities across the region reported increasing local food production or shifting their use of local foods in response to the food systems shocks associated with COVID-19. In their open-ended responses, the most common ways people reported they were ensuring sufficient food for everyone were: maintenance of local farming (31%) and fishing (23%) practices; increased agricultural production (17%); and food sharing (20%, detailed in 3.2.1). Some respondents were selling more local foods to purchase store bought goods or foods only available in other villages (12%). Conversely, in Palau, some people were using foods that might otherwise have been marketed for direct consumption; a Palauan woman explained, "I noticed some people starting their own farms. For my family, we stopped selling our crops to the markets and we started saving them."

Most increases in local food production came from agriculture, not fisheries. Overall, 72% of all respondents reported that fishing pressure had remained the same or decreased compared to before the pandemic

(Fig. 4). Though region-wide there was not a significant difference between men and women, gender differences did emerge in some sites. For example, men in Kosrae, Solomon Islands, and Yap were more likely than women to report an increase in fishing pressure.

Region-wide, people in villages that experienced in-migration were significantly more likely to observe increases in fishing pressure, X^2 (4, n = 266) = 14.9, p = .005. Connectivity to global markets through trade and tourism at the country level also predicted changes in fishing pressure: respondents in countries more reliant on imports (i.e., with a highly negative trade balance) were significantly less likely to increase fishing pressure, X^2 (4, n = 633) = 48.44, p < .0001, and those in countries with a heavy reliance on tourism were also significantly less likely to increase fishing pressure, X^2 (4, n = 633) = 69.02, p < .0001. The latter finding is likely related to reduced fishing effort for the tourist market; we found a strongly significant difference in changes to fishing effort between commercial and non-commercial fishers in Palau, with commercial fishers significantly more likely to report a decrease in their personal fishing effort, X^2 (1, n = 275) = 15.3, p < .001.

However, increasing local agricultural production was difficult or impossible in a small number of communities in Fiji due to Category 4 Cyclone Harold, forcing people to rely on imported foods or on fishing. Respondents noted that farms had already been negatively impacted the cyclone at the onset of the pandemic. An *iTaukei* man noted, "We are eating a lot of rice and flour products as our cassava plantations were destroyed by the cyclone." An *iTaukei* woman noted that her village was engaging in turtle fishing to meet short-term food needs. Travel restrictions imposed to prevent the spread of the virus further constrained food choices. An *iTaukei* woman explained, "Some farms were affected during the cyclone and, on top of that, we couldn't go to town to buy groceries because of travel restrictions. So, we were depending on seafood."

3.3. Effects on local seafood markets

Impacts on fishing effort, prices, and income associated with fish trade and sale varied greatly across sites, with the largest negative impacts on the commercial fishing sector, and in countries with greater reliance on tourism. No clear region-wide trend emerged from the data on how local seafood markets responded to early shocks (Table 2). Respondents were overall most likely to report no change in sales (38%) or prices (45%) of fresh fish during the assessment period, yet there was high variation between villages and countries, and between men and women in some places (e.g., PNG, Tonga, and Tuvalu).

Reliance on tourism at the country level at least partially predicted market response, with countries more dependent on tourism significantly more likely to report a decrease in prices of fresh fish, X^2 (4, n = 375) = 18.42, p = .001, and somewhat more likely to report a decrease in sales of fresh fish, though this difference was not statistically significant, X^2 (4, n = 374) = 8.21, p = .08. In Palau, the nation with the highest dependence on tourism in this study, half of all women (50%) and men (50%) reported a decrease in seafood sales, and just over half (51%) of men and 38% of women reported a decrease in prices; the remainder of men and women were most likely to report no changes in sales or prices. This gender difference may be reflective of gendered resource use, with men in Palau more likely to be targeting species favored by tourists.

Local seafood markets impacted how people produced and used resources. For example, a Palauan fisherman explained, "It is part of our culture to share food with others. Us fishermen started sharing more than we normally do because we couldn't sell our catch, especially when COVID-19 started and there were no tourists coming." However, in some contexts, reduced prices incentivized increased fishing pressure; for example, a fisherman in Fiji explained, "We are now travelling to the edge of the barrier reef to catch bigger fish so that it fetches a higher price and allows us to feed our families."

4. Discussion

The findings of our regional assessment, which was conducted during the first shockwave of the COVID-19 pandemic from May to October 2020, suggest that rural food systems in the Pacific were relatively resilient to early global food systems shocks. Despite the disruptions caused by the COVID-19 pandemic and response, region-wide, the majority of respondents reported no change in food availability or fishing pressure in their communities. Still, there was significant variation between sites depending on their connectivity locally and globally.

Our study supports the role that modularity—that is, not being under- or over-connected—plays in the resilience of a food system [90], with strong local connections providing support when global connections were disrupted. As imported foods became less available due to the market shocks caused by COVID-19, communities were, in most cases, able to maintain sufficient levels of food through food sharing and increased local food production. Our finding that respondents in villages with more returnees from urban areas and those in countries more dependent on imports (i.e., more globally connected) were more likely to report food insecurity highlights the risk of being overconnected. Meanwhile, in places where local food production systems were severely impaired—for example, by Cyclone Harold—or where village populations swelled beyond the capacity of these local food production systems, food security challenges may have been alleviated by imports, pointing to the risks of being globally under-connected. Connectivity through tourism also shaped responses, with people in the most tourism-dependent countries (i.e., Fiji and Palau) significantly less likely to report food insecurity or increased fishing pressure but more likely to observe declines in sales and prices of fresh fish. In Palau, respondents connected these trends directly, noting that fish they would have sold to tourists was now being shared with locals.

Adaptive capacity in small islands communities varies widely [19,58], and shocks produced by massive disturbances reveal variable levels of system resilience [1,6,33,41]. We found that responses to the food

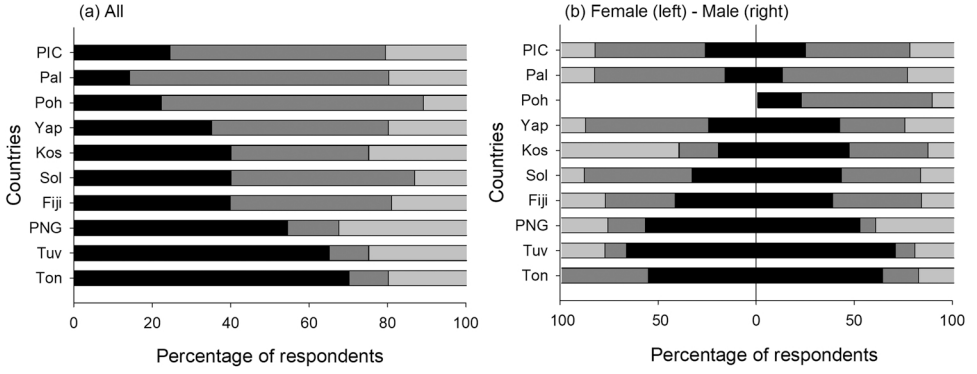

Fig. 4. Changes in fishing pressure. Key informants were asked, "Are people fishing more now compared to in the beginning of February this year?" Black=more pressure, dark grey=same, light grey=less pressure. Three states in FSM (Kosrae (Kos, n = 21), Yap (n = 20), and Pohnpei (Poh, n = 9) are presented separately. Fiji (n = 78), Ton=Tonga (n = 10), Tuv=Tuvalu (n = 20), PNG=Papua New Guinea (n = 46), Sol=Solomon Islands (n = 50), Pal=Palau (n = 276). Note, no women were surveyed in Pohnpei. Number of women and men available in Table 1.

Table 2
Changes in sales and price of fresh fish (numbers are percentages of respondents in each country/state).

State	sales of fish						price of fish					
	men			women			men			women		
	increase	no change	decrease	increase	no change	decrease	increase	no change	decrease	increase	no change	decrease
Fiji	28.6	57.1	14.3	30.0	50.0	20.0	23.5	70.6	5.9	26.7	70.0	3.3
Kosrae	20.0	46.7	33.3	40.0	40.0	20.0	53.3	46.7	0.0	60.0	40.0	0.0
Palau	13.0	37.0	50.0	12.0	38.0	50.0	15.0	34.0	51.0	9.0	53.0	38.0
PNG	52.0	12.0	36.0	28.6	38.1	33.3	40.0	32.0	28.0	9.5	33.3	57.1
Pohnpei	44.4	44.4	11.1	N/A	N/A	N/A	55.6	22.2	22.2	N/A	N/A	N/A
Solomon Islands	17.0	44.7	38.3	29.4	43.1	27.5	29.8	44.7	25.5	30.0	52.0	18.0
Tonga	20.0	50.0	30.0	0.0	55.6	44.4	54.6	27.3	18.2	12.5	25.0	62.5
Tuvalu	80.0	20.0	0.0	44.4	55.6	0.0	80.0	20.0	0.0	77.8	22.2	0.0
Yap	41.7	41.7	16.7	25.0	50.0	25.0	75.0	25.0	0.0	25.0	62.5	12.5
Pacific	35.2	39.3	25.5	23.3	41.2	24.5	47.4	35.8	16.8	27.8	39.8	21.3

systems shocks associated with the COVID-19 pandemic have varied across the study locations, with some communities less impacted or better able to adapt than others. The two most common adaptations employed were food sharing and increased local food production, primarily through agriculture.

Dacks et al. [27] highlighted the importance of food sharing networks to social-ecological systems resilience in the Pacific. The authors noted how the reciprocal exchange of resources and knowledge can serve as a mechanism that enables coping and recovery after major disturbances. In a case study from the Solomon Islands, Lauer et al. [58] documented that, in response to a devastating tsunami in 2007, the ethic of reciprocal exchange and sharing strengthened, conferring resilience. This was consistent with our observations that, where possible, people across the Pacific relied on sharing foods with one another. Similarly, social capital—the collective values that enable individuals and groups to trust each other and work together—was both a source of resilience during and was itself resilient to the devastating Cyclone Pam in Vanuatu [31].

However, not all communities in the Pacific enjoy strong sharing networks. Despite the cultural rootedness of the principles of intra-community solidarity, reciprocity, and collective support (e.g., [76]), Schwarz et al. [78] found that monetization of inter-household exchanges, alongside the relatively new values associated with modernity and democracy, "gradually erode the collective nature of the traditional social system." Dacks et al. [27] similarly found that higher market integration resulted in weaker sharing networks. A recent investigation with small-scale fishing communities in Indonesia suggests that market integration also directly increases fishers' vulnerability to the shocks associated with COVID-19 [101]. Steenbergen et al. [81] noted that the increased transition to cash-based economies in villages in Vanuatu exacerbated vulnerability to the shocks associated with COVID-19. Mangubhai et al. [63] found that non-Indigenous groups, such as Indo-Fijian fishers and traders, had higher rates of food insecurity due to higher market integrations. Our observation that commercial fishers in Palau were significantly more impacted than non-commercial fishers also supports the role that market integration might play in reducing resilience to food systems shocks. Furthermore, in the context of COVID-19, restrictions on movements and gatherings constrained food sharing in some communities during the pandemic; had the virus been more widespread in rural Pacific villages during the survey research period, it is likely we would have observed less food sharing and more food insecurity. Some of the social features that improve resilience in the face of shocks may offer vulnerabilities in the response to infectious diseases, such as COVID-19, as strong local connectedness and reciprocity networks may depend on regular interactions that run counter to preventive isolation and quarantine.

The other common adaptation strategy we observed—increasing local food production—has the potential to promote not just food security, but also food sovereignty [60] and public health [87]. In the context of the COVID-19 pandemic, the increased incidence in many Pacific islands of comorbid conditions including diabetes associated with diets high in low nutritional quality imported foods, has rendered Pacific communities highly vulnerable to the virus [55].

However, increasing local food production was not possible in all communities, as some struggled with concurrent natural disasters. Steenbergen et al. [81] found that, in Vanuatu, these co-occurring threats compounded one another. Our findings were also likely influenced by the geographic location of our sites, which generally had access to arable land, making agriculture a possible food production strategy. Communities living on highly unproductive atolls or facing saltwater intrusion would not be able to rely on agriculture in a similar way. Furthermore, increasing local food production is not without its risks. Increased fishing pressure could create or exacerbate fisheries sustainability challenges (e.g., [44]). Given that these increases in fishing pressure were significantly more likely to occur in communities dealing with in-migration, there are likely trade-offs in short- and long-term food security that warrant careful planning and close examination. Increased agricultural production may also present sustainability challenges associated with land use change on small island systems, which may also lead to increased sediment and nutrient inputs to nearshore environments and further impact nearshore ecosystems and fisheries (e.g., [74]).

The fact that 72% of respondents reported fishing pressure had either remained the same or decreased in their village was surprising in light of concerns that rural Pacific fisheries would be heavily impacted by the disruptions of COVID-19 [13,36]. Instead, people turned first and primarily to agriculture to ensure food was available in their communities. The COVID-19 crisis has unfolded over months—as of the writing of this article, it is still unfolding—meaning communities were able to invest in the relatively slow but significant boost provided by agriculture. Cyclones, by contrast, are catastrophic disasters, unfolding in hours or days, and can cause large-scale destruction of farming areas. Communities impacted by cyclones may have no short-term alternative but to fish for immediate sustenance and income, though increasing fishing effort does not yield comparable returns to agriculture over the longer-term and can, in fact, reduce returns over time, especially if fisheries are already heavily exploited. More studies are needed on the differences in how communities can respond to slow-onset versus catastrophic disasters to ensure food security and long-term sustainability ([80] provides a review of this literature). Steenburgen et al. [81] and Mangubhai et al. [63] explored the intersections of slow-onset and catastrophic disasters in the context of COVID-19 and cyclones in Vanuatu and Fiji, respectively.

When talking about resilience, specificity is required regarding resilience 'of what?', 'to what?', 'for whom?' [18,26], and 'over what timeframe?' ([67,68]). Local adaptive capacities in the Pacific have developed over centuries, largely in response to local-scale social and ecological changes [58]. However, the processes of globalization have altered many of the parameters of local production systems ([7,54, 100]), possibly rendering such capacities ineffective in the face of these

new sources of variability [58]. Ecological disruptions caused by climate change are likely to create new food systems challenges in the future that put at risk the ability of people to access sufficient, safe, and nutritious foods locally [8]. For example, severe tropical cyclones—which may increase in the future (e.g., [91])—can have a serious impact on both agriculture (i.e., loss of crops) and fisheries (i.e., loss of fishing gear, damage to boats and engines, damage to critical habitat for fish and invertebrates), creating a crisis where communities are highly dependent on food relief from government and humanitarian organizations [21]. Climate change is predicted to lead to a decline in nearshore fisheries [10], local extinctions of up to 80% of marine species [5], and decreased yields of staple and cash crops [11], as well as threatening the ability of countries to import food, systems for the distribution of food, and the ability of households to purchase and utilize food [8]. Thus, the novel food systems challenges posed by climate change have led to calls for both diversification of the supply of foods [8] and reduced reliance on imported foods [11] in order to strengthen Pacific food system resilience. Protection and restoration of local food practices, including those developed for dealing with shocks (e.g., [17,59,66]), also has a role to play.

These challenges are emerging as rural populations grow and the risk of overfishing increases [9]. Thus, Barnett [8] argues that "there is an urgent need for the diversification of supply in order to make rural communities more resilient to climate change and extreme events and help rebuild overexploited fisheries resources." The tension between the need to meet present food security challenges posed by COVID-19 and the need to plan for projected future climate scenarios and long-term sustainability highlights the importance of situating 'resilience' in context: systems are rarely if ever resilient to all types of disturbances, and different strategies may be adaptive, inert, or maladaptive depending on the threat [58]. Thus, responses that have proved adaptive to local-scale ecological and social change for centuries may not be appropriate to the types of global threats posed by the COVID-19 pandemic or by climate change, and vice versa. For example, increased local food production, which sustained many communities during the pandemic, might not be possible under future climate conditions, and food sharing might be maladaptive in communities with higher rates of community transmission of the virus, as was the case in PNG in early 2021 [97].

A key consideration beyond the scope of this study is: resilience *of whom*? Not all members of a community will be equally resilient to a given shock, with gender in particular being a key organizing identity in societies across the globe. Women and men typically occupy different roles in seafood value chains, globally [93] and in the Pacific [95]. Where women fishers play significant and diverse roles in fisheries (e.g., Fiji, [85]), they can shift between fisheries to support household food security post-disaster [21]. Yet evidence suggests that women in seafood value chains are more vulnerable to the market shocks associated with COVID-19 and, in some places, their gendered role in feeding family members is strained in times of reduced harvests [2,32,34]. Women are also less likely than men to receive support [62]. Though we found no significant differences overall between women and men in our study with respect to food security, fishing pressure, or changes to seafood markets, we did observe gendered impacts in some communities across each of these dimensions. Such examples might be reflective of gendered resources or responsibilities and might in the longer-term create differential impacts for men and women that should be monitored. The finding that women were more likely in most countries to report food insecurity also warrants further investigation.

Furthermore, gender is not the only social position of relevance to fisheries and food security; intersecting identities [24,25] such as ethnicity, age, religion, marital status, and nationality shape individuals' access to resources and markets [40]. Thus, an intersectional analysis, beyond the scope of this rapid assessment, is necessary to understand how different groups and individuals are impacted differently by the COVID-19 pandemic and how resilience to various shocks is distributed within communities.

5. Conclusion

While connectivity to global food systems through trade may be critical under some conditions, it also makes communities more vulnerable to global market shocks such as those caused by COVID-19. Local leaders, policymakers, practitioners, and community members should weigh these costs and benefits in their decision-making around food trade and production to ensure that communities do not become overly dependent on imported foods, and that systems are in place, including the integration of Indigenous and local ecological knowledges, to meet food needs when local production becomes insufficient or unviable. This is particularly important to bear in mind for the anticipated post-COVID recovery efforts.

Resilience to the impacts of COVID-19 does not necessarily imply resilience to other disturbances, such as natural disasters or the effects of climate change. These global challenges are expected to intensify in the coming years, including a possible increase in the frequency of pandemics [45,99]. The expected impacts of climate change on regional food production in the Pacific suggest that regional or international trade may be necessary to meet food needs in the future. Folke [42] argues that "managing for resilience enhances the likelihood of sustaining desirable pathways for development in changing environments where the future is unpredictable and surprise is likely." Thus, policies that support resilience of food systems can help prepare communities for a future shaped by climate change.

Shocks create opportunities to strengthen, transform, reimagine, and reconfigure. The COVID-19 pandemic offers an opportunity to build more sustainable, equitable, and resilient food systems for the future, especially as part of post-COVID recovery. Our study suggests that recognizing and bolstering sustainable local practices around food production and food sharing has a key role and potential for sustaining rural Pacific communities in the face of unprecedented change.

CRediT authorship contribution statement

Caroline E. Ferguson: Conceptualization, Data curation, Data analysis, Writing – original draft, Writing – review & editing. **Teri Tuxson:** Conceptualization, Methodology, Data curation, Supervision, Writing – original draft, Writing – review & editing. **Sangeeta Mangubhai:** Conceptualization, Methodology, Data curation, Supervision, Data visualization, Writing – original draft, Writing – review & editing. **Stacy Jupiter:** Conceptualization, Methodology, Writing – review & editing. **Hugh Govan:** Conceptualization, Methodology, Supervision, Writing – review & editing. **Victor Bonito:** Conceptualization, Data collection, Writing – review & editing. **Semese Alefaio**, **Maxine Anjiga**, **Jonathan Booth**, **Tracey Boslogo**, **Delvene Boso**, **Ambroise Brenier**, **Akanisi Caginitoba**, **Ana Ciriyawa**, **Joeli Bili Fahai'ono**, **Margaret Fox**, **Andy George**, **Hampus Eriksson**, **Alec Hughes**, **Eugene Joseph**, **Sean Kadannged**, **Eferemo Kubunavanua**, **Sesimani Loni**, **Semisi Meo**, **Elizah Nagombi**, **Rebecca Omaro**, **Anouk Ride**, **Annisah Sapul**, **Ann Singeo**, **Karen Stone**, **Margaret Tabunakawai-Vakalalabure**, **Marama Tuivuna**, **Caroline Vieux**, **Vutaieli B. Vitukawalu**, **McKenzie Waide:** Conceptualization, Data collection, Writing – review & editing. **Fiorenza Micheli:** Supervision, Writing – review & editing.

Declarations of Interest

We do not have any conflicting interests, and we declare ourselves to be entirely responsible for the scientific content of the paper. We have acknowledged all sources of funding in the manuscript and declare that publication of this research will not result in any financial gains.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.marpol.2022.104954.

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