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RESEARCH

Small fish consumption in rural Myanmar

Quennie Vi Rizaldo[1] · Wae Win Khaing[2] · Ben Belton[3,4]

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Abstract

Assessments of fish consumption are based primarily on data from household surveys that do not capture information on the intra-household distribution of the size or species of fish consumed. Such studies can yield partial or misleading information about the adequacy of aquatic food consumption. We address this gap by focusing on individual-level fish consumption within the household, using data from a survey conducted in a rural part of the Ayeyarwady Region in Myanmar—an area with high levels of fish consumption. We disaggregate fish consumption by the gender of household members and by the quantity, species, and size of fish eaten, estimating quantities of fish consumed using models for reference, to identify gendered patterns of fish consumption at the intrahousehold level. We find higher average levels of fish consumption than reported in previous consumption surveys in Myanmar. Moreover, small fish are consumed more frequently than larger-sized fish. The popularity of small fish species highlights the continued reliance of survey respondents on wild fish stocks, despite all surveyed households also practicing small-scale aquaculture. The average consumption of fresh fish reported by women was 36% lower than that reported by men. Men were more likely to eat large fish species, but women ate more small fish, which may contain higher levels of micronutrients vital for addressing nutrient deficiencies.

Keywords Aquatic foods · Small indigenous fish species · Food and nutrition security · Fish-based processed products · Myanmar

Introduction

Fish and other aquatic foods play a crucial role in livelihoods and provide nourishing and sustainable diets for millions of people worldwide (UN Nutrition 2021, Von Braun et al. 2021). Fish is often the cheapest available animal-sourced food in low-income countries in Africa, Asia, and the Pacific (FAO 2020). In particular, many small indigenous species of fish (SIS) are rich in vitamin A, vitamin B12, iron, calcium, and essential fatty acids (Roos et al. 2003; Bogard et al. 2015; UN Nutrition 2021) and are readily available. Promoting the consumption of SIS by poorer members of rural communities with inadequate access to nutritious foods has been shown to help improve diet diversity, resulting in better nutrition, particularly for children under 5-year-old (U5) and pregnant and lactating women (PLW), who suffer mostly from undernutrition and micronutrient deficiencies (MOHS 2018).

Aside from their contributions to nutrition, small fish are integral to sustaining livelihoods in many locations globally. For instance, in the great lake regions of Africa (Molsa et al. 1999, Obiero et al. 2019), freshwater pelagic small fish like dagaa, omena, and sardinella are an important source of income for fishers, processors, and traders (Ba et al. 2017). Similarly, in Myanmar, marine pelagic small fish like sardines and anchovies account for a large share of fisheries landings (Exeter et al. 2021), contribute significantly to fisheries employment via fishing and processing activities (Okamoto 2010), are traded across the country in dried form, and make important contributions to the economy in areas where they are produced (Joffre and Aung 2014; Belton et al. 2019).

Myanmar's fish supply comes from capture fisheries and aquaculture, but wild fish stocks are reported to be declining (IMR 2014; Hosch et al. 2021). This decline has contributed

✉ Quennie Vi Rizaldo
q.rizaldo@cgiar.org

Wae Win Khaing
khaingww@myumanitoba.ca

Ben Belton
B.Belton@cgiar.org; beltonbe@msu.edu

1 WorldFish, Yangon, Myanmar

2 University of Manitoba, Winnipeg, Canada

3 WorldFish, Penang, Bayan Lepas, Malaysia

4 Department of Agricultural Food and Resource Economics, Michigan State University, East Lansing, MI, USA

to a demand for aquaculture, which has grown briskly over the past two decades (Tezzo et al. 2021), paralleling trends in Thailand, Vietnam, and Bangladesh (Belton and Thilsted 2014). However, fisheries remain far more important than aquaculture in terms of employment, nutrition security, and fish consumption in Myanmar, especially for rural households, with > 900,000 households engaged in fishing, compared to only 34,000 practicing aquaculture (Belton and Fang 2022).

Fish and aquatic foods are considered important components of sustainable and healthy diets. However, although fish consumption rates in many parts of Myanmar are comparable to or higher than the global average, malnutrition has remained persistent in the country and has intensified since the "triple crisis" of COVID-19, a military coup ousting the elected government, and fuel and food price inflation, beginning in 2020 (MAPSA 2021). Even prior to the crisis, one-third of households in Myanmar suffer from food insecurity, and undernutrition among under-five children was high (MOHS 2018).

To date, the literature on fish consumption in Myanmar has been limited to a few household-level studies of food consumption (Belton et al. 2015; So Jung et al. 2018; Aung et al. 2022; Scott et al., forthcoming). These are based mainly on the national Integrated Household Living Conditions Assessment survey (IHLCA) conducted in 2005 and 2010 which do not disaggregate consumption at the intra-household level. This approach may yield partial or misleading information about the adequacy of consumption, because food cannot be assumed to be allocated equitably among household members and because household members may have different consumption preferences that cannot be adequately captured by aggregate household-level data.

In this paper, we address this methodological and empirical gap by focusing on the individual-level consumption within the household. We disaggregate fish consumption by the gender of household members and according to the quantity, species, and size of fish eaten. This allows us to identify variations in fish consumption behavior between women and men, that may support contextualization of why nutrition insecurity is persistent despite apparently high average levels of fish consumption.

In addition, this study also disaggregates fish consumption by species and sizes of fish. These choices are closely linked to economic status as, for instance, large fish are eaten more frequently by wealthier households than poorer ones. This tendency has been documented in Myanmar and numerous other countries, including Bangladesh and Zambia (Belton et al. 2011; So-Jung et al. 2018; Genschick et al. 2018). The species and quantity of fish consumed may also vary with gender and age, as reported by Genschick et al. (2018) and Bradley et al. (2020) for Malawi and Nigeria.

The size at which fish are consumed has possible nutrition and health implications, as small fish are often eaten whole, including head, bones, and viscera, while larger fish may be eaten as fillets, discarding the other parts of the fish (Roos et al. 2003; Bogard et al. 2017). Small indigenous fish species (SIS) are characterized by having a body length at maturity of less than four inches in length and by being self-recruiting species that do not require regular stocking (FAO, 2006). Certain SIS have been found to contain particularly elevated levels of micronutrients, such as vitamin A, zinc, and iron (Bogard et al. 2017).

This paper analyzes data from a survey conducted in a rural area of the Ayeyarwady Region in Myanmar to identify gendered patterns of fish consumption at the intrahousehold level. This region was selected for inclusion in the survey due to its vibrant fishing and aquaculture industry (Belton et al. 2015) and high rates of fish consumption compared with other areas of the country (So-Jung et al. 2018). The study reveals a highly detailed picture of gendered fish consumption behaviors in an area of Myanmar that experiences a high prevalence of stunting among under 5-year-old children (38%) and anemia among women of reproductive age (40%) (MOHS 2018), with potentially important implications for food security and future nutrition sensitive agri-food system program design. The study also makes an important methodological and empirical contribution to the literature by reflecting on the differences between our findings and conventional household-level survey methods that rely on collecting recall data on aggregated categories of fish and fish products. This study found higher levels of fish consumption than previous studies using conventional reporting methods.

The following section outlines the geographical area and the characteristics of the respondents interviewed. Subsequently, we present study results classifying the type, size, and quantity of fish consumed by female and male respondents, followed by respondents' perceptions regarding the health and nutrition benefits of different fish species. We conclude by reflecting on these findings and their significance for the implementation of nutrition-sensitive interventions in Myanmar and the paper's contribution to the global agenda on aquatic foods and nutrition.

Methodology

Study area, sample population, and survey tool

The present study was conducted in the southern part of the Ayeyarwady Region, comprising part of the floodplains and delta of the Ayeyarwady river (MIMU, 2018). Data were collected for the project "Promoting sustainable growth of aquaculture in Myanmar to improve food security and income for communities" (MYFC), funded by the Livelihoods and Food Security fund and implemented by WorldFish from 2016 to 2020. The project aimed to increase

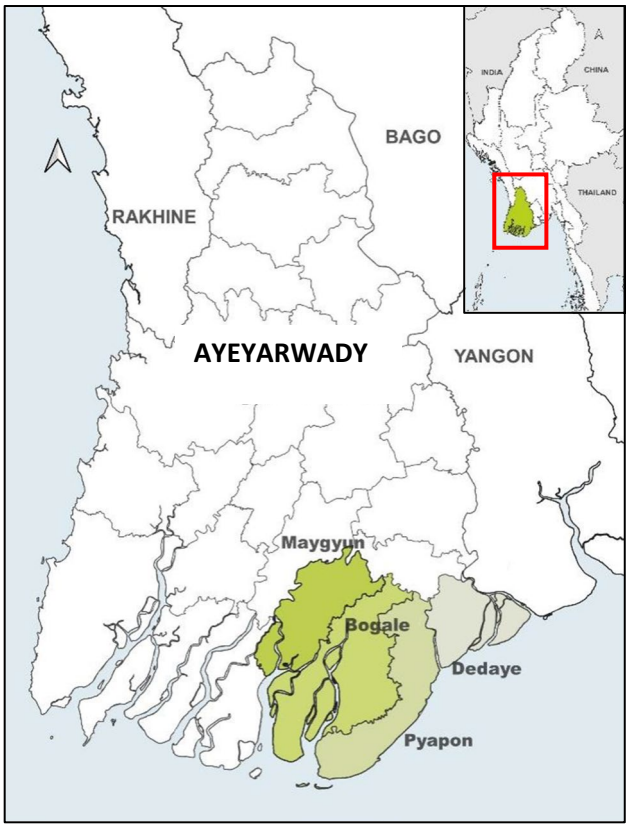

Fig. 1 Map of the study areas

income and improve nutrition among rural households in the Ayeyarwady Delta, Myanmar.

The paper's first author oversaw the implementation of the project's human nutrition activities. Four townships—Dedaye, Pyapon, Bogalay, and Maygyun (Fig. 1)—were selected for inclusion in MYFC, based on the presence of small-scale aquaculture farmers and the potential to improve aquaculture activities to increase income and food and nutrition security. The current study covers all four townships and was conducted after 1 year of project implementation. During this period, the project provided technical support and inputs such as fingerlings and vegetable seeds to a total of 276 farmers from said townships.

A combination of purposive and random sampling techniques was used to select 128 study households by geographical area from the project participant database, all of whom were small-scale aquaculture (SSA) farmer households. Whichever adult member of the household was present at the time of interview and agreed to participate was interviewed, resulting in 123 respondents. As resources for the study were limited, it was decided only interview respondents enrolled in the project. This might have implications for the interpretation of the study results since project beneficiaries are more likely to have been exposed to information about SSA technology and nutrition. Data was collected in April and May 2018, during the dry season, a period when fish is generally less available than during the monsoon.

We collected the data from one member of each household based on the following: (1) socio-demographic information on family composition, age, livelihood activities, and income; (2) a 24-h food recall with a focus on the fresh and processed fish species consumed by the study participants; (3) quantification of amounts of fresh and processed fish consumed during the preceding 24 h with the aid of fish models, where study participants with U5 children were asked to report the amount of fish consumed by the child; and (4) perceptions regarding fish consumption related to health and nutrition. Due to resource limitations, the 24-h food recall was conducted once. Thus, the data do not capture variations in the consumption of fish over several days or between seasons and may not fully represent the general consumption behavior of the respondents. However, the method was considered appropriate for providing a snapshot of the quantity of the fish consumed by respondents with minimal recall bias.

To elicit 24-h food recall on amounts of fish consumed by respondents, we used fish models as a visual aid (see Fig. 2) to enable easier and more accurate quantification (see Gibson and Ferguson 2008). Respondents were shown relevant models and could hold them to estimate the weight of the amounts of fish consumed.

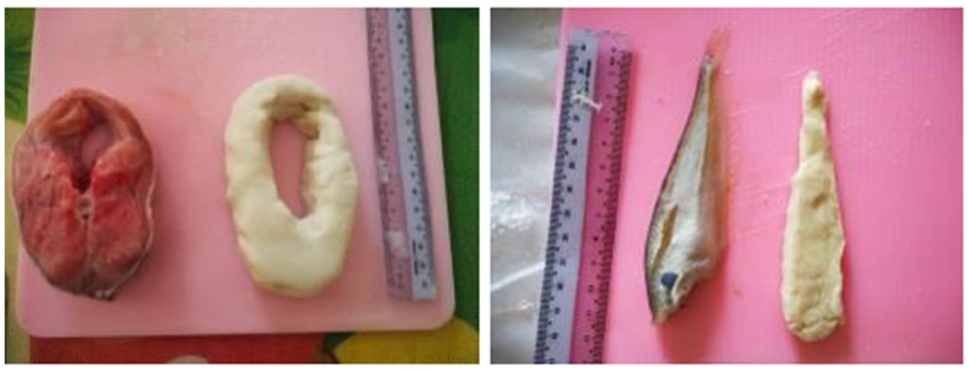

Fig. 2 Samples of fish model used in the study (left, rohu; right, sheat fish)

Table 1 Fresh fish consumption in the previous 24 h by the size of fish and gender

	Any size of fresh fish			Large-sized fresh fish			Medium-sized fresh fish			Small-sized fresh fish			Total *N*
	Grams	%	*n*	Grams	%	*n*	Grams	%	*n*	Grams	%	*n*	
Male	132	59	29	102	36	17	160	8	4	91	34	16	49
Female	84	62	46	70	19	14	55	8	6	82	43	31	74
All	102	61	75	87	25	31	97	8	10	85	38	47	123

Most interviews were conducted in the participants' homes in an open space, free of disruption. Participants who lived far away were asked to meet enumerators at a central location, where privacy and confidentiality guidelines were observed during interviews. Enumerators obtained informed consent after explaining the purpose of the study and ethical guidelines such as anonymity, privacy, confidentiality, and legal rights of the participants. A small token of appreciation was given to study participants after the interview.

Data analysis

Survey data were entered directly into the SPSS software package (IBM Analytics, 2018). Data was cleaned using SPSS, followed by descriptive statistical analysis.

Many types of fish were reported as consumed by respondents, so we compiled a list of all species reported and classified them as small, middle-sized, or large based on IHLCA definitions, which classify large freshwater fish as being 11 inches or more and small fish as 4 inches less (IHLCA 2011), as well as the FishBase database (https://www.fishbase.se) and commonly observed fish sizes at local markets. The consumption of processed fish (dried, fermented fish paste) was analyzed using this categorization during the 24-h recall. For fresh fish consumption, the identification of fish size (small, medium, large) relied entirely upon the respondent's recall.

Results and findings

Profile of respondents

Of the 123 respondents, 74 (60%) were female, and among those, 59% were women of reproductive age (15–49 years old). A quarter of the respondents had secondary education, almost half of the respondents had attended primary education, and the remainder reported having had no education. A quarter of respondents (26%) reported having U5 children (e.g., own child, grandchild, niece/nephew) living in the household. Most respondents were engaged in rice farming (60%), followed by livestock farming (29%) and aquaculture (26%), and more men reported involvement in these activities than women (90% vs. 60%). Consequently, men are more likely to report having multiple sources of income than women (63% vs 36%).

Consumption of fish

Ninety-seven percent of respondents had consumed fish within the 24 h preceding the survey, in fresh, dried, or fermented paste form or in combination. Fermented fish paste was the most common item consumed by 90% of respondents, followed by fresh fish and dried fish, eaten by 62% and 24%, respectively. Of the respondents who consumed fish paste ($n=108$), the average consumption was 43 g/person/day, which was lower than the average amount of dried fish ($n=29$) (60 g/person/day) and fresh fish ($n=75$) (102 g/person/day). This finding is as expected, as fish paste is usually consumed as a condiment in Myanmar. Although larger absolute weights of fresh fish were consumed compared to dried fish, the quantity of dried fish consumed exceeded the amounts of fresh fish when correcting for the weight of dried fish in its original form as fresh fish.[1]

Men and women were equally likely to have consumed fresh fish during the preceding 24 h. However, gender influenced the quantity of fresh fish consumed as men reported having eaten 132 g/person/day of fresh fish in the preceding 24 h, while women reported having eaten 84 g/person/day (see Table 1). Therefore, men on average consumed 57% more fish of all sizes than women.

Moreover, while 43% of female respondents indicated that they had consumed small-sized fresh fish[2] (see Table 1), only 19% reported consumption of large fish. In contrast, 36% of male respondents reported that they had consumed large fish, while 34% indicated consumption of small fish. However, as women consumed a lower quantity of small fish on average relative to men in absolute terms (grams), it is unlikely that women benefited from the high levels of micronutrients in SIS.

[1] Dried fish weight was multiplied by 4 to estimate the fresh fish weight (c.f., Scott et al. forthcoming). Thus, 60 g of dried fish is equivalent to 240 g of fresh fish.

[2] This refers to all types of small fish: small pelagic fish, small indigenous fish species, juvenile fish.

Table 2 Frequency of all fresh fish species consumed by respondents as per 24-h recall

Fish size	No	English name	Phonetic Burmese	Scientific name	Main source	Frequency
Large	1	Striped snakehead	Nga yant	*Channa striata*	Capture fishery	14
	2	Walking catfish	Nga khu	*Clarias batrachus*	Capture fishery	11
	3	Rohu	Nga myit chin	*Labeo rohita*	Farmed	5
	4	Mrigal	Nga gyin	*Cirrhinus cirrhosus*	Farmed	1
	Sub-total					31
Medium	1	Panna croaker	Nga pote thin	*Panna microdon*	capture fishery	5
	2	Tilapia	Salivia/Telapia	*Oreochromis niloticus*	farmed/capture fishery	4
	3	Silver barb	Nga khone ma gyi	*Barbonymus gonionotus*	Farmed	1
	Sub-total					10
Small	1	Gangetic mystus	Nga zin yaing	*Mystus cavasius*	Capture fishery	20
	2	Climbing perch	Nga bye ma	*Anabas testudineus*	Capture fishery	8
	3	Mango fish	Ngar ponnar	*Polynemus paradiseus*	Capture fishery	7
	4	Colorful eel	Nga mhway htoe	*Mastacembelus unicolor*	Capture fishery	4
	6	Bronze featherback	Nga phe	*Noptopterus noptopterus*	Capture fishery	4
	7	Wallago	Nga bat	*Wallago attu*	Capture fishery	3
	8	Spotted snakehead	Nga pa naw	*Channa punctata*	Capture fishery	2
	9	Shrimp	Pazun	*Penaeidae*	Capture fishery	2
	10	Prawn	Pazun	*Palaemonidae*	Capture fishery	2
	11	Other types of small fish			Capture fishery	5
	Sub-total					57
Grand total						98

Table 3 Dried fish consumption in the previous 24 h by the size of fish and gender

	Any size of dried fish			Dried large and medium-sized fish			Dried small fish		
	Grams	%	*n*	Grams	%	*n*	Grams	%	*n*
Male	58	24	12	57	20	10	64	4	2
Female	61	23	17	50	14	10	78	10	7
All	60	24	29	53	16	20	75	7	9

Most fresh fish consumed was small. Respondents who reported consuming large or medium-sized fish only listed one species, while respondents consuming small fish reported eating 1 to 3 species, which contributes to the intake of multiple nutrients as each fish species has different micronutrient profiles. The 47 respondents who consumed fresh small fish in the previous 24 h identified more than ten different types of fish species in total (Table 2).

Dried fish were consumed by 24% of respondents. The average weight eaten was 60 g/person/day. Nine out of the 29 respondents who consumed dried fish ate small species (Table 3). The average quantity of dried small fish consumed was higher than that of other sizes of dried fish (75 g vs 53 g).

Men and women consumed similar quantities of dried fish. However, men reported higher consumption of large/medium-sized dried fish compared to women, with women consuming more larger amounts of dried small fish. Although the sample sizes are small, these findings are in line with the consumption of fresh fish, whereby men are more likely than women to consume large fish. Among dried small fish, the most frequently consumed species were gold spotted grenadier anchovy and panna croaker, which are obtained mainly from marine or estuarine capture fisheries.

Table 4 Amounts of fish paste consumed in past 24 h, gender

	Fish paste			Total *N*
	Grams	%	*n*	
Male	43	82	40	49
Female	44	92	68	74
All	44	88	108	123

Table 5 Popular fish in fish paste reported by respondents

Fish size	No	English name	Phonetic Burmese	Scientific name	Main source	Frequency
Non-small	1	Largehead hairtail	Nga da gon	*Trichiurus lepturus*	Capture fishery	73
	2	Striped snakehead	Nga yant	*Channa striata*	Capture fishery	14
	3	Banded gourami	Nga pyin tha let	*Trichogaster fasciata*	Capture fishery	3
	4	Other types of non-small fish			Capture fishery	7
	Sub-total					97
Small	1	Burma hairfin anchovy	Nga pya	*Setipinna wheeleri*	Capture fishery	31
	2	Gold spotted grenadier anchovy	Myi than twel	*Coilia dussumieri*	Capture fishery	6
	3	Snakehead	Nga pa naw	*Channa punctata*	Capture fishery	6
	4	Climbing perch	Nga bye ma	*Anabas testudineus*	Capture fishery	6
	5	Swamp barb	Nga hkone ma	*Puntius chola*	Capture fishery	3
	6	Other types of small fish			Capture fishery	6
	Sub-total					58
Unknown	1	Other types of fish unknown size			Capture fishery	2
	Sub-total					2
Grand total						157

The average intake of fish paste in the preceding 24 h was 44 g/person/day, with no difference between men and women (see Table 4), which may suggest that consumption of fermented fish paste is more gender equitable than consumption of other forms of fish and fish products. Fish paste is eaten as a condiment and is the cheapest of all the three forms of fish, thus perhaps less valued so the distribution within household is not as gender differentiated as more expensive or higher status food items. This hypothesis warrants further investigation. As fish paste is often made from several fish species, especially when including small fish, it was not possible to break-down the amount consumed by fish size.

Fish paste made from fish identified as small species was consumed by 42% of the respondents, with an average consumption of 44 g of fish paste/person/day, or close to 3 tablespoons, with little difference between women (44 g/day) and men (43 g/day). The most popular fish paste ingredients were Burma hairfin anchovy, spotted snakehead, and climbing perch, all of which are obtained primarily or exclusively from capture fisheries (Table 5).

Regarding young children, 23 out of 32 (72%) respondents with U5 children gave fresh fish, dried fish, and/or fish paste to a child in the 24 h preceding the interview. Sixteen respondents with U5 children reported giving fresh small fish, primarily to children of 2–5 years of age and in one case to a 6–23-month-old child. Twelve respondents with U5 children gave fish paste, while only one respondent gave dried fish to an U5 child. These results suggest that most 6–23-month-old children are unlikely to any fish-derived proteins and other essential nutrients that are important during the critical period of the first 1000 days of life, from conception till the child reaches 2 years of age.

Perceptions on the consumption of fish

Respondents listed species of fish that they perceived as contributing to good health and nutrition among young children (Fig. 3). From a total of 282 responses, mola carplet (*Amblypharyngodon mola)*, a nutrient-rich small indigenous fish, was mentioned most frequently. This may reflect respondent's exposure to nutrition messages about the importance of small indigenous fish species for improving nutrition which were promoted by WorldFish staff during the project period. Mola carplet was perceived to be good for health and nutrition and to contribute to intelligence. Unfortunately, despite the high level of positive perceptions about consuming mola, low levels of consumption were found among respondents, as reported above (see Table 2), suggesting that it is not abundant in the area where the survey took place.

Conversely, consumption of hilsa (*Tenualosa ilisha*) and striped catfish (*Pangasianodon hypophthalmus*) was perceived by some respondents to cause disease and sickness such as diarrhea, muscle tension, and seizures in young children. In Myanmar, food taboos and cultural beliefs exist which are passed on to the next generations that can result in inadequate intake of nutrients among young children.

Similar results were found regarding perceptions around the consumption of mola carplet by pregnant and lactating women (PLW). Thirty-two percent of respondents who mentioned mola associated it with strength, and 27% with good fetal development. Other small indigenous fish, such as mango fish (*Polynemus paradiseus*), walking catfish (*Clarias batrachus*), and flying barb (*Esomus ahli*), were also perceived to be beneficial for the health of PLW (Fig. 4). However, 70% of respondents who mentioned hilsa associated it with counteracting serious health conditions

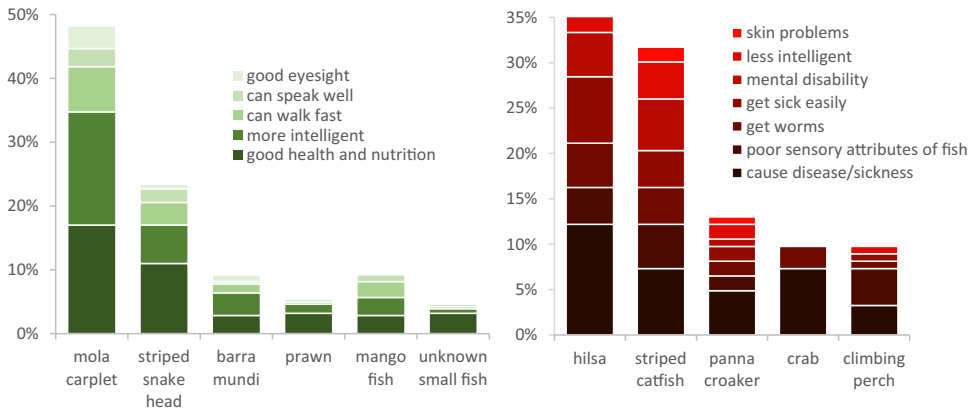

Fig. 3 Fish species with perceived positive associated health attributes (282 responses) and negative health attributes (123 responses), for U5 children

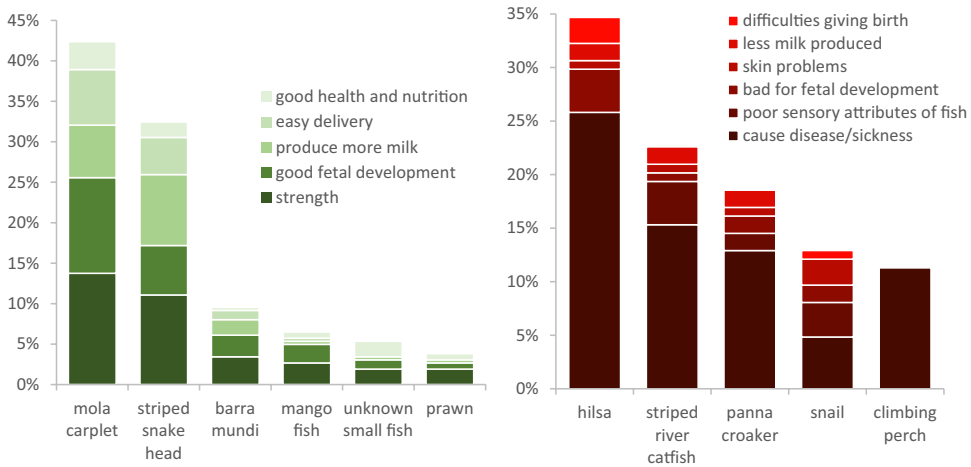

Fig. 4 Fish species with perceived positive health attributes (262 responses) and negative health attributes (124 responses) for pregnant and lactating women

such as hypertension, perhaps because it is an oily fish, rich in Omega-3 fatty acids.

Discussion

Our study confirms that aquatic foods play an important role of the diets of inhabitants of the Ayeyarwady Delta. Fish paste is the most frequently consumed aquatic food product, followed by fresh fish and dried fish. This finding coincides with results from a study conducted by Lin et al. (2022) in Ayeyarwady.

Small fish are consumed more frequently than larger-sized fish. The popularity of small fish, which are sourced primarily from the wild, in all product forms (fresh, dried, paste) highlights the reliance of survey respondents on wild fish stocks from capture fisheries, despite the fact that all surveyed households also practiced small-scale aquaculture. This finding underlines the continued importance of captured fish in diets even though this vital resource is thought to be in decline in Myanmar (FAO 2019). Despite recent increases in aquaculture production in Myanmar, which mirror global trends, the declining availability of captured fish negatively would impact the availability of nutrient-rich small fish such as small pelagic fish for consumption and impact the livelihoods of households dependent on fishing.

The average reported fresh fish intake of women respondents was 36% lower than that of men (84 g vs 132 g). Women's average consumption of fresh fish is lower than the recommended daily intake of 100 g of animal-sourced food for adults in the EAT Lancet reference diet (a globally accepted reference diet (Willet et al. 2019) with recommended quantities of food items needed for optimal health and well-being of adults while simultaneously keeping a low environmental footprint).

Even though nutrition promotion activities were conducted by the project, the results indicate that more effort is required to support women in increasing their intake of fish. Approaches on behavior change with gender transformative education as well as providing guidance on the recommended quantities for target groups could help ensure sufficient consumption to meet dietary needs. Such an initiative (i.e., food-based dietary guidelines) was launched recently in Myanmar, and countrywide dissemination is in process.

Male respondents were more likely to eat large fish species, while female respondents ate more small fish which

may contain higher levels of micronutrients vital for addressing nutrient deficiencies. It can be hypothesized that men in this study are provided with large fish because they are perceived as the "breadwinner" of the family; large fish and in particular large-capture fish are generally more expensive than small fish. In Myanmar society, men are presumed superior to women and are usually prioritized by their mothers and wives. For instance, research on women's empowerment in Myanmar has found that men are perceived to be "more spiritually developed or simply more skilled" (Lambrecht and Mahrt 2019, p. 19).

However, in Myanmar households, women usually purchase and cook food, preparing the same meal for everyone. Thus, when a fish is cooked, all household members will eat the same fish, although the part of the fish (head, body, tail) may differ according to preference, age, and/or hierarchy. This pattern is also common in other parts of the world (see Gomna & Rama 2007 for an example from Nigeria). Since this research did not look at intra-familial food distribution, it is difficult to conclude that men eat large fish more often than women, as other factors such as availability or preference could play a role. In addition, the 24-h recall only gives a snapshot of one day of food consumption. This limitation is discussed further below.

To be able to compare amounts of fish consumed with other available data sources, we calculated the annual consumption including all forms of fish (fresh, dried, fermented) consumed. This resulted in a total amount of 32 kg/capita/year[3] which is higher than the Ayeyarwady Delta average rate of 28 kg/capita/year reported by Belton et al. (2015), based on analysis of IHLCA survey data. Lin et al. (2022) reported fish consumption of 45 kg/capita/year in the Ayeyarwady Delta, based on a survey of households that focused on itemizing and quantifying all fish and fish products consumed by households during a 7-day recall. These observations call into question whether a food recall with emphasis on fish may lead to an overestimation of amounts consumed by respondents since they are pre-conditioned that questions are about fish consumption. Another factor that could contribute to an overestimation is that respondents might perceive that they are expected to eat more fish and therefore report higher amounts since they belong to fish-producing households.

On the other hand, the reported consumption of 28 kg/capita/year by Belton et al. (2015) might be an underestimate, as this data was collected through a lengthy survey covering many topics, implying that enumerators spent a long-time conducting interviews, which could lead to interview fatigue with less time devoted to probing and clarifying, potentially resulting in recall bias by respondents. Moreover, the IHLCA survey asked about aggregated groups of fish, not individual species and products consumed, possibly increasing the likelihood of underestimation.

Hence, to verify the results and get a more accurate measurement, a 3-day food diary could be considered, in line with a study conducted by Ahmad et al. (2016) in Malaysia whereby respondents recorded daily meals, including the quantity of food consumed, for 3 consecutive days to identify individual consumption patterns. Food weighing would also provide a more detailed estimate of amounts consumed. An alternative method is conducting repeated visits throughout the year to account for seasonality, but these methods require significant resources (trained enumerators, time, money), which were not available at the time of this study. Furthermore, the use of fish models in the study may also affect the reported amounts consumed. Garaway and Arthur (2019) found that when asking respondents to recall the amount of fish consumed, a fish stick with different lengths is more accurate than asking the weights of fish.

Regardless of any possible bias, the current study enables a comparison between forms of fish consumed by respondents. Adding to a growing body of literature (e.g., So Jung et al. 2018; Lin et al. 2022; Scott et al., forthcoming), it highlights the importance of dried fish and fish paste in Myanmar diets.

However, pesticides are sometimes used during the processing and storage of dried fish products to minimize insect infestation (Myanmar Times 2017). This practice is harmful to health as it is linked to respiratory diseases and forms of cancer (Brody and Rudel 2003; Mamane et al. 2004). Similar practices have been found in other countries (Belton et al. 2022), which suggests this could be a widespread problem, but little is done to address the issue.

In addition, parasites were found in fish paste sold at local markets in Myanmar (Shinn 2020), that have potential to infect humans when eaten raw or when not cooked properly. Therefore, building capacity in suitable storage techniques and investing in improved processing methods among processors and traders may be required to make safe, high-quality products available to consumers.

Although fish plays a vital role in the diets of the Myanmar people, negative perceptions related to consuming certain types of fish persist, especially during pregnancy and lactation, which has nutritional implications for mothers and their infants who rely on their milk for the first 6 months of life. Therefore, nutrition communication activities should focus on the benefits of consuming fish at all stages of life to facilitate changes in consumption behavior. Messages could be based on the feedback from respondents regarding fish with positive perceptions such as consumption of fish being good for cognitive development in children and ease of delivery during pregnancy.

[3] When the amount of dried fish (60 g) is multiplied by 4 to convert into fresh fish form, the total annual fish consumption is equivalent to 60 kg/capita.

Although negative perceptions of the health implications of some species exist, consumption of certain small fish species like mola carplet was widely perceived as having benefits for the health and nutrition of young children, which was also documented in Bangladesh by Thilsted and Roos (1999). This finding may reflect the efficacy of nutrition education and awareness campaigns promoting mola by the project. However, only half of the respondents with U5 children reported that the child consumed small indigenous fish species such as mola, and only one of the respondents gave SIS to a 6–23-month-old child.

This finding raises the question of why more U5 children were not given small fish to eat. It could be that caregivers are afraid that children will choke on fish bones, which was found to be one of the barriers in feeding fish to young children in one of the townships studied (Rizaldo and Weatherson 2018). A possible solution for this is grinding dried small fish into fine powder as it can easily be added to complementary foods for infants and family foods for young children (Rizaldo and Morris 2020; Nway et al. 2021). Promotion of this type of solution and awareness of the importance of small indigenous fish species in achieving good nutrition during behavior change communication activities can help increase the intake of essential nutrients among young children.

Conclusion

The study analyzed fish consumption among rural individuals in Myanmar's Ayeyarwady Delta. This work reveals the importance of fresh fish, dried fish, and fish paste in their diets with an estimated 32 kg/capita/year consumption, higher than the IHLCA which reported an average consumption in the same area of 28 kg/capita/year. This could suggest that the individuals studied are on track to achieve healthier and sustainable diets as fish, especially small-sized fish, contain essential nutrients and are generally recognized to have a relatively low environmental footprint when compared to terrestrial animal source foods (Gephart et al. 2021. 2021). However, the amount of fish consumed by women is lower than the global recommendation which can put them at risk of micronutrient deficiencies and will be insufficient to reduce any existing micronutrient deficiencies.

Moreover, negative perceptions of consuming certain types of fish during pregnancy and lactation (the critical period of 1000 days—from conception until a child reaches 2 years of age) persist. These beliefs have the potential to cause irreversible damage resulting in poor health outcomes and lower productivity later in life. Therefore, behavior change communication activities are paramount to facilitate and promote fish consumption practices among rural mothers and children.

The results underline the continuing centrality of capture fisheries in Myanmar's nutrition security (c.f. Belton et al. 2022), and the importance of strengthening community-based management of fishery resources to reverse declining wild fish stocks, and in parallel, complementary investments supporting small-scale aquaculture development. More than ever, a concerted effort from donors, the private sector, development partners, researchers, government institutions, and communities is needed to keep up the momentum of integrating fish into the development agenda to ensure a healthy and productive citizen.

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Data availability Data is available upon request.

Declarations

Competing interests The authors declare no competing interests.

References

Ahmad, N., Mahiyuddin, W., Mohamad, T., Ling, C., David, S., Hussein, N., Abdullah, N., Shaharudin, R., and L. Sulaiman. 2016. Fish consumption pattern among adults of different ethnics in Peninsular Malaysia. *Food & Nutrition Research 60*. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4989178/. Accessed 5 Feb 2018.

Aung, Yee Mon, Ling Yee Khor, Nhuong Tran, Michael Akester, and Manfred Zeller. 2022. A disaggregated analysis of fish demand in Myanmar. *Marine Resource Economics* 37: 467–490. https://doi.org/10.1086/721054. Accessed 3 Apr 2022.

Ba A, Schmidt J, Deme M, Lancker K, Chaboud C, Cury P, Thiao D, Diouf M and Brehmer P. 2017. Profitability and economic drivers of small pelagic fisheries in West Africa: a twenty year perspective. *Marine Policy 76*, 152–158. https://www.sciencedirect.com/science/article/abs/pii/S0308597X16305462. Accessed 3 Dec 2021.

Belton, B. and Fang, P. 2022. Livestock, capture fisheries, and aquaculture in Myanmar: status and recent trends. Myanmar Strategy Support Program Working Paper 20. Washington D.C.: International Food Policy Research Institute (IFPRI). https://doi.org/10.2499/p15738coll2.135940. Accessed 23 Aug 2022.

Belton B, and Thilsted S. 2014. Fisheries intransition: food and nutrition security implications for the global South. *Global Food*

Security 3: 59–66. https://www.sciencedirect.com/science/article/pii/S2211912413000515. Accessed 14 Dec 2017.

Belton B, Karim MI, Thilsted S, Murshed-E-Jahan K, Collis W, & Phillips M. 2011. Review of aquaculture and fish consumption in Bangladesh. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.593.5876&rep=rep1&type=pdf. Accessed 3 Dec June 2017.

Belton, B., Hein, A., Htoo, K., Kham, L.S., Nischan, U., Reardon, T., Boughton, D. 2015. Aquaculture in transition: value chain transformation, fish and food security in Myanmar. International Development Working Paper 139. Michigan State University, East Lansing.

Belton, B., M. Marschke, and P. Vandergeest. 2019. Fisheries development, labour and working conditions on Myanmar's marine resource frontier. *Journal of Rural Studies* 69: 204–213. https://doi.org/10.1016/j.jrurstud.2019.05.007.

Belton B, Johnson D, Thrift E, Olsen J, Hossain M, and Thilsted S. 2022. Dried fish at the intersection of food science, economy, and culture: a global survey. Fish and Fisheries. https://doi.org/10.1111/faf.12664.

Bogard J, Hother A, Saha M, Bose S, Kabir H, Marks G, & Thilsted S. 2015. Inclusion of small indigenous fish improves nutritional quality during the first 1000 days. *Food and Nutrition Bulletin 36*(3), 276–289. http://pubs.iclarm.net/resource_centre/WF-3882.pdf. Accessed 1 May 2017.

Bogard J, Marks G, Mamun A, and Thilsted S. 2017. Non-farmed fish contribute to greater micronutrient intakes than farmed fish: results from an intra-household survey in rural Bangladesh. *Public Health Nutrition 20*(4): 702–711. https://www.ncbi.nlm.nih.gov/pubmed/27702421. Accessed 28 Apr 2017.

Bradley B, Byrd KA, Atkins M, Isa SI, Akintola SL, Fakoya KA, Henrietta Ene-Obong, Thilsted SH. 2020. Fish in food systems in Nigeria: a review. Program report. https://digitalarchive.worldfishcenter.org/handle/20.500.12348/4210. Accessed 10 Apr 2022.

Brody, J. and R. Rudel. 2003. Environmental pollutants and breast cancer. *Environmental Health Perspectives*. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1241551/pdf/ehp0111-001007.pdf. Accessed 23 Aug 2022.

Exeter, Owen M., Thaung Htut, Christopher R. Kerry, Maung Maung Kyi, Me'ira Mizrahi, Rachel A. Turner, Matthew J. Witt, and Anthony W. J. Bicknell. 2021. Shining light on data-poor coastal fisheries. Frontiers in Marine Science 7: 625766. https://doi.org/10.3389/fmars.2020.625766.

Food and Agriculture Organization of the United Nations. 2019. Official presentation of the results of the 2018 fishery resources and ecosystem surveys in Myanmar waters. https://www.fao.org/in-action/eaf-nansen/news-events/detail-events/en/c/1254014/. Accessed 3 Nov 2021.

Food and Agriculture Organization of the United Nations. 2020. The State of World Fisheries and Aquaculture 2020. Sustainability in action. Rome: FAO. https://www.fao.org/documents/card/en/c/ca9229en. Accessed 23 June 2020.

Genschick S, Marinda P, Tembo G, Kaminski A, and Thilsted S. 2018. Fish consumption in urban Lusaka: the need for aquaculture to improve targeting of the poor. Aquaculture 492: 280–289. https://www.sciencedirect.com/science/article/abs/pii/S0044848617316186. Accessed 22 June 2018.

Garaway, C., and R. Arthur. 2019. Measuring fish catch and consumption: practical methods for small-scale fisheries based on length as an alternative to weight-based approaches. *Fisheries Management and Ecology* 27: 270–278. https://doi.org/10.1111/fme.12409.

Gephart, J., P. Henriksson, R. Parker, A, Shepon, K. Gorospe, K. Bergman, G. Eshel, C. Golden, B. Halpern, S. Hornborg, M. Jonell, M. Metian, K. Mifflin, R. Newton, P. Tyedmers, W. Zhang, F. Ziegler, Troell M. 2021. Environmental performance of blue foods. *Nature.* 597. https://doi.org/10.1038/s41586-021-03889-2.

Gibson RS & Ferguson EL. 2008. An interactive 24-hour recall for assessing the adequacy of iron and zinc intakes in developing countries. Washington D.C. http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/128218. Accessed 1 Dec 2018.

Gomna, A., and K. Rana. 2007. Inter-household and intra-household patterns of fish and meat consumption in fishing communities in two states in Nigeria. British Journal of Nutrition. https://doi.org/10.1017/S0007114507201734.

Hosch, G., B. Belton, and G. Johnstone. 2021. Catch and effort trends in Myanmar's offshore fleets operating out of Myeik - 2009–2018. *Marine Policy* 123: 104298.

IBM Analytics. 2018. IBM SPSS Software. https://www.ibm.com/analytics/data-science/predictive-analytics/spss-statistical-software. Accessed 12 Nov 2021.

Joffre, O., and M. Aung. 2014. Fishery value chain analysis in Rakhine State Assessment for village level interventions. Study conducted for the Tat Lan Project. Technical report. https://www.researchgate.net/publication/263320043_Fishery_Value_Chain_Analysis_in_Rakhine_State_Assessment_for_village_level_interventions. Accessed 31 July 2018.

Karim M, Hadayet U, Castine S, Islam M, Jan Keus H, Kunda M, Thilsted S, & Phillips M. 2016. Carp–mola productivity and fish consumption in small scale homestead aquaculture in Bangladesh. Aquaculture International https://link.springer.com/article/https://doi.org/10.1007/s10499-016-0078-x.

Lambrecht I, and Mahrt K. 2019. Gender and assets in rural Myanmar: a cautionary tale for the analyst. Discussion Paper IFPRI Discussion Paper 01894; p. 29. https://doi.org/10.2499/p15738coll2.133533.

Lin ST, Belton B & Khaing WW. 2022. Myanmar dried fish consumption survey. Working paper. https://driedfishmatters.org/blog/dried-fish-consumption-in-myanmar/. Accessed 24 Oct 2022.

Mamane, A., I. Baldi, J. Tessier, C. Raherison, G. Bouvier. 2004. Occupational exposure to pesticides and respiratory health. European Respiratory Review 24. https://err.ersjournals.com/content/24/136/306?ctkey=ERRtw006014. Accessed 21 Aug 2022.

[MAPSA]. 2021. Livelihoods, poverty, and food insecurity in Myanmar: household survey evidence from May 2021. Working paper. Yangon: IFPRI https://doi.org/10.2499/p15738coll2.134444.

Molsa H, Reynolds JE, Coenen EJ and Lindqvist OV.1999. Fisheries research towards resource management on Lake Tanganyika. Hydrobiologia https://doi.org/10.1023/A:1003712708969.

Ministry of Health and Sports. 2018. Myanmar micronutrient and food consumption survey. Interim Report. Nay Pyi Taw: Ministry of Health and Sports. https://www.mohs.gov.mm/page/7339.

Myanmar Times. 2017. Spot Checks by FDA to ensure safe products. Myanmar Times. https://www.mmtimes.com/national-news/26033-spot-checks-by-fda-to-ensure-safe-products.html. Accessed 30 Aug 2017.

[Myanmar Nutrition in Emergencies Working Group].2020. Nutrition-sensitive guidance in the context of COVID 19 in Myanmar. https://www.lift-fund.org/en/nutrition-sensitive-guidance-context-covid-19-myanmar. Accessed 17 Jan 2022.

Nway H, Htoo K, Griffiths D, Rizaldo Q and Khaing W.W. 2021. Report on piloting a low-cost portable fish drier and food safety test results of powdered dried fish. https://fish.cgiar.org/publications/report-piloting-low-cost-portable-fish-drier-and-food-safety-test-results-powdered. Accessed 5 Dec 2021.

Obiero, K., H. Waidbacher, B. Nyawanda, J. Munguti, J. Manyala, and B. Kaunda-Arara. 2019. Predicting uptake of aquaculture technologies among smallholder fish farmers in Kenya. *Aquaculture International* 27: 1689–1707. https://doi.org/10.1007/s10499-019-00423-0.

Okamoto, Ikuko. 2010. The movement of Rural Labor: a case study based on Rakhine State. In *Ruling Myanmar: from cyclone nargis to national elections*, eds. Cheesman, N., Skimore, M., and T.

Wilson. Singapore: Institute of Southeast Asian Studies. https://www.researchgate.net/publication/293185975_The_movement_of_rural_labour_A_case_study_based_on_Rakhine_State.

Rizaldo Q and Morris H. 2020. Dried small fish powder provides opportunity for child health in Myanmar. https://fish.cgiar.org/news-and-updates/news/dried-small-fish-powder-provides-opportunity-child-health-myanmar. Accessed 1 Dec 2020.

Rizaldo Q, and Weatherson J. 2018. Barrier analysis of fish consumption among under 5 year old children in Shwebo Township, Myanmar. http://www.dof-myanmar-fic.org/Multimedia/Research%20Reports/186.%20Nutrition%20Barrier%20Analysis%20Report_MYSAP%20Inland.pdf. Accessed 6 Aug 2019.

Roos N, Islam M and Thilsted S. 2003. Small indigenous fish species in Bangladesh: contribution to vitamin A, calcium and iron intakes. The Journal of Nutrition. 4021S-4026S. https://www.ncbi.nlm.nih.gov/pubmed/14672305. Accessed 9 Dec 2017.

Scott, J.M., Belton, B., Mahrt, M., Thilsted, S.H., and J. Bogard. Forthcoming. Food systems transformation, animal source food consumption, inequality, and nutrition in Myanmar. Unpublished manuscript.

Shinn A. 2020. Screening of fish and shrimp-based pastes for the presence of parasites: an analyis of pastes from Myanmar. MYSAP report. Yangon: Fish Vet Group Asia Ltd. https://fish.cgiar.org/publications/screening-fish-and-shrimp-based-pastes-presence-parasites-analysis-pastes-myanmar. Accessed 4 Mar 2020.

Sigh S, Roos N, Sok D, Borg B, Chamnan C, Laillou A, Dijkhuizen M, and Wieringa F. 2018. Development and acceptability of locally made fish-based, ready-to-use products for the prevention and treatment of malnutrition in Cambodia. *Food and Nutrition Bulletin 39*(3):420–434. https://doi.org/10.1177/0379572118788266.

So-Jung Y, Scott J, van Asselt J, Belton B, Taylor W and Lupi A. 2018. Determining the role of wild-caught and aquaculture-based inland fisheries in meeting Burma's human nutritional needs. Research Project Investigations: Human Nutrition and Human Health Impacts of Aquaculture. https://aquafishcrsp.oregonstate.edu/sites/aquafishcrsp.oregonstate.edu/files/16hhi05ms_fir_tr16-18.pdf. Accessed 30 Apr 2019.

Tezzo, X., H.M. Aung, B. Belton, P. Oosterveer, and S.R. Bush. 2021. Consumption practices in transition: Rural-urban migration and the food fish system in Myanmar. *Geoforum* 127: 33–45.

[UN Nutrition]. 2021. The role of aquatic foods in sustainable healthy diets. Discussion Paper. Rome: UN Nutrition. https://www.unnutrition.org/wp-content/uploads/FINAL-UN-Nutrition-Aquatic-foods-Paper_EN_.pdf. Accessed 28 Oct 2021.

von Braun J, Afsana K, Fresco L, and Hassan M. 2021. Food systems: seven priorities to end hunger and protect the planet. Comment. https://www.nature.com/articles/d41586-021-02331-x. Accessed 25 Oct 2021.

Willett W, Rockstrom J, Loken B, et al. 2019. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. *The Lancet Commissions*. https://doi.org/10.1016/S0140-6736(18)31788-4.