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ORIGINAL PAPER

Fish consumption pathways and food security in an Indonesian fishing community

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Abstract

Coastal communities in Indonesia are often prone to food insecurity because they are highly dependent on fisheries for income and subsistence. However, connections between fish and food security have received limited attention in the national fisheries discourse; Indonesian fisheries are managed according to production-based indicators, despite the important roles that access and distribution play in mediating how fish are used and valued. Combining value chain analysis (VCA) and a "fish as food" framework, we administer survey interviews to members of a small Indonesian fishing community regarding species catch, on-island exchange of fish, and the role of fish species in the broader diet. Our mixed-methods approach and data aim to characterize links between fish harvest and consumption. Two questions guide the research: i) How do the island's fisheries influence access to fish for household consumption? ii) What defines fish dependency in this community? Our findings indicate that island harvest and consumption are dominated by small pelagic species caught by commercial crews; however, small-scale fishers play a key role in providing fish during low catch periods. Catch and consumption are seasonally dependent: households reduce their fish consumption and substitute for less preferred farmed (milk)fish during windy seasons. Evidence of market-based fish trade and strong associations between dietary diversity and non-fish food groups suggest that food security in this community is more related to income from fishing than direct consumption of fish. To address the food security implications of fisheries management, there is a need for coordination among fisheries and public health sectors.

Keywords Fish trade · Spermonde · Indonesia · Food and nutrition security · Food systems · Marine conservation · Value chain

1 Introduction

Food insecurity and malnutrition affect more than a quarter of the global population (Bennett et al., 2018; Micha et al., 2020). A substantial body of evidence now points to fisheries as uniquely equipped to help address both issues; directly, by offering a crucial source of protein and micronutrients to billions of people worldwide (Allison, 2011; Kawarazuka & Bene; 2011, HLPE et al., 2014; Hicks et al., 2019), and indirectly by supporting the livelihoods of 10% of the global population (Bene et al., 2015). Additionally, in communities where livelihoods and consumption depend on marine resources, fish is often a critical factor for culture, identity, and way of life (Bell et al., 2009; Sharma, 2011).

Beginning in the 1960s, Indonesia's government policies shifted fishing practices from subsistence, small-scale operations to commercialized endeavors for regional and global markets (Gorris, 2016). These changes, combined with rapid urbanization and development, spurred a nutrition transition characterized by cheap, processed foods (Lipoeto et al., 2013). Obesity and diabetes now pose significant challenges to the national health system in Indonesia (Gibson et al., 2020; Lipoeto et al., 2013; Roemling & Qaim, 2012). The contribution of fisheries, however, to food and nutrition security is indisputable: fish provide up to 54 percent of dietary

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animal protein and over 6 million people are employed in the fisheries sector (FAO, 2014). Several factors present risks to these benefits, including habitat degradation, destructive and overfishing, climate change, and foreign fleets engaging in illegal, unreported and unregulated fishing (Glaser & Glaeser, 2014; Muawanah et al., 2012; Prescott et al., 2015). Concerns over resource sustainability have motivated the goal of "managing marine resources for food security" in Indonesia's Medium Term Development Plan (Ayunda et al., 2018). Improved food security is also one of the higher-level target outcomes of the Coral Triangle Initiative (CTI), a partnership between conservation organizations and six nations committed to restoring coral reef health including Indonesia. However, fisheries management plans in Indonesia do not provide strategies for conceptualizing or meeting food security goals despite the increased attention on it as an outcome (Clifton & Foale, 2017; Foale et al., 2013).

Coastal communities in Indonesia are often prone to food insecurity because they are highly dependent on fisheries for income and subsistence (Bell et al., 2009; Glaser et al., 2015). Attempts to address coastal community vulnerability to food insecurity in Indonesia have fallen short of their intended outcomes in part because of the narrowly defined principles underlying management and conservation (Clifton & Foale, 2017; Foale et al., 2013; Gibson et al., 2020). One key assumption directing the discourse is that the availability of fish determines food security (Fiorella et al., 2014; Fabinyi et al., 2017). This assumption, however, ignores the roles that other dimensions of food security- access, utilization, and stability- play in mediating how fish are used and valued. For example, Indonesia's government maintains a strong focus on fish availability, employing production-based indicators such as fish price, catch volume, and income, despite the importance of distribution (i.e., trade within and outside local communities) and consumption (i.e., cultural traditions and nutrition) pathways to food security (McClanahan et al., 2013; Olson et al., 2014; Fabinyi et al., 2017; Tezzo et al., 2020). This is one example of a broader disconnect between fisheries and food security: when fish are viewed as resources to be managed rather than the varied roles fish play in livelihoods, nutrition, and culture, technical fishing restrictions become the central focus of management. That food security is defined by availability, access, and use characteristics directs us to consider not only the ways fish are produced, but also traded and consumed within communities and cultures.

To overcome the challenges of food security and malnutrition, researchers have argued for expanding the view of fisheries not just as the outcome of common pool resource management (McCay & Acheson, 1987), but as part of food systems (Clifton & Foale, 2017; Farmery et al., 2021). It is believed that food "systems thinking" best confers resilience and food security by addressing the "multi-functionality" (economic, social, cultural, and ecological aspects) of food through linkages between production and consumption (Farmery et al., 2021; Tlusty et al., 2019). Still today, fish are less featured in food systems discourse than land-based agriculture (Levkoe et al., 2017; Bene et al., 2019; FAO, 2020). The "fish as food" framework assists in filling this gap by conceptualizing fisheries from a food systems perspective, thereby broadening the applicability of fisheries research to include interconnected social, environmental, and economic outcomes (Farmery et al., 2021; Levkoe et al., 2017; Olson et al., 2014). Considering fish as *food* rather than just as resources to be managed requires a different set of values rooted in human rights to fish and equity at all stages of the supply chain (Levkoe, 2017; Lowitt et al., 2019). As an alternative to the production-based paradigm, the fish as food framing has the potential to address the complexity of food insecurity and malnutrition by considering a broader range of factors that affect access to fish and characterize fish dependence (e.g. relationships, traditions).

As conservation interventions and management seek to accomplish socio-economic objectives through marine protection, understanding the dynamics between production and consumption has never been more pressing (Mello et al., 2010; Bene et al., 2016). Value-chain analysis (VCA) can be a useful tool for examining how harvest-level indicators affect fish access and food security. Although VCAs are designed to assess barriers to livelihood benefits, few move beyond production performance indicators (i.e. income, fish volume, pricing) and value chain actors like fishers and their buyers (Bene et al., 2007; Bell et al., 2009; Thyresson et al., 2013; Kittinger et al., 2015; Rosales et al., 2017; Bennett et al., 2018). Such perspectives tend to exclude local distribution and consumption pathways (Bennett et al., 2021). If research is to shed light on the potential for conservation and management to achieve socio-economic outcomes, fish acquisition, consumption, relationships, and cultural preferences are key research gaps (Bennett et al., 2018; Noack & Pouw, 2015; Thilsted et al., 2016). How fish are valued and utilized has powerful implications for conservation and management interventions and the resulting social and ecological changes (Bene et al., 2016; Fabinyi et al., 2017); to the extent that fish are embedded in local economies, social, and cultural contexts, changes in their access can also affect social networks, and access to other staple foods (Bene et al., 2016; Fabinyi et al., 2017).

The fish as food framework has had limited empirical research to date, and most of the available data are regional or national in scale (Bell et al., 2009; Bene et al., 2016;

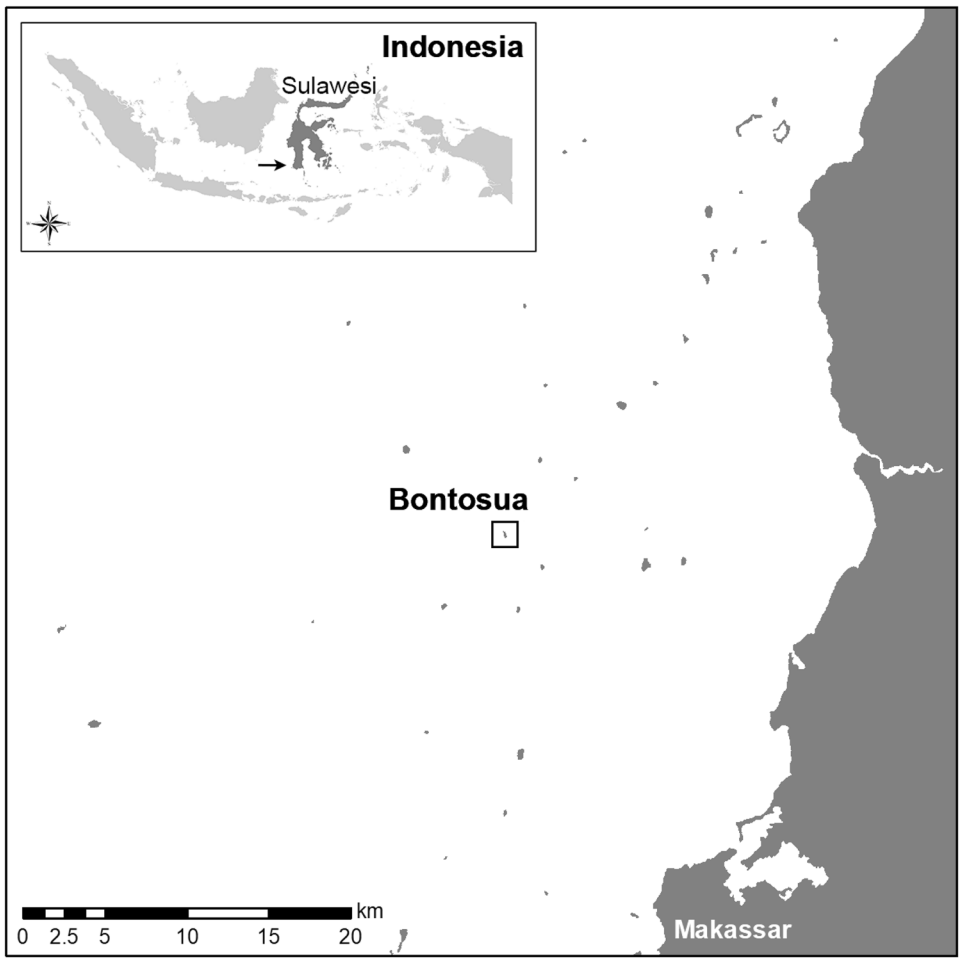

Fig. 1 Map of the study region of Sulawesi and the Spermonde Islands (shown by the arrow) with the study site of Bontosua Island labeled. Much of the fish caught by islanders on Bontosua is traded in regional fishing ports located in the city of Makassar

Levkoe et al., 2017; Lowitt et al., 2019). Thus far, research of this kind has revealed governance challenges brought on by a narrow focus on harvest in fisheries management, rather than social and cultural relations involved in distribution (Lowitt et al., 2019) Bene et al. (2016) argue that place-based studies are better able to capture the multidimensional pathways through which fisheries can contribute to food and nutrition security. Moreover, disaggregated fisheries data at the species level would help assess priorities in conservation, where coral reefs are the current focus in Indonesia. In this study, we use a mixed methods analysis to characterize the links between fish harvest and consumption in a small Indonesian fishing community. Two main questions guide the research: i) How do the island's fisheries influence access to fish for household consumption? ii) What defines fish dependence in this community? In addition to advancing the discourse of fisheries' contributions to food security and nutrition, our broader aim is to inform conservation and management strategies in the region that are more receptive to local values and needs.

2 Materials and Methods

2.1 Study site and context

The Spermonde Archipelago extends approximately 60 km offshore of Makassar in South Sulawesi Province, a popular port for the region's fish trade (Fig. 1). Out of the approximately 6,500 households dispersed throughout the islands, nearly all are involved in fishing full-time (Ferse et al., 2012; 2014). Fisheries are characterized by a variety in gear types and boats that target reef and pelagic areas (Glaeser et al., 2018). A number of intersecting issues have created a "perfect storm" for declining fisheries in the region: poor value chain governance and enforcement, the industrialization of fisheries, and destructive fishing practices (Deswandi, 2012; Gibson et al., 2020; Gorris, 2016). Although no empirical data exists on household diets in the Spermonde, the region's strong ties to urban development and globalization (Schwerdtner Mañez & Ferse, 2010; Sutherland, 2011) and nutritional outcomes from other Indonesian fishing communities (Gibson et al.,

2020) suggest that island diets in the Spermonde have been similarly affected.

The data collection for this study takes place on the island of Bontosua, located approximately one hour from the city of Makassar (Fig. 1). Nearly all of the 182 households rely on fishing as their primary source of income. The island's sandy topography combined with its small size makes other methods of income generation, including agriculture, scarce. Ferry transportation and food vending are some of the only viable alternative or supplemental livelihoods available to islanders. The retail sector employs adult women in Bontosua households, while the few men who are not involved in fisheries have the option of working as ferry operators. The people who live on Bontosua possess generational knowledge about fish trading, fish types, and foodways—the ways that foods are valued, acquired, prepared, and eaten. Fishers on the island catch and trade a variety of species that are retained locally or directed to the mainland city of Makassar. The island's diverse fisheries and proximity to a major trading center open up several pathways for household consumption of fish. Seasonality also plays a major role in fish availability on the island, as poor fishing conditions at certain times of the year reduce catch volumes. Fisheries serve myriad social and cultural functions (e.g., intergenerational knowledge transfer, spiritual customs) in places like the Spermonde with a traditional history of fishing and limited access to fresh foods (Lowitt et al., 2019).

2.2 Data collection

To quantify fish dependence, data on the frequency and volume of individual and household consumption of fish were collected in household surveys (Appendix 1; IRB reference number 1539056–1). Female heads of house were interviewed because they tend to make the majority of food decisions for households in Indonesia (Asmal et al., 2020; Gibson et al., 2020). The fieldwork took place from December, 2019 to February, 2020. We applied a stratified random sampling approach by island area, as it is known that different fishing groups reside on the north, south, east, and west of the island ($N=4$). Using a household list for each side of the island and a random number generator, we obtained a roughly even sampling of household types and reached a total of 62 households. Before the start of data collection, we spoke with a random subset of respondents following the same sampling strategy to identify general fish acquisition patterns, common dishes, and ingredients. These responses informed the finalized version of open and closed-ended survey questions. Surveys were administered by native-speaking Makassarese using paper and pencil. Consent was obtained verbally, and the interviewer took all notes. Women interviewed female heads of house due to gender norms. We piloted the questionnaire with over 10 participants before administering it and collecting data.

The final household surveys gauged access to and utilization of fish for consumption through questions on: i) acquisition pathways (i.e. on or off Bontosua, for free or payment), ii) fish types acquired and their prices, iii) relationships with sellers, iv) factors influencing the purchase decision, v) preference for consuming particular fish types, and vi) the role of fish species in the context of the entire diet. Dietary questions were formulated using the 24-h dietary recall method. For simplicity and accuracy, questions were framed to represent the diets of the individual respondents as opposed to households. The survey also included a food security scale to evaluate household socioeconomic status as it relates to food acquisition and consumption. Finally, to better contextualize the harvest-consumption link and illustrate how the value chain informs access to fish, survey responses on species-specific data and buying pathways were examined against the island's fish production and trade on Bontosua. This information was gathered through concurrent surveys administered to Bontosua fishers which examined fish consumption preference along with other parameters related to trade: i) fish price, ii) fish volume, iii) points of distribution, and iv) modes of production. The fisher surveys were administered using the same stratified sampling approach that was used to locate the female heads of house. Market prices were acquired from end traders in the city of Makassar's primary regional fishing port. A concurrent study by Roberts et al. (2022) covers more detail related to supplementary data collection for the fisher portion of the study.

2.3 Data analysis

All household survey data were transcribed and translated by enumerators before analysis in SPSS Version 26. A final check by project staff (that speak both Makasaresse and English) on the final translated version of the data ensured quality control was maintained during the translation. Frequency of fish consumption by species, seller identity, and fish preference in the consumer surveys were analyzed descriptively alongside fisher-trader parameters including frequency of harvest and trade by species, proportion retained for household consumption, and fish preference among fishers.

Utilization and stability dimensions were captured with the different components of the survey including a 24-h dietary recall, 7-day food frequency questionnaire (FFQ), and food security scale. We used the 24-h dietary to estimate dietary diversity (DD), an important indicator of micronutrient adequacy (Gibson et al., 2020). The FAO and FHI 360 (2016) guidelines categorize food into 10 food groups, each of which contribute to the overall dietary diversity. It is recommended that at least 5 food groups be consumed to achieve adequate micronutrient status, so this number served as our threshold (FAO & FHI

360, 2016). A food list created from the pre-survey conversations served as a guide to prompt participants in the event that they could not remember certain items that they ate. To minimize redundancy and burden on participants, responses for the 24-h recall were in the "I ate" format, and then later converted into "yes" and "no". This method also reduced recall bias on the part of the enumerator. This was followed by the FFQ, a method for assessing the nutritional status of populations with relatively homogenous food intake (FAO, 2018). Our study developed a quantitative FFQ with portion sizes in order to assess the contribution of fish to nutritional status. During the interviews, portion sizes were estimated with household dishware (e.g. plates, bowls) and commonly bought and consumed quantities (i.e. handfuls, bunches) and then converted to kilograms for analysis. Associations between the dietary diversity and food group consumption were tested with Chi-Square and Fisher's exact tests to evaluate whether dietary diversity score was dependent on a particular food group Fisher's exact tests are appropriate for small sample sizes.

We used the food security scale created by Tufts Nutrition (Nord et al., 2002). Their module adapted the U.S. Food Security Survey for low-income countries. In this variation, the 18-question U.S. module was modified to 11 questions to reflect seasonal disruptions to income in India. Similar natural shocks are present in the Makassar context during the "windy", or monsoon, season. Another modification made by Nord et al. (2002) to the U.S. Food Security Survey was the reduction of the reference period from 12 months to 30 days to improve recall accuracy. An introductory pilot survey was tested in November, 2019 with Bontosua households to ensure that the questions were understood. Each food security score was calculated based on the number of times a respondent answered affirmatively to a question, with each point representing one affirmative answer. The scores were then divided into three categories: food secure (0–1 with or without children), food insecure without hunger (2–4 with children, 2–3 without children), and food insecure with hunger (5 + with children, 4 + without children).

3 Results

3.1 Household fish consumption pathways

Survey sampling with female heads of house and fishers identified three main forms of fishing that supplied fish to Bontosua households: medium-sized vessels (~ 20 GT) (hereafter called crew boats) targeting pelagic fish with purse seine nets; independent fishing for pelagic or reef fish; and independent squid fishing in the nearshore pelagic areas. All independent fishers- an umbrella term which includes both individual pelagic/reef fishers and squid fishers operating single-person boats- are considered small-scale fishers in Indonesia because they operate vessels under 10 GT in size (De Alessi, 2017). A variety of fishing formats on the island allowed households to consume a wide range of species; 15 distinct reef species and 14 pelagic species were reported by Bontosua households. The following section highlights the 5 fish types consumed by households- small pelagic, large pelagic, reef, pelagic squid, and farmed- and the ways in which they were acquired during the calm (high catch) and windy (low catch) seasons (Table 1).

3.1.1 Calm season

Throughout the calm season, fish were mainly acquired for free through surplus catch from the island. Ninety-three

Table 1 Fish species included in the fish acquisition portion of the consumer surveys, stratified by fish type

Fish type	Fish species		
	Scientific name	Common name (English)	Common name (Makassarese)*
Small pelagic fish	*Rastrelliger kanagurta*	Long-jawed mackerel	*Banyara*
	Selar boops	Oxeye scad	*Katombo*
	Sardinella gibbosa	Goldstripe sardine	*Tembang*
	Decapterus macarellus	Mackerel scad	*Layang*
	Karalla dussumieri	Dussumier's ponyfish	*Bete-bete*
Large pelagic fish	*Sphyraena qenie/jello*	Pickhandle/blackfin barracuda	*Asa-asa*
	Katsuwonus pelamus	Skipjack tuna	*Cakalang*
Reef fish	*Siganus lineatus*	Golden lined spinefoot	*Baronang*
	Balistapas undulatus	Orange-lined triggerfish	*Papakulu*
	Unknown	Unknown	*Jannati*
Pelagic squid	*Loligo spp.*	Mixed pelagic squid	*Cumi teropong*
Farmed fish	*Chanos chanos*	Milkfish	*Bolu*

**Makassarese is the local language spoken in Makassar and on Bontosua Island*

percent of the fish consumed by weight across households consisted of fish caught by islanders and provided at no monetary cost (hereafter "shared") to the consumer, while only 7% was purchased from traders (who only sell but do not fish) or fishers (who fish and sell/share) on-island. Most of the on-island supply originated from crew boats, which harvested small and large pelagic species that totaled 78% of the island's total catch volume on a typical day in the calm season (Fig. 2). Independent fishers harvested the remaining catch, divided between small pelagic (2%) and pelagic squid (19%). No large pelagic species were reported in the small-scale catch. A small portion (3%) of the fish caught by Bontosua fishers was kept for daily household consumption and sharing in the calm season, while the rest (97%) was traded off-island or made available for on-island purchase (Fig. 2).

During the calm season, catch and consumption were mainly composed of small pelagic species. Fifty-eight percent of the total volume consumed by households (Fig. 3) and 48% of the total volume caught on Bontosua (Fig. 2) came from small pelagic fish. Additionally, the types of fish most commonly shared by fishers matched the two most consumed species: Long-jawed mackerel (*Rastrelliger kanagurta*; local name "banyara") and oxeye scad (*Selar boops*; local name "katombo"), both in the small pelagic fish group. Ninety-five percent of households ($N = 62$) reported consuming either or both of these species.

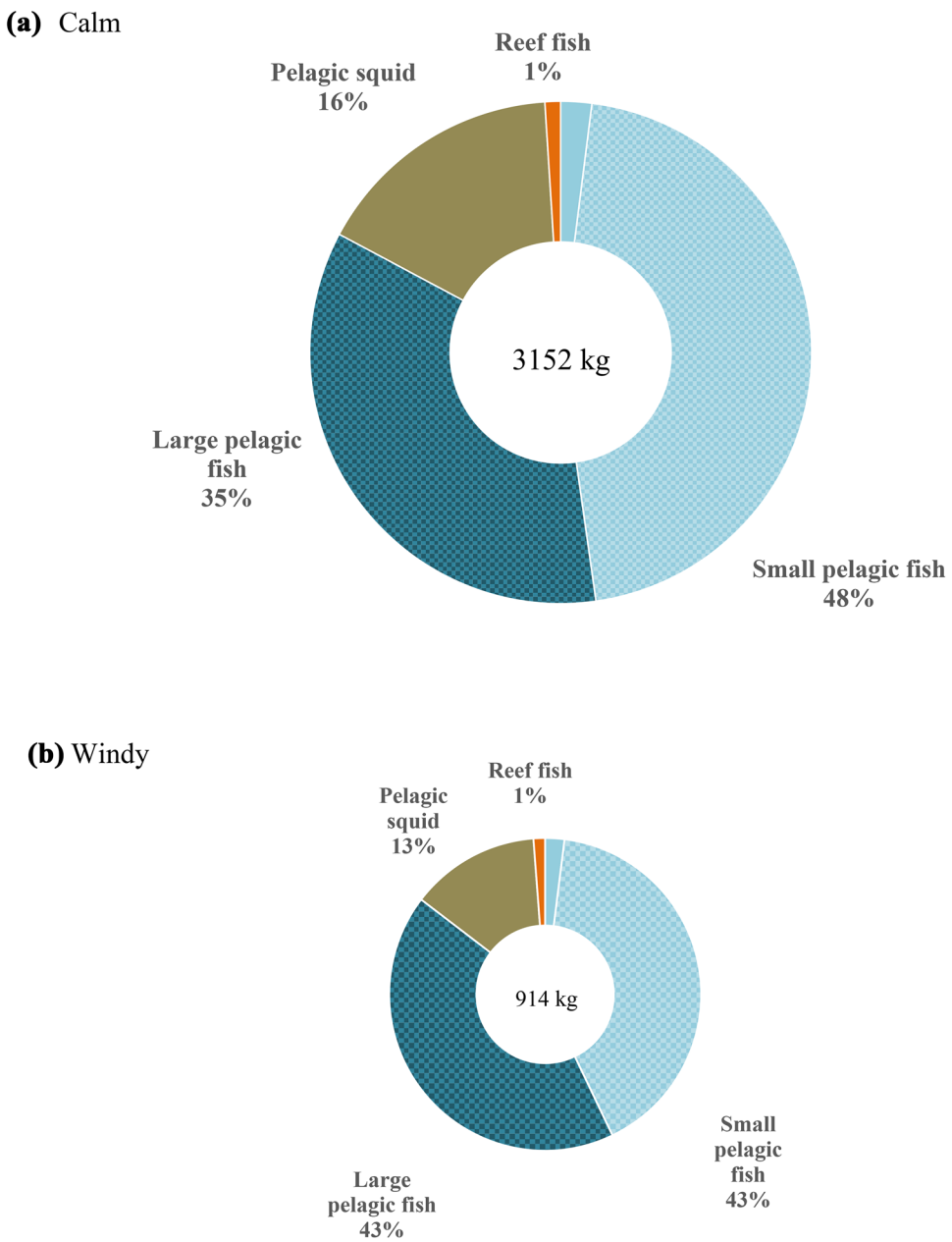

Fig. 2 Total amount by fish type captured by Bontosua fishing crews (patterned) and independent fishers (solid) on a typical day in the (**a**) calm and (**b**) windy seasons. Pie chart size is roughly proportional to the amounts harvested in either season

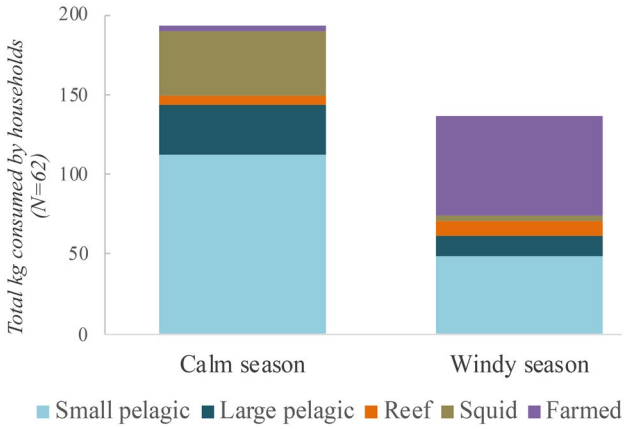

Fig. 3 Total amount of fish consumed, in kg, by surveyed households ($N=62$) on a typical day during the calm and windy season

Although large pelagic fish were ranked second in catch volume to small pelagic fish (Fig. 2), households derived their second largest portion of fish from the seasonal pelagic squid fishery (Fig. 3). Large pelagic species were the next most popular fish type (15% of the total amount consumed, Fig. 3; 35% of the total volume captured, Fig. 2), while reef fish was the least popular wild-caught fish type at 6% of the total volume consumed (Fig. 3) and 1% of the total catch (Fig. 2). Thirteen percent of households ($N=62$) had reported consuming reef species during the calm season.

3.1.2 Windy season

Consumption patterns and pathways shifted during the windy season as pelagic crews experienced a 71% decrease in harvest (Fig. 2). In this low catch period, overall consumption of wild captured fish decreased by approximately 60%, and total fish consumption decreased by 25% (Fig. 3). Small pelagic species remained the top species caught for consumption at 53% by volume. However, as surplus catch became scarcer, the average number of days per month that households bought fish increased significantly ($Z=-6.754$, $p<0.0001$) and 80% of the total catch consumed was purchased (Fig. 4). To fill the gap left by the loss of wild catch, islanders purchased a farmed fish called milkfish (*Chanos chanos*; local name "bolu") produced in fishponds on mainland Makassar; a majority of the purchased fish volume (54%, Fig. 4) and nearly half of the consumed volume (44%, Fig. 3) during this season consisted of milkfish. The only pathway households obtained this fish was through individual off-island traders who traveled to Bontosua on days where no fishing was anticipated. Similar to the calm season, the composition of consumed and caught fish differed. While equal parts large and small pelagic fish comprised the overall fish catch (Fig. 2), small pelagic fish made up a majority of the consumed wild-caught fish (66%) followed by large pelagic (15%), reef (15%), and pelagic squid (4%, Fig. 3).

Responses detailing the identity of on-island fish sellers revealed different origins for sale versus on-island sharing of wild-caught fish. While sharing appeared to be most common in pelagic fishing crews, sale of catches occurred mostly with independent fishers. With the exception of three buying interactions with crew members or independent collectors, all the purchasing of wild-caught fish involved independent fishers (Fig. 4). Most of the pelagic fish supplied to households (65%, Fig. 4) in the windy season came from sales with independent fishers, and over half of consumers (55%, $N=62$) purchased from them. Of the consumers who reported relying on sellers for fish ($N=34$), none reported pelagic crews or on-island traders, but 26% listed one or more independent fishers.

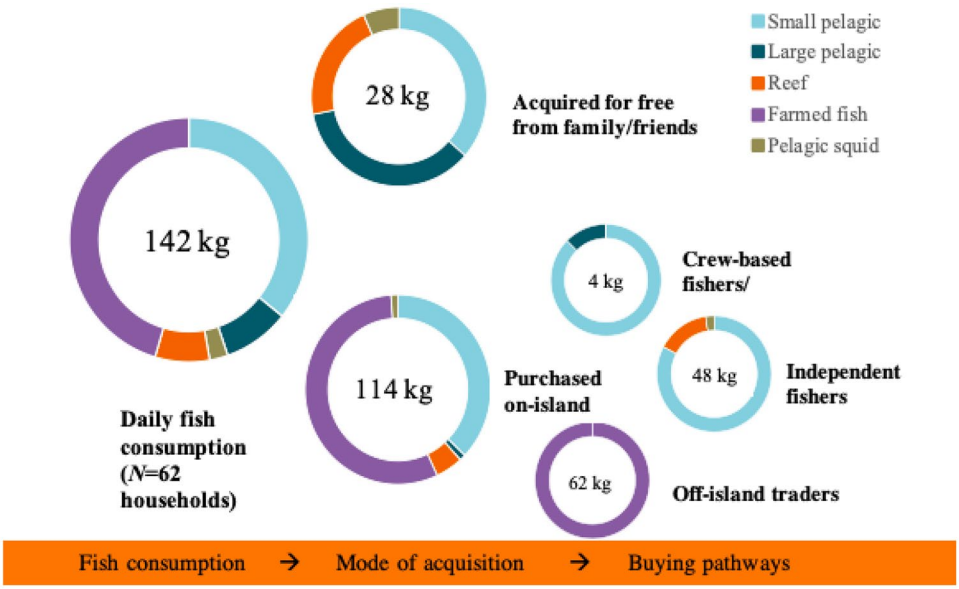

Fig. 4 The first pie chart shows the total amount of fish consumed by all households surveyed ($N=62$), in kg, on an average day during the windy season. All remaining pie charts represent the division of pathways summing to the total. Next, the pathways for acquiring the fish for households are shown with their relative proportion purchased versus acquired for free. The last three pie charts depict the relative proportion of fish purchased from various fishers and traders on the island. All pie charts are stratified by fish type

While reef fish consumption was negligible during the calm season, species of this type played a more substantial role during low catch periods. Thirty-nine percent ($N=78$) of regular buying interactions involved traders of reef fish, which included Bontosua reef fishers along with the outside traders who would also supply farmed milkfish. Only one wild-caught fish- a reef fish known locally as *jannati*- increased in the amount consumed and the number of consumers from the calm to windy season. The consumed amount increased sixfold (Fig. 3), and the number of consumer households increased from 3 to 16. The higher consumption level of this species was the main driver for an overall increase in reef fish consumption across households: from 8 households (13%) in the calm season to, 20 (32%) in the windy season. Conversely, the number of consumers eating pelagic fish reduced from 62 (100%) to 39 (63%) in the windy season.

3.2 Factors affecting household fish buying patterns

Both flexibility and need defined the buyer–seller relationships on Bontosua. A majority of consumers (55%)

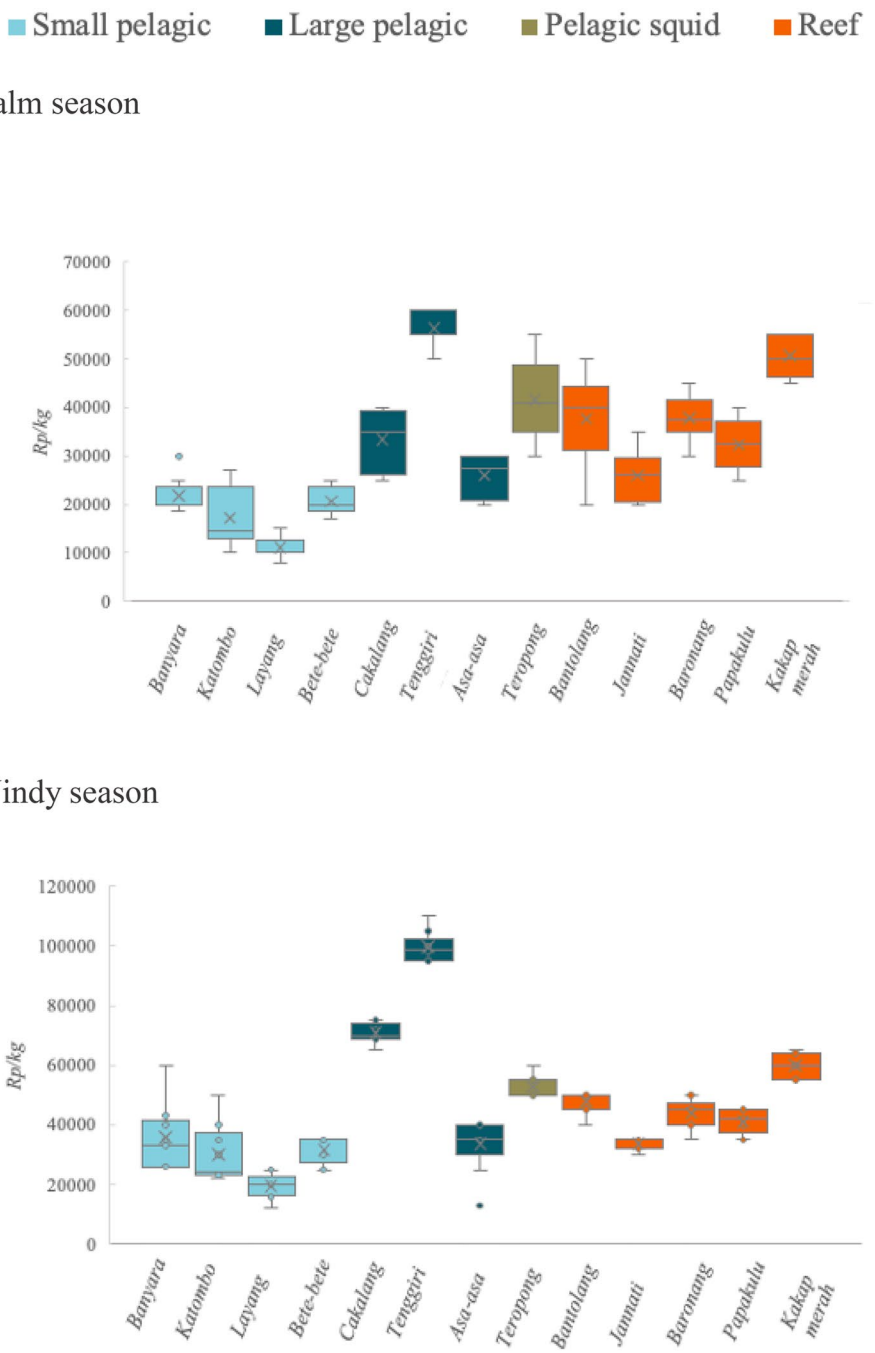

Fig. 5 Boxplots with median (horizontal line), mean (x), and quartiles (box ends) of market prices of fish species caught and/or consumed in the (**a**) calm and (**b**) windy season. Error bars represent one standard deviation from the mean

reported relying on one or more of their fish sellers to meet their daily needs. Of these, 74% were milkfish sellers and 26% were independent fishers. In all but one of these relationships ($N=32$), consumers would have felt able to replace the seller if a different seller offered a better price or assistance.

Most consumers (61%; $N=62$) adjusted their buying habits to changes in the price of fish. Coping strategies for when fish prices were high included buying cheaper kinds of fish (44%), reducing the amount of fish purchased (28%), or replacing fish with cheaper staples such as egg or noodles (28%). The most popular response to the question, "what factors affect which fish you buy?" was "no other options", an experience shared by 79% of respondents. Other constraints included price or income, which affected the decisions of 66% of respondents, and loyalty to sellers who are family or friends (16%). The preference-related factors included desire (24%) and taste (39%).

Households tended to purchase less expensive fish on the island. Small pelagic species had significantly lower average market prices during the calm (*Welch's F* (3, 31.98) = 52.98, $p<0.001$)) and windy (*Welch's F* (3, 47.57) = 49.76, $p<0.001$)) seasons (Fig. 5) than any other fish type caught on the island. Reef species were more expensive than pelagic fish ($p<0.001$) in the calm season. In the windy season, Games-Howell post hoc tests stratified each fish type by market price levels. Large pelagic species fetched the highest prices (68037 ± 28170 Rp), followed by squid (52778 ± 3632), reef (45833 ± 4618), and small pelagic species (28425.93 ± 10927) (Fig. 5). Windy season prices of large pelagic species were on average 28% more expensive than squid, 48% more expensive than reef, and 143% more expensive than small pelagic fish (Fig. 5).

3.3 Preference and importance of fish species to consumers

A fish ranking activity in the household surveys gauged the importance of fish species consumed by households to their eating habits. Consumers were asked to rank the species that they reported consuming as a household. Importance was left as subjective to the respondent; most women chose to evaluate each species based on taste (66%) or what was most often eaten in their household (19%) ($N=53$). Three small pelagic species- Long-jawed mackerel (*Rastrelliger kanagurta*; local name "banyara"), oxeye scad (*Selar boops*; "katombo"), and sardines (*Sardinella gibbosa*; local name "tembang")- had the highest average ratings (Fig. 6). These species were also the most popular, measured by the proportion of households who reported eating them on a typical day during the calm and/or windy season. The fourth most important species was a reef triggerfish (*Balistapas undulatus*; local name "papakulu"). Besides this one fish, most of the documented reef species were in the "least consumed" and "least important" quadrant (Fig. 6).

To the survey question, "do you prefer eating milkfish or wild-caught fish?", most women (74%) said wild-caught (Table 2). Negative attributes of milkfish given by women including high bone content (30%), high cholesterol (23%), and general dislike (13%) justified the preference for wild-caught fish. Other reasons included the cheap/free cost (15%), taste (15%), and custom (5%) associated with wild-caught fish. When asked to elaborate on which species they prefer over milkfish, all but four respondents out of 53 listed one or more commonly consumed small pelagic fish species. Two others included skipjack tuna (*Katsuwonus pelamus*; local name "cakalang"), a large pelagic species, and two

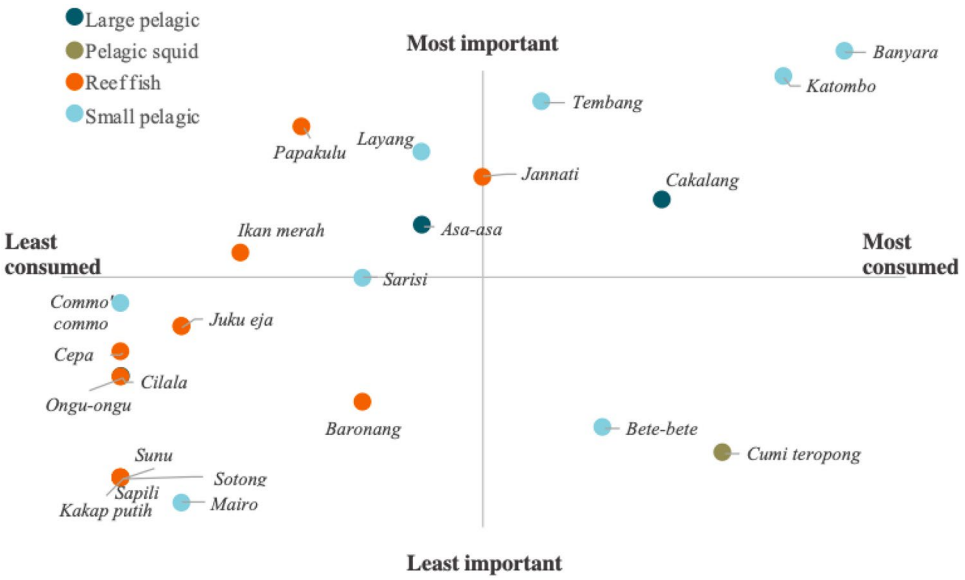

Fig. 6 Level of importance indicated by consumer rankings of fish consumed against the consumption level of the species (number of households consuming in either the calm or windy season). Importance was subjective; according to the survey notes, the ranking criteria used by respondents was based on taste or frequency of consumption

Table 2 Proportion of consumers ($N=62$) and fishers ($N=53$) on Bontosua who preferred eating wild caught to farmed fish, and the fish types that they included in their responses. The sample sizes for proportions preferred refers to the number of times that a species was mentioned in the consumer ($N=57$) and fisher ($N=66$) survey responses. Each respondent could list multiple species in their responses

Type of respondent	% who preferred wild caught to farmed fish	Proportion of wild-caught fish types preferred		
		Small pelagic	Large pelagic	Reef
Consumer	74%	91%	5%	4%
Fisher	91%	77%	13%	10%

listed one or more reef species (Table 2). When asked the same question, 91% of fishers ($N=53$) preferred consuming wild-caught fish. The main reason was taste (58%), followed by the dislike of high bone content in milkfish (15%), the "free" cost of wild-caught fish (15%), and health benefits compared to milkfish (10%). One individual mentioned that their avoidance of milkfish was due to "doctor's orders". Similarly, all but one respondent included small pelagic species in their preference list. Three respondents listed skipjack tuna (*Katsuwonus pelamus*; local name "cakalang") and two listed reef species (Table 2).

For a more granular characterization of fish buying decisions during the windy season, consumers were asked whether they bought more farmed fish or other types, and to explain their reasoning. A majority (63%) chose milkfish, with most (86%) doing so because it was the only fish available for purchase. For the remaining population (37%) who purchased other types of fish more often, a wider array of reasons were presented: preference for wild-caught fish/dislike for milkfish, cheaper prices, health, and unreliability of the milkfish sellers, who were not always able to travel to the island. A handful of respondents noted that milkfish was most expensive during the holidays and full moon when demand was high and fishing activity low. When asked if fishers ate milkfish on a regular basis, 90% responded affirmatively. Their reasons related mostly to their availability during the full moon (91%), when a majority of fishers on Bontosua did not fish.

3.4 Role of fish in diets and food security

The food frequency questionnaire (FFQ) and 24-h dietary recall identified fish as the most frequently consumed animal protein source (Fig. 7). Ninety-eight percent of women ($N=55$) had consumed fish in the last 7 days, and 69% had eaten fish in the previous 24 h. Egg was the next most common animal protein and was present in the diets of 80% of women heads of house in the last 7 days and 67% in the 24-h recall. Chicken and beef were consumed by fewer respondents (Fig. 7).

3.4.1 Individual consumption of fish species

The women surveyed had consumed a wide variety of fish species individually: on average, 2 (± 1.07) in the previous day and 7 (± 2.48) in the previous week. The most consumed fish species in the 7-day recall were small pelagic species and milkfish. Long-jawed mackerel (*Rastrelliger kanagurta*; local name "banyara") (44%), milkfish (*Chanos chanos*; local name "bolu") (43%), oxeye scad (*Selar boops;* local name "katombo") (38%), ponyfish (*Karalla dussumieri*; local name "bete-bete") (36%), and sardines (*Sardinella gibbosa*; local name "tembang") (22%) were most popular based on the proportion of consumers eating. Overall, 85% of women

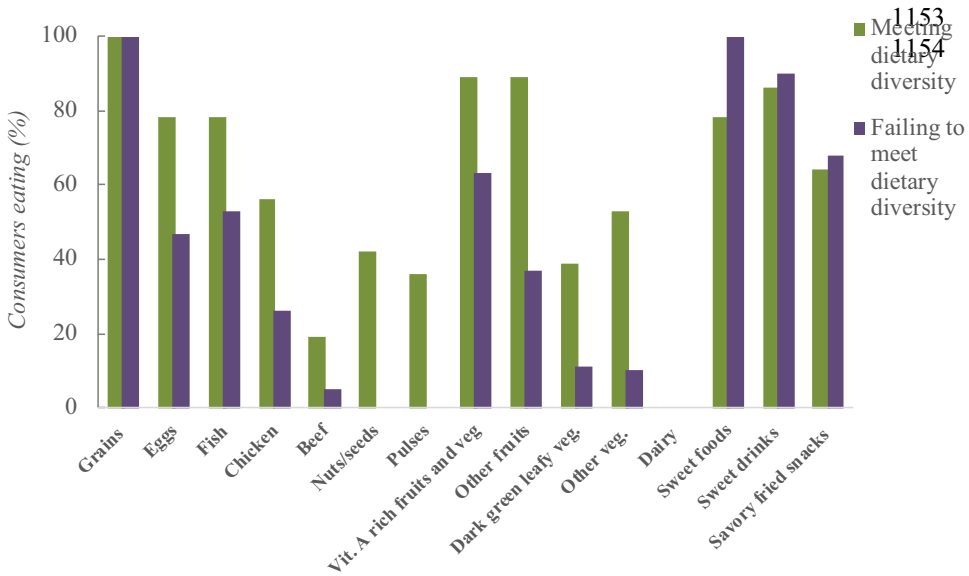

Fig. 7 Food groups consumed by consumers who had achieved dietary diversity ($N=36$) and those who had not ($N=19$). Results were based on a 24-h recall of food intake. The proportion of consumers is based on the N values for each group

Table 3 Association between consuming a food group ($N=55$) and achieving dietary diversity, with the food group "meats/poultry/fish" stratified into its subgroups. The "consumed and met" category is the proportion of those consuming the food group who achieved minimum dietary diversity (>4 food groups). The "not consumed and met" category is the proportion of those who did not consume the food group and achieved minimum dietary diversity. The odds ratio, CI, and p-value outputs are derived from Chi-square and Fisher's Exact tests

Respondent's consumption of _____ (Y/N) ($N=55$)	Consumed and met	Not consumed and met	Odds ratio	95% CI	*p* value
Vitamin A-rich fruits and vegetables (80%)	73%	36%	4.67	1.15–18.85	**0.035**
Other fruits (71%)	82%	25%	13.71	3.40–55.40	**< 0.001**
Fish (69%)	74%	47%	3.14	0.95–10.41	0.055
Eggs (67%)	76%	44%	3.89	1.18–12.85	**0.022**
Chicken (45%)	80%	53%	3.50	1.04–11.79	**0.049**
Beef (15%)	88%	62%	0.59	0.13–2.65	0.156
Other vegetables (38%)	90%	50%	9.50	1.91–47.27	**0.002**
Green leafy vegetables (29%)	88%	56%	5.40	1.08–27.09	**0.033**
Pulses (31%)	100%	55%	N/A	N/A	**0.006**
Nuts/seeds (27%)	100%	53%	N/A	N/A	**0.001**

**Confidence intervals and odds ratios could not be generated for consumption of nuts/seeds and pulses*

had eaten small pelagic fish, 5% had eaten large pelagic fish, and 42% had eaten milkfish in the previous week. Reef fish had been consumed by 14% of women, amounting to 4% of the total volume. In the 24-h period, the most consumed fish products were sardines (*Sardinella gibbosa*; local name "tembang") (41%) and dried fish (28%) based on the proportion of women eating fish. Only 15% had eaten milkfish, 13% had eaten long-jawed mackerel (*Rastrelliger kanagurta*; local name "banyara"), and 18% had consumed ponyfish (*Karalla dussumieri*; local name "bete-bete").

3.4.2 Contribution of food groups to dietary diversity

According to the 24-h recall, 65% of women had achieved dietary diversity, defined as consuming more than four food groups in a 24-h period (Fig. 7). All respondents had eaten rice, a component of the "grains" food group. Other food groups eaten by the majority included meats/poultry/fish (85%), vitamin-A rich fruits (80%), other fruits (71%), and eggs (67%). Other vegetables (38%), green leafy vegetables (29%), nuts/seeds (27%), and pulses (24%) were less common in the diet (Fig. 7). No respondent had eaten dairy.

A majority (> 50%) of the respondents who had achieved dietary diversity consumed seven food groups, compared to three food groups for the inadequate dietary diversity respondents, when considering meat/poultry/fish separately (Fig. 7). Three food types were staples across both groups: grains, vitamin A-rich fruits and vegetables, and fish. Chi-square and Fisher's exact tests showed that consuming each of the food groups ($p=0.156$, Chi-square test, Table 3) improved the likelihood of meeting dietary diversity, except for beef. Seventy-four percent of those who consumed fish achieved dietary diversity compared to 47% of those who did not (Fig. 7), a difference that was weakly significant ($p=0.055$, Chi-square test, Table 3). Food groups with the strongest association to achieving dietary diversity included other fruits, other vegetables, and green leafy vegetables (Table 3). Based on the odds ratio, those who ate other fruits were nearly 14 times more likely to meet the minimum dietary diversity requirements than those who did not include it in their diet. Consumption of nuts/seeds ($p=0.001$, Fisher's exact test, Table 3) and pulses (i.e. legumes) ($p=0.006$, Fisher's exact test, Table 3) was highly significant in meeting dietary diversity, however confidence intervals could not be generated because the category of those who failed to meet dietary diversity and achieved minimum dietary diversity had no respondents. For the food group categories not included in dietary diversity, sweet foods had a significant negative association with achieving dietary diversity ($p=0.040$, Fisher's exact test, Table 3), while savory foods ($p=1.00$, Fisher's exact test, Table 3) and sweet drinks ($p=1.00$, Fisher's exact test, Table 3) were not statistically significant.

Just over half of the population (58%) had experienced some form of food insecurity in the previous 30 days (Fig. 8). Forty percent could be classified as having "food security without hunger", or exhibiting low food security, while 18% had "food security with hunger", or very low food security. This meant that 42% were "food secure", or had high food security (Fig. 8). When asked to classify their family's consumption habits in the previous 30 days, most (74%) chose the statement "enough but not always the kinds of foods we want". Twenty-four percent believed that they had enough of the kinds of foods they wanted, while only one individual classified their household's eating habits with

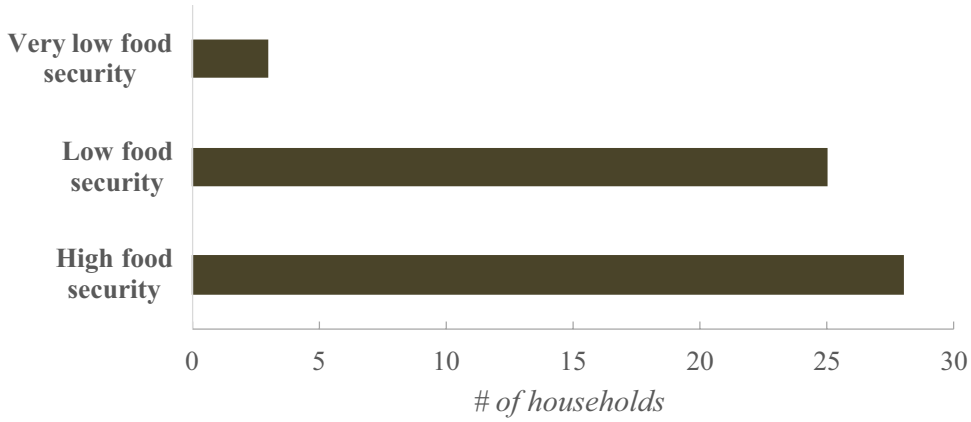

Fig. 8 Level of food security experienced by households ($N=62$) in the previous thirty days

the phrase "sometimes not enough to eat" (Fig. 8). Just over half (54%, $N=61$) of women reported spending 65% or more of their income on food, placing them in the "high to very high" category for expenditures. A minority of women (46%, $N=61$) had medium or low average expenditure.

4 Discussion

Managing fisheries for food security will become increasingly necessary as trends continue toward environmental degradation, marine use conflicts, and increasing reliance on fisheries for coastal developing communities (McClanahan et al., 2013; Paddock, 2017). The ways in which fisheries are embedded into households and communities have important implications for the strategies offered to protect and improve food security. Numerous studies point to the importance of fishing as a livelihood for coastal communities in the Spermonde region of Indonesia (Deswandi, 2012; Ferse et al., 2014; Nurdin & Grydehoj, 2014; Glaeser et al., 2018); to our knowledge, this study is the first to document the specificities of Spermonde fisheries and their cultural dietary importance to community. By illustrating local pathways from catch to consumption, we have provided a baseline understanding of fish access and utilization at the island level. Our findings concur with studies in other small fishing communities based on high consumption of lower-value species (Adhuri et al., 2016; Glaeser et al., 2018; Gibson et al., 2020), subsistence pathways (Bell et al., 2009; Gibson et al., 2020; McCoy et al., 2018), and the responsibilities of women in procuring household nutrition (Gibson et al., 2020; Harper et al., 2017). To this body of data, we have added richness by identifying three main characteristics that define on-island fish acquisition and dependence: i) dominance of small pelagic species, ii) seasonal dynamics and importance of small-scale fishers, and iii) participation in the market economy. This evidence points to the need to elicit multi-directional relationships between production, provisioning, consumption (Tezzo et al., 2020). A strong understanding of fish pathways to household consumption is essential for adequately addressing the food security goals on the island of study and for island communities in the Spermonde region more generally.

4.1 Role of small pelagic and farmed species

A production-based focus on fisheries tends to obscure access and utilization dimensions of food security (Kawarazuka & Bene, 2010; Tezzo et al., 2020). This is no exception in Indonesia where there exists a lack of data on fish consumption by species (Gibson et al., 2020, 2021). Study indicators on catch, acquisition, and consumption show that small pelagic species are dominant on the study island. This is motivated by the activity of pelagic fishing crews using purse seines, which landed small pelagic species in higher numbers than independent fishers on the island. The contribution of fishing crews to subsistence is also substantial; two species of fish commonly caught by crew-based fishers—long-jawed mackerel (*Rastrelliger kanagurta*) and oxeye scad (*Selar boops*)– were reported more often to be kept for at-home consumption than any other fish species. The patterns are representative of other studies depicting purse seine fisheries as the most productive and popular fishing modes in Indonesia (Nelwan et al., 2020; Pet-Soede et al., 2001).

In the windy season, small pelagic species continued to be important to the island's catch. However, islanders shifted consumption in response to reduced fish volume. Farmed milkfish comprised nearly half of all fish consumed by surveyed households- a dependence noted anecdotally in the Spermonde, but never quantified (Deswandi, 2012; Ferse et al., 2012). While our study documented one farmed fish species on a single island, similar patterns on neighboring islands with other species are plausible. Since community members rely on a single seller for most of their farmed fish, other fishing communities could have agreements with their own sellers who deliver certain species. Such research would allow policymakers to

envision farmed fish in a food-secure future for coastal Indonesia – a critical consideration as fisheries across Indonesia face declines that are expected to have widespread socioeconomic impact (Warren & Steenbergen, 2021).

Even with the high level of milkfish consumption in this community, most women and fishers preferred eating pelagic fish and considered those species most important. Reasons provided for this preference included taste and texture, health, and affordability. Meanwhile, importance was based on taste and availability. Additional evidence supports several community perspectives provided in the study. For instance, low market price is one of the most cited factors driving widespread consumption of small pelagic species in other developing coastal states (Thyresson et al., 2013; Belton & Thilsted, 2014; Adhuri et al., 2016). Small pelagic species have also been recognized for their nutritional role in low-income countries like Indonesia where micronutrient deficiencies (e.g. iron, vitamin A) are a concern, as many contain higher levels of iron, calcium, zinc, and vitamin A compared to larger farmed and wild species (Kawarazuka & Bene, 2011; Reksten et al., 2020). Even though milkfish is a popular food fish in Indonesia, only one Indonesian study has assessed its micronutrient content (Malle et al., 2019), and to our knowledge there are no comparative studies. Milkfish is one of the most popular fish species for low-income households in the Philippines, a neighboring country (Salayo, 2010); however, the value chain analyses performed there are aimed at production parameters, which limits conclusions that can be drawn about their nutritional value to coastal communities (Roxas et al., 2017; Salayo et al., 2021). Given that aquaculture production is expected to overtake Indonesian capture fisheries by 2030 (Tran et al., 2017), research on access parameters of farmed milkfish in Indonesia is warranted. Future research would also benefit from a greater understanding of the cultural, nutritional, and social values assigned to milkfish, as they can play an important role in shaping localized consumption patterns (Noack & Pouw, 2015).

4.2 Importance of season for on-island food provisioning

We pay additional attention to the windy season since this is the most vulnerable time for fisheries harvest and overall nutrition on the island. A 71% decline in harvest leaves little surplus for on-island subsistence, thus shifting acquisition patterns to purchasing over sharing. To supplement the loss of free catch from fishing crews during this time, two main actors—milkfish sellers from Makassar and on-island independent (reef) fishers- sold most of the fish consumed by households. While independent fishers targeting pelagic and reef fish harvested only 3% of the total Bontosua catch on a typical day during the windy season, they sold nearly 40% of the fish eaten by households. Many women reported relying on milkfish sellers, but their buying ties were fluid: only one respondent reported being unable to switch to another seller. For those remaining, most would buy from another seller if there were other sellers or if a milkfish seller did not arrive on the island that day. The general feeling among most consumers (75%), however, was that there was not enough variety in the fish available for sale.

As shown in this study, seasonal conditions make disaggregating catch across time paramount. Due to resource constraints, all surveys were performed at one time point and captured comparative seasonal data with estimates. Time-series scales with repeated surveys during the calm and windy seasons would have achieved more accurate results (FAO, 2018). Furthermore, since households were asked to list all the species they consumed on a typical day in each season, it is likely that the absolute amounts acquired were overestimated. We attempted to account for this discrepancy by gathering data on individual fish consumption in a 7-day period, but the recalls relied on memory. Other factors leading to misestimation include portion size estimation by participants, as social desirability for healthy or unhealthy foods could have resulted in inaccurate portion sizes. Participant observation of meals and meal types could have eliminated some of this potential bias. Similarly, buyer–seller interactions were documented through recounts with women heads of house, rather than observing interactions as they occurred. Building from this research, ethnographic studies could capture the real-time complexities inherent to buying, sharing, and consumption of fish on the island that were beyond our scope (Garcia Rodrigues & Villasante, 2016; Noack & Pouw, 2015).

4.3 Participation in the market economy

Coastal developing states often exhibit mixed modes of reliance on fish ranging from subsistence to market-based (O'Garra, 2012; Kittinger et al., 2015; Charlton et al., 2016). In some Pacific Island settings, for example, only a small fraction of catch goes to market (Bell et al., 2009). On the other hand, a common feature among full-time fishing households is that fishing is more associated with a market economy than subsistence. The reason is two-fold: fishing households cannot only live on fish (Fabinyi et al., 2017), and market pressures encourage sale (Brewer, 2011; Thyresson et al., 2013; Ferse et al., 2014). Resource-dependent communities such as Kenya (Fiorella et al., 2014) and the Philippines (Fabinyi et al., 2017) have fishing economies with similar attributes. That ability to sell fish and buy other foods is what defines food security on the study island.

Consumption data confirm that fish are a staple item in household diet. They represented most of the animal source protein consumed at the household and individual level during the 7-day recall. Even with the surveys occurring in the

windy season, women reported consuming two times more fish than the national average (KKP, 2018). Yet, the consumption of fish was only weakly associated with achieving dietary diversity. Stronger associations with other food groups, and their relative scarcity in household diets, suggests that access to fish is not at risk in this community; rather, the ability to access other foods with income may be crucial for improving food security indicators. Like other tropical locations such as Kenya (McClanahan et al., 2013) and Pacific Island communities (Charlton et al., 2016; Corsi et al., 2008), plant sources of protein, including legumes and nuts/seeds, were far less common in Bontosua diets. These and other nutritionally dense food groups including green leafy vegetables are only available for sale on the mainland of Makassar, a trip that takes up to 2 and a half hours each way by ferry. Aside from fish, the only on-island offerings consist of cheaper packaged sweets and fried snacks. Given these access barriers, the negative association found between eating sweet foods and achieving dietary diversity is concerning but expected. Diet transformations in coastal communities are highly relevant, as food security rests not only on access to sufficient food, but nutritious food.

Only around 5 to 10% of the total catch on Bontosua was shared on-island or kept for consumption. Several pieces of evidence help to explain this low level of subsistence. According to our price analysis in Makassar markets, the community's least consumed fish types- reef, pelagic squid, and large pelagic- were more expensive than small pelagic species. Large pelagic fish- the most expensive of the types analyzed- made up a larger proportion of catch than consumption. Across the Spermonde and other areas of Indonesia (Ferse et al., 2012, 2014; Adhuri et al., 2016; Fabinyi et al., 2017; Glaeser et al., 2018), the sale of high-value fish is a strong indicator of market-based trade. This market pattern and orientation towards high-volume, commercial crew-based fisheries also fits with Indonesia's political history. During the nation's bid to grow their global fish trading capacity in the 1960s and 70 s, subsidies began to squeeze out subsistence-based small-scale fisheries in favor of high-volume purse seine fleets (MacFadyen & et al., 2002; Deswandi, 2012; Prescott et al., 2015). Despite this shift, small-scale subsistence fishers still play an important role by providing fish diversity to local communities and during times of low catch such as the windy season.

If fish consumption were the primary determinant of food security, we would expect a uniform distribution of food security scores to accompany regular fish consumption. Instead, the population was split amongst food-insecure and food-secure categories independent of fish consumption. Taken together, this is further evidence supporting previous assertions that fisheries income, not consumption, defines food security (Vandenberg et al., 2021). While often an afterthought in marine conservation, the "cash crop" functions of fisheries can be foundational to food security (Allison, 2011; Fabinyi et al., 2017). Benefits to food security from trade are often dependent on power relations (Allison, 2011); on the study island, several different fishing and trading professions exist, accompanied by an equally wide range of revenue and other socio-economic benefits.

4.4 Management and policy implications

With this study, we set out to understand household acquisition in a single fishing community. In considering policy implications, several issues emerge. At the broader level, this research supports the need to move away from a sole focus on the connection between harvest and livelihoods (Fabinyi et al., 2017; Bennett et al., 2018, 2021). Increasingly, management and conservation efforts in Indonesia have adopted food security goals (Foale et al., 2013). However, proposed links between fish and food security in management and conservation are based mainly on the availability of fish stocks and tend to exclude social dynamics which require a more focused lens (Fabinyi et al., 2017). Determining more detailed connections between harvest, acquisition, and consumption at a community level can broaden the policy scope for addressing food security and conservation (Bennett et al., 2018; Foale et al., 2013).

In reflecting on the discussions above, it is imperative that small pelagic fish be given greater priority in management. Like many islanders across Indonesia (Clifton & Foale, 2017; Deswandi, 2012), fishers on Bontosua depend on small pelagics for food and income. Specialized fishing households are especially high-risk for food insecurity because they face critical tradeoffs between sale and consumption (Gibson et al., 2021). High domestic demand and industrial catch methods have led to severe depletion of pelagic stocks in Indonesia (Ferrol-Schulte et al., 2015), but these issues have received less attention in marine conservation than reef-based fishing (Clifton & Foale, 2017; Foale et al., 2013).

The nutritional conclusions in this study underscore the need for coordination among fisheries and public health sectors (Bene et al., 2016; Bennett et al., 2021). Islanders on Bontosua, especially women, suffer from diabetes (Lampe et al., 2020), a condition with strong connections to poor diet and lifestyle (Stefani et al., 2018). Incomes from the fish trade can potentially enable the purchase of fruits and vegetables off-island and are therefore crucial for supporting dietary diversity. Focusing on improving access to fresh foods through a multi-pronged approach- promoting equity in the fish trade and programs to grow produce on the island- may realize greater progress than any fisheries management measure that focuses on increasing fish production. Particularly where fisheries income can provide access to a broader diet, as it does in this study community, balancing direct nutritional interventions with ways to improve livelihood status would pave the way for

more effective social systems. Nutritional measures like these could also place greater importance on conserving the on-island pathways for nutrient-dense small pelagic fish such as ponyfish (*Karalla dussumieri*; local name "bete-bete"), which has higher levels of micronutrients than other fish in our study (Reksten et al., 2020).

The impact of conservation and management on food security is mediated by a range of social, political, and cultural factors (Clifton, 2013; Fabinyi et al., 2017). Preference for small pelagic species is one socio-cultural dimension that we found in this study. The statement best describing household food patterns on the island- "enough but not always the kinds of foods we want"- implies the desire to satisfy needs beyond nutrition. Food habits develop with repeated interactions, giving rise to beliefs, values, norms, and taboos that can influence consumption (Belton & Thilsted, 2014; Lyana & Manimbulu, 2014; Noack & Pouw, 2015). Fish preference has been measured in developed countries, but few applications pertain to well-being (Kawarazuka & Bene, 2010). If food security is about more than just "sufficient" or "nutritious" food, but "preferred" food, some alternative questions might be considered by managers: i) how will management actions impact the ability of communities to access culturally appropriate food; ii) what are the aspirations of this community in achieving better access to food?

5 Conclusion

Considering the rise of community-based marine conservation and food security goals in countries such as Indonesia, scholarly arguments have increasingly taken the stance that projects must do more to incorporate the multi-faceted links connecting fisheries to food security outcomes (Bennett et al., 2021). Our study argues that tracing the multifaceted socioeconomic, nutritional, and cultural value of fish within the community is a key element in this vision. In linking on-island fish catch to dietary consumption and preference, we offer several lines of evidence for the fisheries-food security connection: 1) strong role of fish in household diets and dietary preferences for small pelagic fish; 2) crucial provisioning roles for small-scale fishers within the community; 3) fishing income-based food security; 4) dependence on pelagic fish during the high-catch season and farmed fish during the low-catch season. These conclusions highlight the governance challenges that lie at the heart of supporting small fishing communities, especially those that rely on seasonal fisheries for income and nutrition. If the goal is to create effective food and nutrition interventions at a community level, then why and how these foods exist in the diet are salient, yet undervalued, questions.

In addition to their significant contributions to nutrition and income-based food security, fish contribute to social cohesion, featuring prominently in sharing and cultural use. Here we demonstrated that households assigned social values to fish species. A better understanding of the cultural and social factors that define subsistence use would help to establish a baseline for management to sustain these social values in communities. Fishery managers and policymakers should remain aware of a fishery's social and cultural characteristics when implementing capacity-building measures. Incorporating social dynamics of the value chain into the structure of planning would allow initiatives to honor and leverage multiple interacting factors to achieve conservation and management success. From this perspective, future policies can better predict and understand the consequences of marine management and shifting supply and be prepared to enact a food security framework which matches the needs and function of heterogeneous coastal communities.

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Declarations

Conflicts of interest The authors declare that they have no conflicts of interest.

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