Maritime Studies (2023) 22:35
https://doi.org/10.1007/s40152-023-00325-1

RESEARCH

A cross-sectional study on the nutritional status, dietary diversity, and small fish consumption patterns in coastal fishing communities of Ghana

Bhagya Janananda[1] · Richard Stephen Ansong[2] · Anne Hatløy[1,3] · Amy Atter[4] · Peter Andersen[5] · Inger Aakre[6] · Theophilus Annan[4] · Frank Peget[4] · Yaw Opoku Agyei-Mensah[1] · Matilda Steiner-Asiedu[2] · Marian Kjellevold[6]

Received: 27 December 2021 / Accepted: 21 July 2023 / Published online: 12 August 2023

Abstract

Fish is readily available to fishing communities. Given the high nutritional value of fish, these communities are expected to have better nutritional status, compared to non-fishing communities. However, this assumption is not well studied across coastal fishing communities in Ghana. Hence, this cross-sectional study was conducted to investigate the nutritional status, dietary patterns, and fish consumption of children living in coastal fishing communities in Ghana. Nutritional status of 384 randomly selected children was assessed using the mid-upper arm circumference (MUAC) measurement. MUAC less than 12.5 cm was used as the cutoff to identify malnourished children. Food and fish consumption patterns were assessed using an adopted and pretested food frequency questionnaire. The findings showed a prevalence of 0.5% wasting among surveyed children. The mean dietary diversity score (DDS) of the study participants was 4.3 ± 1.2. The mean DDS of the children of fisher mothers was less than that of the children of the female caregivers who are involved in other occupations. However, no significant difference was observed in the DDS across the coastal regions. Seventy eight percent of the children who participated in the study consumed an adequately diversified diet, and more than 40 different small fish species were consumed across the four coastal regions. The average median weekly fish intake among the children in the study sample was 213 (64–468) g. Considering that one-third of the employed respondents were fisherfolk, coupled with the availability of a great diversity of small fish in the communities, the findings of our study suggest that there is great potential to incorporate small fish into strategic interventions aimed at improving nutrition, food security, and achieving economic sustainability in these communities.

Keywords Small fish · Fishing communities · Child nutrition · Dietary diversity · Fish consumption

✉ Marian Kjellevold
marian.kjellevold@hi.no

1 Centre for International Health, University of Bergen, Bergen, Norway

2 Department of Nutrition & Food Science, College of Basic and Applied Sciences, University of Ghana, Accra, Ghana

3 Fafo Institute for Labour and Social Research, Oslo, Norway

4 Council for Scientific and Industrial Research, Food Research Institute, Accra, Ghana

5 Department of Geography, University of Bergen, Bergen, Norway

6 Department of Seafood, Nutrition and Environmental State, Institute of Marine Research, Bergen, Norway

Introduction

Small indigenous fish species that usually grow to a maximum of 25 cm in their mature stages (Roos et al. 2003) or fish that are small enough to be consumed whole with head and bones (Bavinck et al. 2023), living in the waters of Ghana, constitute an important part of the diet of Ghanaians. The main focus of this study was the consumption patterns of these small fish species consisting of both marine pelagic species and inland freshwater species in Ghana. The country's marine fishery resource is associated with the Western Gulf of Guinea that harbors small pelagic fish species with higher commercial value such as sardines, anchovy, and mackerel which account for about 70% of the total marine catch (Tall and Failler 2012). These small fish species are not well recorded in catch statistics and information about small fish consumption patterns among communities are sparse. Therefore, further studies are needed to determine the exact contribution of different small fish species consumed in various communities of Ghana in order to incorporate small fish into interventions targeting food security. Moreover, the link between consuming small fish and its health benefits is largely overlooked in national food polices, in global food security discourses, and in current strategies developed to combat nutrient deficiency in low-income populations (Kolding et al. 2019). This emphasizes the need for a detailed characterization of small fish consumption patterns in Ghanaian communities to understand the role of small fish in food and nutrition security in Ghana. As a first step towards achieving this goal, we carried out a descriptive, cross-sectional study with the overall aim of assessing the nutritional status, dietary diversity, and small fish consumption patterns of under 5-year-old children living in coastal fishing communities of Ghana.

Ghana is a West African country with a population of 29 million. Over 2.6 million Ghanaians depend on fisheries for their livelihood (Onumah et al. 2020). Ghana's fisheries sector can be divided into marine capture fisheries, inland fisheries (rivers, lakes, and lagoons), and aquaculture (Akpalu et al. 2018). Eighty percent of the total fish consumption in Ghana comprises marine fish, with marine fisheries providing employment for most coastal communities (Aikins 2018). The estimated mean per capita fish consumption is about 25 kg (Rutstein and Johnson 2004), and 75% of the annual fisheries production is consumed locally (Asiedu et al. 2018). Between 50 and 80% of the animal protein requirement in Ghana is fulfilled by fish (Mutimukuru-Maravanyika et al. 2013). Twenty two percent of the household food expenditure was spent on fish products, which accounts for as much as 60% of animal protein in the average Ghanaian diet (FAO 2016). Around 2.6 million people rely on marine capture fisheries, including family members, input suppliers, and office workers linked to fishing fleets (Rehulkova et al. 2019). Coastal communities rely on artisanal fisheries, which provide them with income, employment, and fish as a cheap source of protein (Kolding et al. 2019).

Smoked and dried fish can be considered as the main tradable, traditional fish products that contribute to incomes of artisanal fishermen and women processors (Diei-Ouadi and Mensah 2005). Fisheries is one of the most cost-effective and sustainable ways to improve food security in rural communities. The provision of financial, technical, and institutional support, especially for women who engage in fisheries in low-income households is an effective way to achieve household food security (Belhabib et al. 2015). With such valuable attributes, Ghana has the potential to use the fisheries industry effectively to achieve food security, poverty reduction, and sustainable livelihoods (Rehulkova et al. 2019).

Malnutrition in fishing communities

In general, the presence of fish and higher levels of fish consumption are considered to be a major characteristics of a fishing community (Bandoh et al. 2018). The estimated per capita fish consumption in Ghana is 25 kg, which is considerably higher than the African average of 10.5 kg (Onumah et al. 2020). As a survey conducted by Bandoh et al. 2018 in a peri-urban fishing community in Ghana points out, in spite of the abundance of nutrients gained by consuming fish and other staples, fishing communities still suffer from the burden of malnutrition. According to this study (Bandoh et al. 2018), more than one-quarter (26.4%) of the children were under-nourished, even though they were reported to have consumed fish products, more than three times in the past week assessed. Apart from health-related issues, findings of a recent household survey show higher prevalence of poverty among fishing communities (Coastal Resources Center 2018). Therefore, research aimed at identifying the underlying causes of malnutrition in fishing communities, despite the high levels of fish consumption, is of critical importance. Data collected through such research will eventually be beneficial for increasing the wellbeing of communities (Bandoh et al. 2018).

Significance of small fish in human diet

Fish, which are rich in amino acids, vitamins, unsaturated fatty acids and trace elements are considered as an easy to digest animal source of food for a healthy diet (Can et al. 2015). Small fish species eaten whole with head, bones, and viscera are proven to be rich in bioavailable calcium, vitamin A, iron, and zinc (Thilsted 2012), and oily fish rich in omega-3 fatty acids are important for a child's brain development (Onumah et al. 2020). Compared to other animal proteins, fish is an easily digestible, affordable and yet, nutrient-rich source of protein, mainly for people who consume a carbohydrate-based diet in low-middle income countries (Kawarazuka and Béné 2011). Studies have shown that the intake of animal proteins such as meat, fish (oily and lean), and poultry can facilitate the non-heme iron uptake from the diet, which is termed as the "meat factor" (Navas-Carretero et al. 2008). This effect would be an added advantage of incorporating fish and other animal sourced proteins into a plant-based diet. However, a recent review has concluded that it is not possible to quantify the amount of animal sourced food needed to obtain this effect, and presently data on small fish are limited (Consalez et al. 2022). A study on the contribution of fish consumption to maternal and child nutrition in Zambia shows that small fish species such as

Kapenta is an animal-source food that is particularly important in the diet of urban poor households, as it contributes to better nutritional outcomes (Marinda et al. 2018).

Nutrients provided by small fish can be used to effectively fight micronutrient deficiencies that cause a considerable number of premature deaths that are attributed to malnutrition or "hidden hunger" in sub-Saharan Africa (Kolding et al. 2019). Moreover, small-scale fisheries can contribute to food security in two ways: by direct consumption and by increasing purchasing power through income and employment (Belhabib et al. 2015). Despite the declining overall fisheries income due to environmental degradation, the income received from small-scale fisheries in Ghana generally remains above the poverty line (Belhabib et al. 2015).

Given the significant role played by the fisheries sector in Ghana, there is great potential for involving the fisheries sector in food-related interventions to combat malnutrition and food insecurity, especially among children in these communities. However, a significant knowledge gap remains on the specific contribution of small fish across different domains of food security (stability, sustainability, access, availability, and utilization) (Clapp et al. 2021) in these communities and how these domains interact to influence nutrition and health outcomes. Without such knowledge, the ability of the fisheries sector to contribute meaningfully to reduce malnutrition is significantly impaired. Nutritional status of under 5-year-old children is considered as a sensitive indicator to assess the overall health of a population (High Level Panel of Experts (HLPE) et al. 2014). Therefore, characterizing the small fish consumption patterns among under 5-year-old children in coastal communities along with an assessment of the existing nutritional status and food consumption is a necessary starting point to address this knowledge gap.

With regard to the above-described knowledge gap, the main objective of this study was to assess the nutritional status, dietary diversity, and small fish consumption patterns of under 5-year-old children living in coastal regions of Ghana. As most of the research and interventions are done at the regional level, our first aim was to compare across the four coastal regions. Women's participation in small-scale coastal fisheries value chains is recognized as crucial for their empowerment and household income, resulting in improved health and nutrition outcomes in their children (Gibson et al. 2020). Based on this assumption, we came up with the second aim: to assess and compare the nutritional status, dietary diversity and fish consumption patterns between female caregivers who are involved in fisheries (fisher-mothers), and female caregivers with other occupations with the intention of identifying any significant health and nutrition outcomes for children of female caregivers who were involved in fisheries.

Materials and methods

Study area

Ghana comprises 16 regions, of which four make up the coastline bordering the Gulf of Guinea in western Africa. These four regions — Greater Accra, Volta, Central, and Western — that were included in this study, are collectively termed as "coastal regions." These coastal regions are known to possess the highest interaction with the ocean, compared to other inland-located regions because of their location. We purposefully selected four fishing communities from each region, resulting in a total of 16 fishing communities to obtain a thorough understanding of fish consumption patterns in coastal fishing communities and for subsequent comparisons between regions (Fig. 1). Any person involved in a livelihood related to fisheries was defined as a "fisherfolk." The female caregivers who were involved in a livelihood related to fisheries were defined as "fisher-mothers." We defined a fishing village/community as a location where fisherfolk reside and have an "Assembly man/Chief fisherman" as the head of the community (Mutimukuru-Maravanyika et al. 2013; Crawford et al. 2016). There is a clear division of labor based on gender with men fishing and women processing and trading the fish (Obeng et al. 2010). The processing and trading of fish is done exclusively by women who are referred to as "fishmongers" (Obeng et al. 2010), when engaged in both activites.

Calculating the sample size

Cochran's formula (Cochran 1977) was used for calculating the sample size for this study. The formula was developed to calculate a representative sample when the population is infinitive.

$$n_0 = \frac{z^2 pq}{e^2}$$

where n_0 is the sample size; z is the selected critical value of desired confidence level; p is the estimated proportion of an attribute in the selected population‘ $q = 1-p$, and e is the desired level of precision. We used a z-score of 1.96, which corresponds to a 95% confidence level. We based our sample calculation on the level of inadequate dietary diversity score; which was unknown in the population, and we therefore assumed maximum variability, which is 0.5, and a confidence level of 5%.

$$\frac{1.96^2 \times 0.5 \times (1-0.5)}{0.05^2} = 384$$

To achieve the sample size of 384 with desired precision or confidence interval after removing missing data or

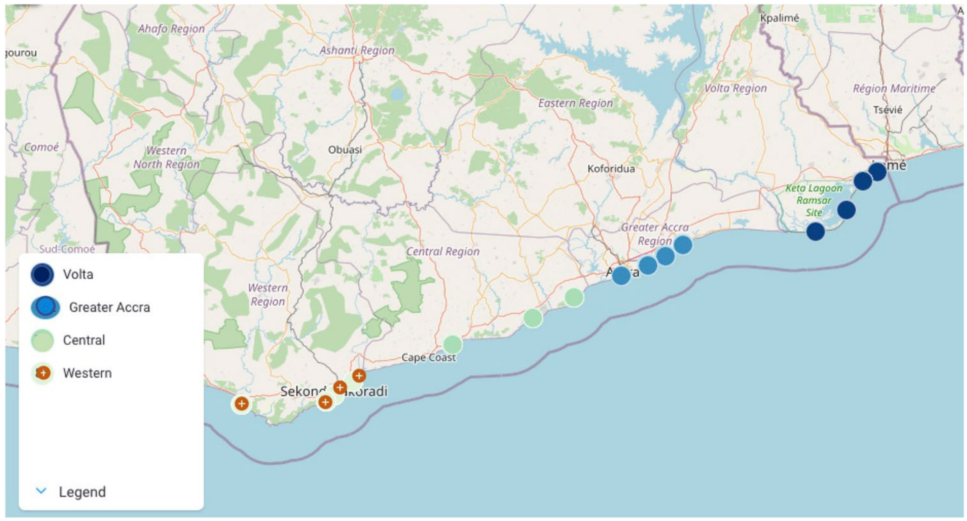

Fig. 1 Sixteen sampling sites representing the four coastal regions, Greater Accra, Central, Volta and Western. The four regions are denoted by four different colors. Source: Kobotoolbox

non-responders from the data set, we decided to oversample 6% of the calculated sample size. This resulted in a required sample size of 407 participants.

The *Ghana living standards survey-GLSS6* defines a household as "a person or group of related or unrelated persons who live together in the same housing unit, sharing the same housekeeping and cooking arrangements and are considered as one unit, who acknowledge an adult male or female as the head of the household" (Ghana Statistical Service: p.4 2014). Therefore, we selected 384 child-caregiver pairs from 384 different households to include in our study.

Sampling procedure

After obtaining permission to enter the community from the chief fisherman of the area, the field assistants located an important landmark, such a school, hospital, or church as the starting point. Then, a random direction was chosen by spinning a pen as the direction of their movement to select eligible households. If there were more than one eligible caregiver-child pairs living in a selected household, the child who has had the most recent birthday was selected to be included in the sample. After selecting an eligible household, the field assistant carried out a quick assessment to determine the eligibility of the caregiver and the child. To be eligible for the study, the household had to have a child of the age 18–59 months, living with a person who was willing to give full consent as the child's main caregiver who could either be the biological mother or other main caregiver.

The field assistants visited a total of 407 households. Sixteen participants did not consent to participate after explaining the sampling procedure, and 5 participants withdrew participation due to interruptions. Data from a total of 391 caregiver-child pairs were collected, out of which, seven caregiver-child pairs were removed due to missing date of birth and the recorded age of the child being below 18 months. This resulted in a total of 384 children between the ages of 18–59 months and their caregivers from the four coastal regions in Ghana being included in the study (Fig. 2).

Instruments

Mid-upper arm circumference measurement to assess the nutritional status Selected children were screened for wasting (acute malnutrition) based on the MUAC measurement. This measurement was taken by using a standard color coded MUAC tape recommended by WHO, at the mid-point of the left upper arm, while the arm is fully stretched. The color and the quantitative readings of the MUAC tape are correlated as red: MUAC < 11.5 cm, indicating severe acute malnutrition; yellow: MUAC $=$ 11.5 to 12.5 cm, indicating moderate acute malnutrition or wasting; and green: MUAC ≥ 12.5 cm, indicating no acute malnutrition (Lamsal et al. 2021; Barro et al. 2021). Regardless of whether the caregiver could read the MUAC based on color or measurement, the field assistants were advised to reveal the malnutrition status of the child to the caregiver upon completion of the procedure. The presence of wasting, defined as a MUAC measurement of less than 12.5 cm was used as the cutoff to identify malnourished children in this study. Caregivers of the children who were identified as malnourished were informed and advised to seek guidance from a nearby health center.

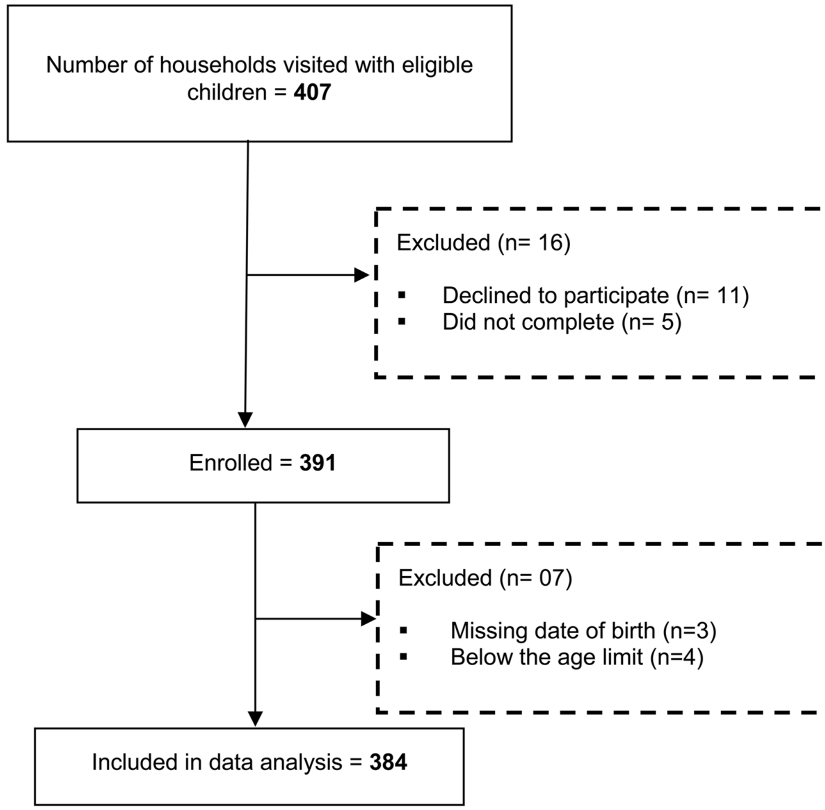

Fig. 2 Flow diagram showing the selection of the caregiver-child pairs. Reasons for exclusion from the sample are given inside the dash-lined boxes

Food Frequency Questionnaire to assess dietary diversity The survey collected quantitative data on demographics, nutritional status of the children, dietary diversity and small fish consumption using a structured questionnaire (Supplementary material). This questionnaire was created based on WHO's IYCF guidelines (WHO 2008). Commonly eaten local foods were incorporated into the standardized seven food groups to optimize the food frequency questionnaire to the local community. The food groups were: (1) grains, roots, tubers, plantains and bread, (2) legumes, nuts and seeds, (3) milk and milk products, (4) flesh foods, (5) eggs, (6) vitamin A-rich plant foods, and (7) other fruits and vegetables.

The field assistants conducted face-to-face interviews by asking the caregiver to recall whether the child had consumed food from each of the seven food groups during the past 24 h. Dietary diversity score (DDS), calculated by counting the number of food groups was used as an indicator for dietary adequacy. The DDS was measured using a simple scoring system based on the food groups consumed by 18–59 months old children during the previous 24 h. If the caregivers answer was "yes" regarding a particular food group, it was converted to a score of "1," and if the answer was no, it was converted to a score of "0." After that, the number of "1's" was summed to calculate the DDS for each child. Therefore, the dietary diversity score ranged from 0 to 7 with a maximum of 7, if all the food groups were consumed and 0 if none of them were consumed.

The children were divided into two groups as "adequate" and "inadequate" in terms of their dietary diversity based on the total number of food groups they consumed. A total of "four" out of seven food groups was set as the minimum acceptable cut off (WHO 2008) to determine to which category the child belongs. If the child consumed a total of four or more food groups, the child was categorized as "adequate/ adequately nourished" and if the child consumed a total of three or less than three food groups, the child was categorized as "inadequate/inadequately nourished." In order to compare our data with available data from previous surveys, we categorized children into two age categories as 18–35-month-old and 36–59-month-old.

Questionnaire to collect demographic information and small fish consumption patterns Apart from the questions on the seven food groups, additional questions were included to collect demographic information and fish consumption patterns of the participants. Small indigenous fish species (small fish) defined as fish that usually grow to a maximum of 25 cm or 9 inches in their mature stages (Roos et al. 2003), or fish that are small enough to consume whole with head and bones (Bavinck et al., 2023), living in the waters of Ghana, was the main focus of this study. However, specific data on the habitat, availability, and utilization of small indigenous fish species of Ghana is scarce. Therefore, information gathered in this project is applicable to small fish species in general, without any specific reference to indigenous species. The MUAC measurement, dietary diversity score, and the daily and weekly small fish consumption were compared across the four coastal regions and caregiver occupations.

Ethics

The study was approved by the Regional Committees for Medical and Health Research Ethics (Reference number: 160065), Norway, and Memorial Institute for Medical Research (Study Number: 009/20-21), Ghana. In addition to this, permission to enter and interview the residents of the communities was granted by chief fishermen/assembly men responsible for each community. The study complies with the Declaration of Helsinki, and verbal consent was obtained for the caregiver of the child. The age limit of caregivers was set at 18 years or older. In cases where the mother was less than 18 years old, consent was obtained from the guardian. Participation in the study was voluntary, and the participants were free to discontinue participation at any time, as explained in the Helsinki-declaration. Trained field assistants measured the MUAC of every eligible child while following COVID-guidelines by sanitizing the upper arm with hand sanitizer. The caregivers of the children who were identified as malnourished were informed about the circumstances and were advised to direct the child to a health facility for assistance.

Data management and statistics

KoBoToolbox, which is a free, open-source toolkit for collecting and managing data, was used to build the questionnaire, to collect, store, and transfer data for the duration of field work. Data were downloaded from KoBoToolbox platform into Excel format, then cleaned and coded to be used in the data analysis. Data were analyzed using IBM® SPSS® Statistics version 26. The frequencies, % and mean values of the demographic variables were calculated separately for each coastal region. Categorical variables were described as frequencies, whereas continuous variables were described as means ± SD. To assess the nutritional status, dietary diversity and fish consumption of the children included in the study, we selected the MUAC, DDS, and the daily and weekly fish intake respectively, as dependent variables.

Recorded frequency of daily and weekly small fish consumption were used to calculate the daily and weekly fish intake in grams. Daily fish intake (in grams) on "fish-eating days" was calculated by multiplying the portion size (in grams) by the frequency of daily fish consumption (the number of times a child is given fish per day). The days on which the household cooks fish were considered to be "fish-eating days". Weekly intake of small fish was calculated by multiplying the daily intake of fish by the number of fish-eating days per week. A portion size chart with reference to different fish species was used during data collection and for estimating the portion sizes into grams. Average fish consumption was calculated by dividing the total consumption by the number of children in each subcategory with reference to the specific aims of the study. With reference to the two aims of this study, the four coastal regions and the female caregiver's occupation were chosen as independent variables in descriptive statistics and mean comparisons.

General information such as caregiver sex, age, educational level, employment status, and occupation were also included in the demographics. The education level of the caregiver was categorized as No-formal education, Primary, Junior High School (JHS) and Secondary, and upper education. Secondary and upper education comprises tertiary education and vocational training. Mean MUAC measurements and the DDS were compared between the categories of the selected variables. Chi-square, ANOVA, and the Kruskal-Wallisz tests were performed to test the statistical significance of the comparisons, using a significance level of 0.05 or 0.001 depending on the chosen analysis.

Results

Background characteristics of the respondents

Background characteristics of the caregivers and children are presented in Table 1. The majority of the caregivers were females (98%), and the mean age of the caregivers was 31 ± 7 years. Approximately 26% of the caregivers did not have a formal education, while the remaining 74% had completed either primary, junior high school or secondary, and higher education. Of the 78% who were employed, 40% were involved in fisheries as a livelihood. Among them, 63% were fishmongers (smoking fish and selling); 28% were fish processors (smokers); and 8% were fish vendors (data not shown). A comparatively higher percentage (60%) of the caregivers were involved in other occupations such as traders (26%), tailors (15%), hairdressers (12%), food vendors (22%), and other work (25%) (data not shown).

Table 1 Sociodemographic characteristics of the participants (N = 384)[a]

Variable	Greater Accra (n = 152)	Central (n = 69)	Volta (n = 83)	Western (n = 80)	Total (N = 384)
Caregivers					
Sex					
Female	149 (98)	67 (97)	79 (95)	81(100)	375 (98)
Male	3 (2)	2 (3)	4 (5)	0 (0)	9 (2)
Mean age (years ± *SD*)	32 ± 1	31 ±1	29 ± 6	31 ± 1	31 ± 7
Educational level					
Non-formal	46 (30)	17 (25)	13 (16)	25 (31)	101 (26)
Primary	28 (18)	18 (26)	30 (36)	18 (23)	94 (25)
JHS	59 (39)	24 (35)	30 (36)	30 (36)	143 (37)
Secondary and upper	19 (13)	10 (14)	10 (12)	8 (10)	47 (12)
Work situation					
Employed	122 (80)	45 (65)	69 (83)	65 (81)	301 (78)
Unemployed	30 (20)	24 (35)	14 (17)	15 (19)	83 (22)
Occupation (n = 301)					
Fisherfolk [b]	45 (63)	10 (22)	26 (38)	39 (60)	120 (40)[b]
Other occupations[c]	77 (37)	35 (78)	43 (62)	26 (40)	181 (60)[c]
Children 18–59 months of age					
Sex					
Female	77 (51)	33 (48)	35 (42)	37 (46)	182 (47)
Male	75 (49)	36 (52)	48 (58)	43 (54)	202 (53)
Age group					
18–35 months	72 (47)	38 (55)	54 (65)	41 (51)	205 (53)
36–59 months	80 (53)	31 (45)	29 (35)	39 (49)	179 (47)

[a]Values of the continuous variables are presented as mean ± standard deviation (*SD*); values of categorical variables are presented as frequency distributions and percentages among regions. Frequencies and percentages under the column "Total" were calculated out of the total number of respondents participated (*N*). (% within region or *N*)

[b]Fisherfolk consists of fish mongers, fish processors, and fish vendors. Total percentage was calculated out of the all employed participants (n = 301)

[c]Other occupation consists of professions such as traders, tailors, hairdressers, and food vendors. Total percentage was calculated out of all the employed participants (n = 301)

Table 2 DDS and MUAC of participated children across four coastal regions (N = 384)[a]

Variable	Greater Accra	Central	Volta	Western	Overall
Mean DDS (± SD)[b]	4.8 ± 1.2	4.5 ± 1.2	3.9 ± 1.3	4.1 ± 1.2	4.4 ± 1.3
Mean MUAC (± SD)[b]	15.2 ± 1.3	15.4 ± 1.2	15.3 ± 1.2	15.2 ± 1.1	15.3 ± 1.2
Children with MUAC < 12.5 cm	2 (1.3)	0 (0.0)	0 (0.0)	0 (0.0)	2(0.5)

[a]Values of the continuous variables are presented as mean ± standard deviation (*SD*); values of categorical variables are presented as frequency (%)

[b]Comparison between regions using ANOVA; variations are insignificant according to the significance level at $p < 0.05$

Out of a total of 384 children included in the survey, 182 (47%) were girls, and 202 (53%) were boys. They belonged to the age category of 18–59 months, which was further divided into two groups as 18–35 months and 35-59 months during data analysis. Mean MUAC of the sampled population of 384 children was 15.2 ± 1.3 (Table 2). Only two children (0.5%) were identified as wasted from the Greater Accra region, having MUAC measurements of 12.4 and 12.2 cm. None of the children of the age category 36–59 months were wasted. The mean DDS of the selected children was 4.4 ± 1.3 (Table 2).

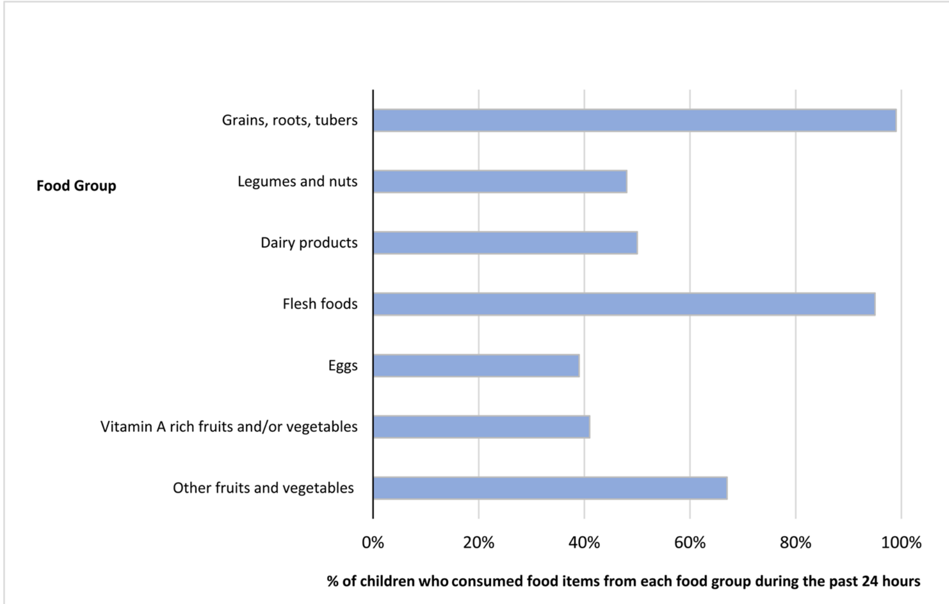

Fig. 3 Percentage of children who consumed each of the seven food groups included in the FFQ

Comparison of selected variables among four coastal regions

Consumption of seven food groups

The diets of the children were mainly composed of grains, roots, tubers, and plantains, as 99% of the children had consumed food belonging to that group (Fig. 3). Flesh foods, which include fish, poultry, red meat, and organ meat, showed the second highest frequency (95%) of consumption. The food groups consisting of eggs and vitamin A rich plant foods were consumed less frequently, compared to other food groups.

Dietary adequacy of children across the four coastal regions

Categorization of children as having an "Adequate" or "Inadequate" dietary diversity is shown in Table 3. The percentage of children with an adequate dietary diversity (78%) and an inadequate dietary diversity (22%) were the same across the two age groups. The inadequate and adequate percentages across the four regions between both age groups were statically significant. Frequency distribution analysis showed that 87% of the under five children in Greater Accra had the highest percentage of adequate dietary diversity, while the lowest percentage (63%) of adequate dietary diversity was identified from the Volta region (Table 3).

Table 3 A compression between the number of children with Adequate-DDS and Inadequate-DDS across the four coastal regions. ($N = 384$)

Age category	Greater Accra	Central	Volta	Western	Total	p-value[a]
18–35 months ($n = 205$)						
Inadequate-DDS	12 (17)	5 (13)	19 (35)	10 (24)	46 (22)	0.039
Adequate-DDS	60 (83)	33 (87)	35 (65)	31 (76)	159 (78)	
36–59 months ($n = 179$)						
Inadequate-DDS	8 (10)	7 (23)	12 (41)	13 (33)	40 (22)	0.001
Adequate-DDS	72 (90)	24 (77)	17 (59)	26 (67)	139 (78)	
Total						
Inadequate-DDS	20 (13)	12 (17)	31 (37)	23 (28)	86 (22)	< 0.001
Adequate-DDS	132 (87)	57 (83)	52 (63)	57 (72)	298 (78)	

DDS classification based on FAO and FHI (2016); data are shown as frequency distributions and percentages among regions. Frequencies and percentages under the column "Total" were calculated out of the total number of respondents participated (*N*)

DDS dietary diversity score, *DDS-Inadequate* is classified as $DDS < 4$, *DDS-Adequate* is classified as $DDS \geq 4$

[a]Pearson chi-square test was performed to find the significance level at $p < 0.05$

Fish consumption of children across the four coastal regions

This survey identified over 40 different fish species consumed by the participants. The most consumed small fish species by children aged 18–59 months were sardinella (*Sardinella aurita*), anchovy (*Engraulis encrasicolus*), and chub mackerel (*Scomber colias*). A complete list of small fish species consumed by the children is included in the supplementary material.

Regional variation of the average frequencies and the average daily and weekly fish intake are given in Table 4. We learned that the average frequency of daily fish intake on fish eating days for the sampled population was 2.0 ± 0.8 times. The average frequency of weekly fish intake across the regions was three times, which was statistically significant. The average median fish intake among the sampled children was 59 (20–156) g per day (on fish eating days). The significance value showed that the difference of the amount of fish consumed between regions was significant. The average median weekly fish intake among the children in our study sample was 213 (64–468) grams. Children of the Western region had the highest median of 261 (78–468) g of small fish per week, compared to the other coastal regions. However, the weekly fish consumption between regions was statically insignificant.

As shown in Fig. 4, the majority of children preferred small fish that were fried (43%) or smoked (38%). Boiled and roasted were also mentioned as other common cooking methods. The age category was not considered for this assessment. When the caregivers were asked why they gave small fish to the children, 44% responded that small fish is a healthier choice of animal protein and 7% that it is specifically good for children. Around 34% chose small fish due to its taste and only 6% because it was cheap (Fig. 5).

Table 4 Frequency and quantity of small fish consumption by children 18–59 months of age across coastal regions ($N = 377$)[1]

Fish consumption	Greater Accra ($n = 148$)	Central ($n = 67$)	Volta ($n = 82$)	Western ($n = 80$)	Overall ($N = 377$)	p-value
Average frequency of small fish consumption						
Intake per day[2]	2±0.7	2±0.7	2.0±1	2.0±0.8	2.0±0.8	0.497[d]
Intake per week[3]	3 ± 1.5	2.7 ± 1	3.6 ± 2	2.5 ± 0.8	3.0 ± 1.6	< 0.001[d]
Small fish consumption in grams[∞]						
Daily intake[4]	39 (20–104)[a]	78 (39–234)[b]	47 (19–156)[bc]	117 (39–156)[c]	59 (20–156)	< 0.001[f]
Weekly intake[5]	156 (59–343)	234 (78–468)	234 (42–479)	261 (78–468)	213 (64–468)	0.132 [f]

[∞]Values in median (interquartile range); interquartile = Q1–Q3

[d]Mean comparison with ANOVA, Significance level at $p < 0.05$

[f]Independent-samples Kruskal–Wallis test; significance level at $p < 0.05$. Different letters indicate significant differences

[1]Analysis based on 377 children who consumed "small fish"

[2]Average frequency of small fish consumption on "fish-eating" days (based on caregiver's answer) ± Standard Deviation (SD)

[3]Average frequency of small fish consumption per week (based on caregiver's answer) ± Standard Deviation (SD)

[4]Small fish consumption in grams, on fish eating days

[5]Small fish consumption in grams per week

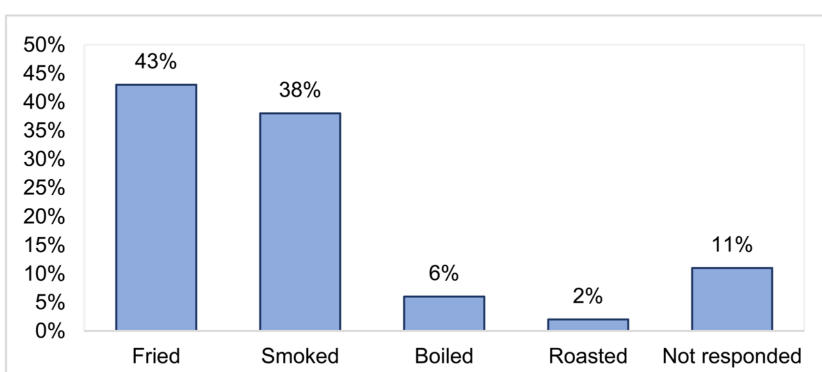

Fig. 4 The most preferred cooking/processing methods of small fish by children

Fig. 5 Caregivers' opinion about small fish consumption, for the question "why do you give small fish for your children?"

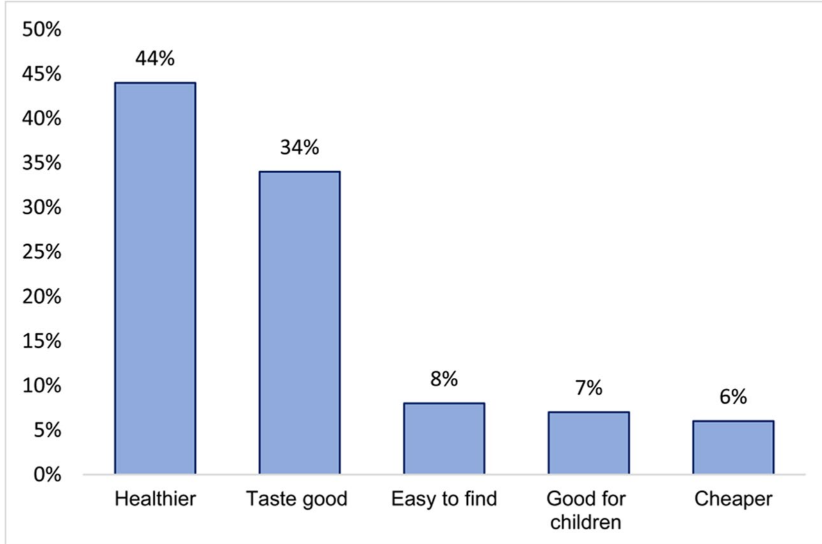

Table 5 Difference in demographics and child MUAC, DDS, and small fish consumption between caregivers/mothers involved in fisheries (fisher mothers) and those with other occupations (N = 296)[a]

Variable	Fisher mothers[b]	Other occupations[c]	Total	*p*-value
Caregiver (n = 296)				
Number of female caregivers (frequency (%))	118 (40)	178 (60)	296 (77) [i]	0.001[e]
Educational level				
Non-formal	50 (42)	32 (18)	82 (28)[j]	**< 0.001**[e]
Primary	34 (29)	34 (19)	68 (23) [j]	
JHS	28 (24)	83 (47)	111 (37) [j]	
Secondary and higher	6 (5)	29 (16)	35 (12) [j]	
Child 18–59 months of age (– = 296)				
Mean MUAC	15.2 ± 1.3	15.4 ±1.2	15.3 ± 1.2	0.148[f]
Mean DDS	4.1 ± 1.3	4.6 ± 1.2	4.4 ± 1.3	0.031[f]
Inadequate DDS	34 (54)	29 (46)	65 (21) [j]	0.008[e]
Adequate DDS	84 (36)	149 (64)	233 (79) [j]	
Average frequency of small fish consumption				
Intake on "fish-eating days"[g]	2.2 (2.9)	1.9 (0.8)	2.0 (1.9)	0.091[f]
Intake per week[h]	3.4 (1.5)	2.9 (1.7)	3.2 (1.6)	0.037[f]
Weekly intake (grams)[d]	156 (56–457)	234 (89–468)	234 (78–468)	0.140[d]

[a]Values of the continuous variables are presented as mean ± standard deviation (SD); values of categorical variables are presented as frequency (% within region or N), N = 296 (employed females)

[b]Employed female caregivers involved in fisheries

[c]Employed caregivers involved in other occupations

[d]Values in median (interquartile), interquartile = Q1–Q3, comparison using Mann–Whitney U test for non-parametric data, Pearson chi-square for categorical variables, Student t-test for parametric data

[e]Pearson chi-square test; significance level at $p < 0.05$

[f]Mean comparison with ANOVA; significance level at $p < 0.05$

[g]Mean frequency of small fish consumption on "fish-eating" days

[h]Mean frequency of small fish consumption per week

[i]% out of 384 participants

[j]% out of 296 participants

Comparison between fisher mothers and mothers with other occupations

Table 5 summarizes the compared data of the selected variables between fisher mothers and mothers of other occupations. Out of 301 employed caregivers, 296 were employed females. Forty percent of the employed female caregivers were involved in a livelihood related to fisheries, thus, referred to as "fisher mothers". The data related to all the other employed caregivers who are involved in occupations other than fisheries were tabulated under the column "other occupations". According to the data, different education levels between fisher mothers and employed female caregivers involved in other occupations are statistically significant. The differences of mean DDS as well as the percentages related to DDS categories were statistically significant between the children of fisher mothers and caregivers involved in other occupations. Only the average frequency of weekly fish consumption is statistically significant between the fisher mothers and female caregivers involved in other occupations.

Discussion

Current nutritional status, dietary diversity, and small fish consumption patterns of 18–59 months old children living in coastal communities of Ghana were assessed in this study. Only two children (0.5%) were found to be acutely malnourished or wasted, and no significant differences in mean MUAC measurement were found across the four coastal communities. Caregivers of the two children identified as wasted were informed about the health status of the children and were advised seek help from the nearest health clinic. The USAID 2018 Ghana Nutritional Profile (USAID 2018) revealed that the national wasting percentages decreased from 9% in 2008 to 5% in 2014. Therefore, it is likely that the low prevalence of wasting in the studied coastal communities reflects these national trends.

Though MUAC alone is still recommended by health organizations and widely used as an accepted and effective way of screening in epidemiological studies, its weaknesses should be taken into consideration to understand whether the current method captures real malnutrition. Some studies suggest that using the fixed MUAC cutoff captures only a small proportion of the total number of wasted children, even though the method can be used as a rapid screening tool to identify wasting in children aged 6–59 months (Lamsal et al. 2021; Barro et al. 2021). It is recommended to administer MUAC-for-height and MUAC-for-age indicators in order to overcome this weakness in using fixed MUAC cutoffs (Barro et al. 2021). Also, this study would have added more insights into the current nutritional status of the study population, if we had used other anthropometric methods such as body mass index (BMI) and weight-for-height measurements. We only used the MUAC in this study due to time constraints and restrictions put forward to minimize contact due to COVID measures. The mean dietary diversity score for the study population was 4.3 ± 1.2, which is higher than the minimum acceptable recommended DDS of "four or more" out of the seven food group category (WHO 2008). The calculated DDS was used as the dietary assessment tool to understand food consumption patterns of the children within the study sample. Our results for the mean DDS is different from that of Bandoh et al. (2018), where they found a mean DDS of 2.29 ± 1.33, which indicates a comparatively low dietary diversity among under five children in another Ghanaian fishing community (Bandoh et al. 2018). Statistical analysis showed a significant difference between the frequencies calculated for the four coastal communities among the two age categories we defined for this study. Greater Accra has the highest percentage (87%) of children with an adequate DDS, while the Volta region has the lowest (63%).

According to the comprehensive food security and vulnerability analysis (CFSVA) for Ghana in 2020, the household food insecurity of the Volta region has a prevalence exceeding 10% (CFSVA, 2020). Eastern, Western, Central, and Greater Accra were among the regions with least food insecurity of less than 10% of prevalence. The higher percentage of inadequate dietary diversity among children might be a result of the higher prevalence of food insecurity in the Volta region. These findings comparing different regions and the country average would provide critical information to help identify and develop ways in which to improve the health and nutritional status of communities with an inadequate dietary diversity.

Furthermore, we found that 78% of the children in the study sample had an adequate dietary diversity, as their diet consists of four or more food groups. According to a study done in 2017 (Frempong and Annim 2017), approximately 47% of the under 5-year-old Ghanaian children consumed a diet with adequate diversity, which is significantly lower than the percentage in our sample. Therefore, it is important to consider the reasons for the high dietary diversity observed in the fishing communities in our study, as this would provide valuable insights into ways in which we could improve the dietary diversity of a given community. At the same time, it is also important to further investigate the underlying reasons for 22% of the children in the current study having a diet with inadequate dietary diversity. The quality of data collected using the Food Frequency Questionnaire (FFQ) method depends on the respondent's ability to memorize and recall the diet, as well as estimate and quantify food portion sizes. These limitations could bring about both systematic errors and biases in the data collected. One reason to administer short-term dietary assessments such as 24-h dietary recalls is to minimize the potential recall bias. We ensured the quality of data collection by administering interviews which were carried out by properly trained field assistants who used appropriate ways of asking the questions and recording the answers more accurately.

We found that the children's diet consisted mainly of starchy foods (grains, roots, tubers, and plantains). Flesh food was the food group with the second highest level of consumption, followed by fruits and vegetables. The findings of the current study together with the findings of Bandoh et al. (2018) suggests that children in coastal communities are more likely to consume foods in the "flesh food" group (Bandoh et al. 2018). However, not including questions to identify the types of flesh food consumed by the participants of this study was one weakness caused by adhering to standardized food frequency questionnaires. This drawback needs to be addressed in future research. According to the responses of the caregivers, 98% of the children in our study sample consumed small fish. Due to the higher frequency of small fish consumption along with the higher diversity of small fish identified, it is likely that the majority of the flesh food consumed in these communities would comprise fish. This assumption is in line with FAO statistics (2016), which identifies fish as the most important animal protein consumed in all regions of Ghana, regardless of the socio-economic situation. The high frequency of fish consumption in these communities might provide them with the added advantage of an increased efficiency of micronutrient absorption from their diet which is known as the meat factor. According to Hicks et al. (2019), incorporation of fish-based food strategies in communities where deficiencies exist can help address nutritional deficiencies, as fish is a rich source of bioavailable micronutrients (Hicks et al. 2019). However, we noted that studies on food group consumption among fishing communities in Ghana is scarce, limiting the possibility of conducting comparative analyses with other inland regions of the country. Therefore, this study provides much needed information for future studies, especially with regard to the food consumption patterns in coastal communities.

The study identified over forty different marine fish species being consumed in the coastal communities within the sample. We came across difficulties in categorizing fish as "small-fish" and "other-fish" based on the size. Most of the species identified by the respondents as small-fish has the potential to grow to a bigger size exceeding the cutoff of 25 cm. Therefore, we decided to follow the classification of the community by expanding the common definition of small fish. Thus, fish species that can be eaten whole with head and bones and are processed and cooked in the same way as other known small fish, which are less than 25 cm in length were categorized as small fish. The respondents considered juvenile stages of certain species of tuna and barracuda as small fish, but these species have the potential to grow into much larger sizes. A recent study done in Ghana identifies anchovies and herrings as the most preferred small fish species within the study community, and different cooking methods were used to prepare them for consumption and preserving (Agyei-Mensah et al. 2023). Consistent with other findings on Ghanaian fish species (Onumah et al. 2020), this study identified sardinella, chub mackerel, and anchovy as the most preferred and most consumed small fish species among children. Chub mackerel, round sardinella, anchovy, and frigate tuna (*Auxis thazard*) were among the most purchased and preferred species among most households (data not shown). According to data from the government of Ghana, marine catch can fluctuate seasonally, and overfishing has resulted in decreasing fish stocks with time (Tall and Failler 2012). However, our study did not capture seasonal variations in marine catch, as it was short-term. Expanding the study period to identify variation in the catch, resulting from seasonal changes, would bring insights into availability and accessibility of small fish in these communities.

The median weekly fish intake was 213 g (about 7 oz.), which is higher than the recommended 1–2 servings (of 2–4 oz.) per week (for children (USFDA 2022)). According to the survey data, a majority (44%) of the caregivers believed that small fish is a healthier choice of animal protein, and 7% believed that it is specifically good for children (Fig. 5). Frying or smoking was found to be the most preferred method of cooking/processing of fish consumed by children (Fig. 4). These findings provide the basis for further studies aimed at characterizing nutrient loss associated with these preparation methods, which in turn would provide insights into the actual nutrient uptake by consuming these small fish species. Smoking and drying may reduce or destroy nutrients like vitamin A (Roos et al. 2002; Hasselberg et al. 2020). Even though small fish is considered to be a micronutrient rich protein source, frequent intake of fish might contribute to certain health issues. One such factor that needs attention is the level of polycyclic aromatic hydrocarbons (PAHs) in smoked fish. PAHs are contaminants produced during the smoking process due to incomplete combustion (USFDA 2022). Since smoked fish can contribute significantly to the intake of PAHs, the high level of consumption of smoked fish in these communities could result in other adverse health conditions. However, the PAH levels depend on various factors such as the ovens used, and the use of new technology can reduce the levels of PAHs significantly (Bomfeh et al. 2019). Together, these findings highlight the pressing need for investigating the specific methods of smoking fish in these communities and the levels of PAHs in the smoked fish consumed in these communities.

Of the 301 employed caregivers in the sample population, 120 were fisherfolk who were involved in a livelihood related to fisheries in the fishing communities studied (Table 4). Among them, 118 fisherfolks were females, and they are referred to as “fisher mothers.” There is a dearth of studies that discuss women’s role in reducing poverty and establishing food security in their households. According to Walker (2002:390), Ghanian women have served as “capitalists, entrepreneurs, and innovators” playing a major role in the fisheries sector (Walker 2002) (Obeng et al. 2010). Similarly, the fisher mothers of our study were mainly fishmongers, processors, and vendors and therefore might be playing a similar role within the studied communities.

Previous studies done in Ghana have shown the importance of mothers’ nutrition literacy and attitudes on infant and young child feeding practices in providing an adequate diet for their children (Bimpong et al. 2020). In an attempt to add information on the nutrition literacy of the mothers, we decided to investigate whether there were any significant differences in the nutritional status, dietary diversity, or fish consumption among children of fishing mothers and other female caregivers (non-fisher mothers) who are involved in other livelihoods apart from fisheries.

The weekly median fish consumption of the children of fisher mothers (156 g) was less than that of the non-fisher mothers (234 g). However, the difference was not statistically significant (Table 5). Having a low level of fish consumption among children of the fisher mothers, compared to the other occupations contradicts the assumption that caregivers involved in fisheries have better access to fish. However, it is possible that this disparity is due to other reasons. One explanation for this disparity could be the level of education of the caregiver. Our data shows a significant difference in the level of education between fisher mothers and non-fisher mothers. For example, 42% of the fisher mothers have no formal education, while only 18% of the female caregivers in other occupations have no formal education. Likewise, 47% of the females involved in other occupations possess JHS qualifications, while only 24% of the fisher mothers have attended JHS. Even though there was no significant difference in MUAC measurements between the two categories of the children studied, we observed a significantly higher DDS among the children of the caregivers involved in other occupations than that of the fisher mothers. A study done in Ethiopia revealed that household income level, mother’s education level and nutrition literacy had a positive association with minimum dietary diversity (Solomon et al. 2017). We observed a similar scenario in our study. The education level of fisher mothers was significantly lower than that of the mothers involved in other occupations. Only 36% of the children of the fisher mothers were adequately nourished, whereas 64% of the children of mothers with other occupations were adequately nourished. Therefore, these findings suggest that children of families with a low socio-economic status and mothers with no formal education might require special attention in dietary intervention programs.

Conclusion

The primary aim of this study was to assess the nutritional status, dietary diversity, and small fish consumption patterns by collecting data that can then be used to optimize the integration of small fish into interventions aimed at achieving food security in Ghana. We identified a very low prevalence of wasting among the children aged 18–59 months, sampled within the study communities, a finding that contradicts previous studies done in Ghanaian fishing communities. About three-fourths of the children, who participated in the study, consumed a diet with an adequate dietary diversity. We identified over forty different fish species that were consumed in the study communities, of which the majority can be categorized as small fish. Overall, the study participants were found to be frequent consumers of small fish and their caregivers showed a positive attitude towards incorporating small fish into the diet of their children. The second aim of the study was to assess and compare the nutritional status, dietary diversity, and fish consumption patterns between fisher-mothers and mothers with other occupations. An important finding was that the mean DDS of the children of fisher mothers were significantly lower than that of children of mothers with other occupations. This is most likely attributed to the lower levels of education of fisher mothers in comparison to mothers of other occupations within the study sample. However, no significant difference was observed in the DDS across the coastal regions. A higher frequency of consuming flesh foods along with frequent weekly small fish consumption suggests that small fish are a significant part of the diet of children in these coastal fishing communities. Considering the significance of small fish in the diet of coastal communities, we highlight the need for further research focusing on the utilization of small fish to establish it as a safe, nutrient rich food source for the community, especially for children under 5 years. With a third of the employed respondents being fisherfolks, coupled with the availability of a great diversity of small fish in these communities, there is great potential to incorporate small fish into strategies aimed at improving nutrition and food security and to achieve economic sustainability in these communities. Furthermore, the findings of this study provide the basis for further research aimed at the benefits of incorporating small fish into the diet through increased public awareness and community development programs centered on the effective utilization of small fish.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s40152-023-00325-1.

Acknowledgements The authors are thankful to the participated caregivers and the children in the study and to the assembly men, district chief executives, and chief fishermen for giving permission and facilitating access to the study area.

Code availability Not applicable

Author contribution Conceptualization: Bhagya Janananda, Anne Hatløy, Peter Andersen, Yaw Opoku Agyei-Mensah, and Marian Kjellevold; methodology: Bhagya Janananda, Anne Hatløy, Peter Andresen, Matilda Steiner Asiedu, Inger Aakre, and Marian Kjellevold; formal analysis and investigation: Bhagya Janananda, Richard Stephen Ansong, Theophilus Annan, and Frank Peget; writing — original draft preparation: Bhagya Janananda and Marian Kjellevold; writing — review and editing: Bhagya Janananda, Anne Hatløy, Amy Atter, Peter Andersen, Inger Aakre, Richard Stephen Ansong, Yaw Opoku Agyei-Mensah, Matilda Steiner Asiedu, and Marian Kjellevold; funding acquisition: Peter Andersen; resources: Amy Atter, Matilda Steiner Asiedu; and supervision: Amy Atter, Anne Hatløy, Peter Andersen, Matilda Steiner Asiedu, and Marian Kjellevold.

Funding Open access funding provided by Institute of Marine Research. This work was funded by the LEAP-Agri ERA-Net co-fund project "SmallFishFood" under Grant Agreement No. 727715 and supported by funds from the Research Council of Norway and the Federal Ministry of Food and Agriculture of Germany.

Data Availability The raw data are not publicly available due to containing information that could compromise the privacy of research participants.

Declarations

Ethical approval Regional Committees for Medical and Health Research Ethics ((REK), Reference number: 160065), Norway and Noguchi Memorial Institute for Medical Research ((NMIMR), Study Number: 009/20-21), Ghana. A thorough project description, including the project proposal and the proposed interview guide were all submitted as part of the requirements to meet the ethical approvals.

Consent to participate Permission was sought from the assembly man, district chief executive, or the chief fisherman, and from the head of the household if applicable. Before the start of each interview, the nature of the research to its full extent was explained to the respondents including the fact that they could withdraw at any time without giving reasons. Verbal consent was sought from the interviewees.

Consent for publication Not applicable

Conflict of interest The authors declare no competing interests.

References

Agyei-Mensah, Yaw Opoku, Theophilus Annan, Ragnhild Overå, Amy Atter, Anne Hatløy, Peter Andersen, Kojo Odei Obiri, Richard Stephen Ansong, Bhagya Janananda, Matilda Steiner-Asiedu, and Marian Kjellevold. 2023. The processing, preparation, and cooking practices of small fish among poor Ghanaian households: an exploratory qualitative study. *Maritime Studies* 22 (2): 15. https://doi.org/10.1007/s40152-023-00300-w.

Aikins, Eric K.W. 2018. Challenges of sustainable marine fishing in Ghana. *International Journal of Animal and Veterinary Sciences* 12 (10): 337–348.

Akpalu, W., Eriksen, S. S., & Vondolia G. K. (2018) *The fisheries sector in Ghana: A political economy analysis*. Norwegian Institute of International Affairs. NUPI Report 7 (2018).

Asiedu, Berchie, Pierre Failler, and Yolaine Beygens. 2018. Ensuring food security: an analysis of the industrial smoking fishery sector of Ghana. *Agriculture & Food Security* 7 (1): 38. https://doi.org/10.1186/s40066-018-0187-z.

Bandoh, Delia Akosua, Abubakar Manu, and Ernest Kenu. 2018. Lacking in abundance: undernutrition in a Peri-urban fishing community in Coastal Ghana. *BMC Nutrition* 4 (1): 20. https://doi.org/10.1186/s40795-018-0229-8.

Barro, Mouhamed, Mohamed Daouda Baro, Djibril Cisse, Noel Zagre, Thierno Ba, Shanti Neff Baro, and Yacouba Diagana. 2021. Upper arm length along with mid-upper arm circumference to enhance wasting prevalence estimation and diagnosis: sensitivity and specificity in 6–59-months-old children. *Family Medicine and Community Health* 9 (2): e000748. https://doi.org/10.1136/fmch-2020-000748.

Bavinck, M., M. Ahern, H.M. Hapke, D.S. Johnson, M. Kjellevold, J. Kolding, R. Overå, and T. Schut. 2023. Small, low-cost fish for food and nutrition security. In *Technical Paper*. Rome: FAO.

Belhabib, Dyhia, U. Rashid Sumaila, and Daniel Pauly. 2015. Feeding the poor: contribution of West African fisheries to employment and food security. *Ocean & Coastal Management* 111: 72–81. https://doi.org/10.1016/j.ocecoaman.2015.04.010.

Bimpong, K.A., E.K. Cheyuo, A. Abdul-Mumin, M.A. Ayanore, C.K. Kubuga, and V. Mogre. 2020. Mothers' knowledge and attitudes regarding child feeding recommendations, complementary feeding practices and determinants of adequate diet. *BMC Nutrition* 6 (1): 67. https://doi.org/10.1186/s40795-020-00393-0.

Bomfeh, K., L. Jacxsens, W.K. Amoa-Awua, I. Tandoh, E.O. Afoakwa, E.G. Gamarro, Y.D. Ouadi, and B. De Meulenaer. 2019. Reducing polycyclic aromatic hydrocarbon contamination in smoked fish in the Global South: a case study of an improved kiln in Ghana. *Journal of the Science of Food and Agriculture* 99 (12): 5417–5423. https://doi.org/10.1002/jsfa.9802.

Can, Mehmet, Aytekin Gunlu, and Hayriye Can. 2015. Fish consumption preferences and factors influencing it. *Food Science and Technology* 35: 339–346. https://doi.org/10.1590/1678-457X.6624.

CFSVA. (2020) Comprehensive Food Security & Vulnerability Analysis, Ghana (2020). https://docs.wfp.org/api/documents/WFP-0000137744/download/

Coastal Resources Center. (2018). Fisheries and Food Security: A briefing from the USAID/Ghana Sustainable Fisheries Management Project, January 2018. The USAID/Ghana Sustainable Fisheries Management Project (SFMP). Narragansett, RI: Coastal Resources Center, Graduate School of Oceanography, University of Rhode Island.

Comprehensive Food Security & Vulnerability Analysis, Ghana (2020). https://docs.wfp.org/api/documents/WFP-0000137744/download/

Consalez, F., M. Ahern, P. Andersen, and M. Kjellevold. 2022. The effect of the meat factor in animal-source foods on micronutrient absorption: a scoping Review. *Advances in Nutrition* 13 (6): 2305–2315. https://doi.org/10.1093/advances/nmac089.

Clapp, Jennifer, William G. Moseley, Barbara Burlingame, and Paola Termine. 2021. Viewpoint: the case for a six-dimensional food security framework. *Food Policy*: 102164. https://doi.org/10.1016/j.foodpol.2021.102164.

Cochran, W.G. 1977. *Sampling techniques*. John Wiley & Sons.

Crawford, B., L. Gonzales, D. Amin, B. Nyari-Hardi, & Y.A. Sarpong. (2016)*Report on the baseline survey of small pelagic fishing households along the Ghana Coast*. The USAID/Ghana Sustainable Fisheries Management Project (SFMP) Narragansett, RI: Coastal Resources Center, Graduate School of Oceanography, University of Rhode Island. GH2014_PGM187_CRC. 122 pp.

Diei-Ouadi, Y., & Mensah, M. E. (2005). *Improving livelihoods through exporting artisanally processed fish*. FAO Fisheries No. 998, (35 pp). Rome, Italy: FAO. https://www.cabdirect.org/cabdirect/abstract/20053208654

FAO. 2016. Fishery aned aquaculture country profiles. Ghana FAO Fisheries and Aquaculture Department [online]. http://www.fao.org/fishery/facp/GHA/en.

Frempong, Raymond, and Samuel Annim. 2017. Dietary diversity and child malnutrition in Ghana. *Heliyon* 3: e00298. https://doi.org/10.1016/j.heliyon.2017.e00298.

Ghana, Statistical Service. 2014. *Ghana living standards survey round 6 (GLSS 6)*. https://studylib.net/doc/11934945/

Gibson, Emily, Natasha Stacey, Terry C.H. Sunderland, and Dedi S. Adhuri. 2020. Dietary diversity and fish consumption of mothers and their children in fisher households in Komodo District, eastern Indonesia. *PLOS ONE* 15 (4): e0230777. https://doi.org/10.1371/journal.pone.0230777.

Hasselberg, A.E., L. Wessels, I. Aakre, F. Reich, A. Atter, M. Steiner-Asiedu, S. Amponsah, J. Pucher, and M. Kjellevold. 2020. Composition of nutrients, heavy metals, polycyclic aromatic hydrocarbons and microbiological quality in processed small indigenous fish species from Ghana: Implications for food security. *PLoS One* 15 (11): e0242086. https://doi.org/10.1371/journal.pone.0242086.

Hicks, Christina C., Philippa J. Cohen, Nicholas A.J. Graham, Kirsty L. Nash, Edward H. Allison, Coralie D'Lima, David J. Mills, Matthew Roscher, Shakuntala H. Thilsted, Andrew L. Thorne-Lyman, and M. Aaron MacNeil. 2019. Harnessing global fisheries to tackle micronutrient deficiencies. *Nature* 574 (7776): 95–98. https://doi.org/10.1038/s41586-019-1592-6.

Kawarazuka, Nozomi, and Christophe Béné. 2011. The potential role of small fish species in improving micronutrient deficiencies in developing countries: building evidence. *Public Health Nutrition* 14: 1927–1938. https://doi.org/10.1017/S1368980011000814.

Kolding, J., P. van Zwieten, F. Marttin, S. Funge-Smith, and F. Poulain. 2019. *Freshwater small pelagic fish and their fisheries in the major African lakes and reservoirs in relation to food security and nutrition, FAO Fisheries and Aquaculture Technical Paper*. Rome, Italy: FAO.

Lamsal, Krishna Prasad, Kedar Raj Parajuli, Bhim Kumari Pun, Ramesh Prasad Adhikari, Manoj Bashyal, Baburaja Dangol, and Kenda Cunningham. 2021. Accuracy of using mid-upper arm circumference to detect wasting among children aged 6–59 months in Nepal. *Global Health: Science and Practice* 9 (4): 881–889. https://doi.org/10.9745/ghsp-d-20-00450.

Marinda, P.A., S. Genschick, C. Khayeka-Wandabwa, R. Kiwanuka-Lubinda, and S.H. Thilsted. 2018. Dietary diversity determinants and contribution of fish to maternal and under-five nutritional status in Zambia. *PLoS One* 13 (9): e0204009. https://doi.org/10.1371/journal.pone.0204009.

Mutimukuru-Maravanyika, T., Asare, C., Laryea, J., Ameyaw, G., Boachie-Yiadom, T. and Mills, D. (2013) *Training workshop proceedings: Adaptive co-management of fisheries*. WorldFish.

Navas-Carretero, Santiago, Ana M. Pérez-Granados, Beatriz Sarriá, Angeles Carbajal, Mercedes M. Pedrosa, Mark A. Roe, Susan J. Fairweather-Tait, and M. Pilar Vaquero. 2008. Oily fish increases iron bioavailability of a phytate rich meal in young iron deficient women. *Journal of the American College of Nutrition* 27 (1): 96–101. https://doi.org/10.1080/07315724.2008.10719680.

Obeng, B. A., Anderson, A., Box, A. H., & Ghana, A. A. (2010). The social constraints on entrepreneurship in a poor Ghanaian fishing community. Ghana Institute of Management and Public Administration (GIMPA). Accra, Ghana. Available at: https://www.researchgate.net/publication/228359477_The_social_constraints_on_entrepreneurship_in_a_poor_Ghanaian_fishing_community

Onumah, Edward E., Elizabeth A. Quaye, Anderson K. Ahwireng, and Benjamin B. Campion. 2020. Fish consumption behaviour and perception of food security of low-income households in urban areas of Ghana. *Sustainability* 12 (19): 7932.

High Level Panel of Experts (HLPE) on Food Security and Nutrition 2014 Sustainable Fisheries and Aquaculture for Food Security and Nutrition (Rome: FAO). https://www.fao.org/3/i3844e/i3844e.pdf

Rehulkova, Eva, Maria Kičinjaová, Zuheir Mahmoud, Milan Gelnar, and Maria Seifertova. 2019. Species of Characidotrema Paperna & Thurston, 1968 (Monogenea: Dactylogyridae) from fishes of the Alestidae (Characiformes) in Africa: new species, host-parasite associations and first insights into the phylogeny of the genus. *Parasites & Vectors* 12. https://doi.org/10.1186/s13071-019-3580-y.

Roos, N., T. Leth, J. Jakobsen, and S.H. Thilsted. 2002. High vitamin A content in some small indigenous fish species in Bangladesh: perspectives for food-based strategies to reduce vitamin A deficiency. *International Journal of Food Sciences and Nutrition* 53 (5): 425–437. https://doi.org/10.1080/0963748021000044778.

Roos, Nanna, Mohammed M. Islam, and Shakuntala H. Thilsted. 2003. Small indigenous fish species in Bangladesh: contribution to vitamin a, calcium and iron intakes. *The Journal of Nutrition* 133 (11): 4021S–4026S. https://doi.org/10.1093/jn/133.11.4021S.

Rutstein, Shea, and Kiersten Johnson. 2004. *The DHS Wealth Index*.

Solomon, D., Z. Aderaw, and T.K. Tegegne. 2017. Minimum dietary diversity and associated factors among children aged 6-23 months in Addis Ababa, Ethiopia. *International Journal for Equity in Health* 16 (1): 181. https://doi.org/10.1186/s12939-017-0680-1.

Tall, A., Failler P. (2012). Fishery and aquaculture industry in Ghana. Series Report N 1 of the Review of the Fishery and Aquaculture Industry in the 22 ATLAFCO Member States, 52, 52.

Thilsted, S.H. 2012. The potential of nutrient-rich small fish species in aquaculture to improve human nutrition and health. In *Farming the waters for people and food. Proceedings of the Global conference on aquaculture 2010. Phuket, Thailand*, ed. R. Subasinghe, J. Arthur, D.M. Bartley, S.S. De Silva, M. Halwart, N. Hishamunda, C.V. Mohan, and P. Sorgeloos. Rome and NACA, Bangkok: FAO.

USAID. (2018). Ghana. Nutrition Profile. Available at: https://2017-2020.usaid.gov/sites/default/files/documents/1864/Ghana-Nutrition-Profile-Mar2018-508.pdf

USFDA. (2022). Questions & answers from the FDA/EPA advice about eating fish for those who might become or are pregnant or breastfeeding and children ages 1 to 11 years. Available at: https://www.fda.gov/food/consumers/questions-answers-fdaepa-advice-about-eating-fish-those-who-might-become-or-are-pregnant-or#III

Walker, Barbara. 2002. Engendering Ghana's seascape: Fanti fishtraders and marine property in colonial history. *Society & Natural Resources* 15: 389–407. https://doi.org/10.1080/08941920252866765.

WHO, UNICEF, IFPRI, UC Davis, USAID, FANTA, Macro International. 2008. *Indicators for assessing infant and young child feeding practices*. Geneva: World Health Organization.