

Socioeconomics and management of small cetacean bycatch in Ghana

SAMUEL K. K. AMPONSAH¹, BERCHIE ASIEDU¹, ANDREWS APRAKU¹, LESLEY NTIM¹,
PIERRE FAILLER², SAMUEL HENNEH¹, WILLIAM AMEKOR¹, RACHAEL ACKAH¹ AND
KOEN VAN WAEREBEEK³

Contact email: berchie.asiedu@uenr.edu.gh

ABSTRACT

Small cetacean bycatch in artisanal fisheries and deep-sea fishing operations is a serious and persistent threat to conservation in coastal communities in Ghana. We assessed the bycatch and management of small cetaceans in four coastal communities by administering 73 questionnaires to fishers and recording their catches. Our findings show that dolphin feeding habits, gear attributes and habitat use of targeted finfish species were the main factors driving bycatch of small cetaceans in Ghana. Gear damage and reduced catches were among the effects of bycatch reported by fishers. In addition to direct consumption of small cetacean meat, fishers use them as bait in shark-fishing activities. Our results suggest the livelihood of over 70% of fishers will be threatened if management measures are implemented. Fishers were unaware of the Wildlife Division that manages small cetaceans in Ghana. We recommended that a co-management approach between the government and locals should be adopted when developing and implementing measures for the conservation of small cetaceans. A community awareness programme should be carried out to raise awareness about threats facing these species and the importance of conservation.

KEYWORDS: BAIT; CONSUMPTION; DOLPHINS; FISHERS; FISHING GEAR; CONSERVATION

INTRODUCTION

The incidental catch of non-target marine mammals in fisheries, known as bycatch, is a worldwide problem (Lewison *et al.*, 2004; Read *et al.*, 2006; Reeves *et al.*, 2013). Bycatch occurs when species not targeted by fishers are incidentally and unintentionally hooked, entangled or trapped by fishing gear (Hall *et al.*, 2000). Cetaceans are particularly vulnerable to the risk of bycatch mortality due to low rates of potential population growth (Read *et al.*, 2006; Read, 2008). Most marine mammal species are affected by bycatch (Read, 2013). In some cases, bycatch is driving species to extinction, such as the Vaquita, the world's smallest and most endangered porpoise endemic to the upper Gulf of California which is by-caught in gillnets (Reeves, 2022). Bycatch not only affects marine mammal populations. It also has wide-ranging impacts on the entire marine ecosystem, including target species, through the reduction of nutrients that are provided by marine mammals (Lavery *et al.*, 2014). While there has been some progress in reducing marine mammal bycatch in some countries, including the United States (Geijer and Read, 2013), most fisheries lack adequate measures to meet bycatch reduction goals (Van Der Hoop *et al.*, 2013), thus threatening the Sustainable Development Goal 14: 'Life below water'.

For marine economists, bycatch is identified as an unpriced or underpriced negative externality which, in this case, has an unintended adverse impact of fishing. The 'costs' of bycatch in terms of impacts on the marine

¹ Department of Fisheries and Water Resources, University of Energy and Natural Resources, P.O. Box 214, Sunyani, Ghana

² Centre for Blue Governance, University of Portsmouth, Richmond Building, Portland Street, Portsmouth, PO1 3DE, UK

³ Conservation and Research of West African Aquatic Mammals (COREWAM), Accra, Ghana

ecosystem and marine mammals are not factored into the costs of fishing: the externality has not been included as part of the individual operator's decision-making. Seafood from fisheries which experience marine mammal bycatch is therefore overproduced and underpriced (Lent and Squires, 2017). Megafauna bycatch, including bycatch of marine mammals, elasmobranchs, seabirds and marine turtles, presents a global resource-management challenge as many marine megafauna migrate between ocean basins, necessitating international action, coordination and, in some cases, the introduction of policy instruments to address bycatch at regional and international levels. Understanding these problems and developing effective bycatch reduction strategies is a complex challenge with a mixture of scientific, sociocultural and socioeconomic components. Most cetacean bycatch occurs in drift gillnet fisheries, but there is also notable bycatch in other types of gear as well, including longlines, set gillnets, stow nets, seines, trawls and pot or trap gear (Read, 2008; Reeves *et al.*, 2006; Read *et al.*, 2013; Soykan *et al.*, 2008; Lewison *et al.*, 2014). Most reported bycatch occurs in industrial fisheries, although bycatch in small-scale artisanal fisheries can still be substantial (Soykan *et al.*, 2008; Mangel *et al.* 2010; Reeves *et al.*, 2013; Lewison *et al.*, 2014).

Small cetaceans are important to the culture, legends, traditions and heritage of many people living in western Africa and Macaronesia. In some traditions, they are viewed as incarnations of humans. According to the mythology of the Ewe people, for example, in eastern Ghana, Benin and Togo, embodied life begins in the ocean and a dead cetacean requires respect and occasionally even a ceremony (Segniagbeto *et al.*, 2012; Sohou *et al.*, 2013). Over 30 million of Ghana's population relies on its fishery resources. In the 1980s, the sale of dolphin meat led to a rise in the sale of mammals, and now – both in terms of the number of dolphins landed and the variety of dolphin species obtained – dolphin captures in Ghana are among the highest and best documented in West Africa. At least 18 species are occasionally bycaught, most in gillnets (Van Waerebeek and Ofori-Danson, 1999; Alfaro and Van Waerebeek, 2001; Debrah *et al.*, 2010; Ofori-Danson *et al.*, 2003; 2012; Van Waerebeek *et al.*, 2014; 2019; de Boer *et al.*, 2016). Since the mid-1990s, landing rates have significantly increased along the coast of Ghana. These communities include Apam, Dixcove and Axim, where dolphin bycatch has transitioned to direct catches. Between 2001–03, the proportion of bycatch in direct catches increased from 1.11% to 5.57% in the Apam fishing community (Debrah *et al.*, 2010; Ofori-Danson *et al.*, 2003). In Dixcove, between 2013–14, 743 dolphins were landed, representing an almost 400% increase from 2003 levels (Van Waerebeek *et al.*, 2014; Debrah *et al.*, 2010). The commercial use of these small cetaceans as food and bait have accelerated their exploitation by artisanal fishers in Ghana (Debrah *et al.*, 2010; Ofori-Danson *et al.*, 2003; Van Waerebeek *et al.*, 2009; 2014; Robards and Reeves, 2011; Weir and Pierce, 2013). As a direct threat, the management of bycatch needs to happen in real time with realistic strategies. More information is required for decision-making. From a legal perspective, despite the presence of a legal instrument (LI 685) that seeks to protect aquatic mammals, there is no particular section aimed at protecting marine mammals in Ghana (Ofori-Danson *et al.*, 2003). Furthermore, even though mammals are among the first schedule of Ghana's 1971 Wildlife Conservation Regulations (LI 685), there are no explicit instructions concerning the use of cetaceans killed in nets (Debrah *et al.*, 2010). Our study tries to establish the state of small cetacean bycatch in Ghana from a socioeconomic and management perspective. The data gathered will be useful for better management of these vulnerable marine mammals.

MATERIAL AND METHODS

Study areas

The study was conducted in four coastal communities: Tema (5°38'39.2"N, 0°01'00.7"E) in the Greater Accra region; Apam (5°17'15.6"N, 0°43'47.1"W) in the Central region; Dixcove (4°47'37.6"N, 1°56'50.0"W) and Axim (4°51'51.7"N, 2°14'34.6"W), both in the Western region of Ghana (Figure 1). These fishing communities were selected as hotspots for dolphin bycatch (Van Waerebeek and Ofori-Danson, 1999; Van Waerebeek *et al.*, 2014). Fishers in these communities use purse seine nets (64%), hook and line (12%), *Ali* net (3%), drifting gillnet (13%), set gillnet (6%), and one-man canoe (2%) gears. *Ali* is a Sardinella drift/surround net, while *watsa* and *poli* are types of purse seine, the main difference being twine and mesh size. The *poli*, which has a much smaller mesh

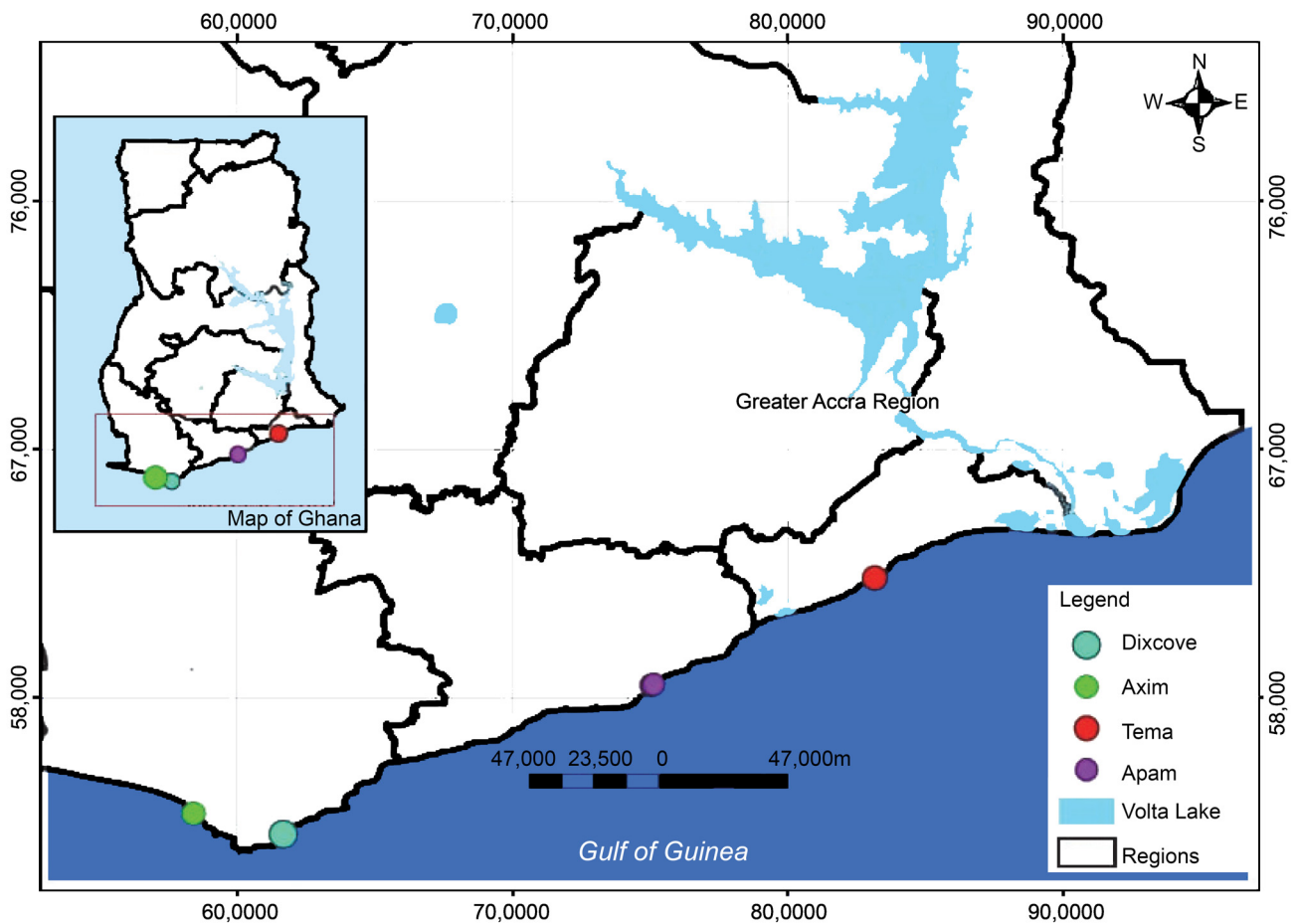


Fig. 1. A map showing the study area

size, is extensively used for the capture of anchovy while the *watsa* is mainly used for larger-sized pelagic species. Drift gillnets may be either multifilament or monofilament (Dovlo *et al.*, 2016).

Selection of respondents and data collection

The criteria used to select fishers at the various sampling locations were as follows: (a) respondent must be an active fisher; and (b) at least age 25. Additionally, all Chief Fisherman (CF) and Fisheries Technical Officers (FTOs) were selected and interviewed. We obtained the number of canoes that land cetaceans in each location from these FTOs (average < 50). In March 2022, 30 written questionnaires were distributed in each of the four selected landing sites (120 in total) using the snowball technique; however, only 73 were retrieved. Verbal consent was obtained before administering the questionnaires. Data collection of small cetaceans landed at each sampling location was done in the morning between 6:30–11am. The questionnaires were separated into four parts: (a) respondent demographics; (b) bycatch of small cetaceans; (c) socioeconomics of small cetacean bycatch; (d) management of marine mammal bycatch on the coast of Ghana. The full questionnaire can be found in Appendix 1. Responses were gathered on a five-point Likert scale: (1) strongly disagree; (2) disagree; (3) neutral; (4) agree; (5) strongly agree. Respondents were asked to select only one option for certain questions, including the use of cetacean meat.

Data analysis

Completed questionnaires were transcribed and coded for analysis. The descriptive statistics used for the study include frequency counts and percentages. A P-P plot was used to check for normality of data before the application of either parametric or non-parametric tests. Income from small cetacean and target catches was compared using a Mann-Whitney Test. The statistical tools used for the study were Statistical Package for Social Sciences (SPSS) 26 and Minitab 19.1.

RESULTS

Socioeconomic features of small cetacean bycatch

More than one-third of respondents (38.4%) hunt small cetacean species. Almost all respondents (98.6%) accidentally catch small cetaceans. Most respondents (90.4%) confirmed the existence of markets for the sale of small cetaceans, with 71.2% obtaining income from the sale of these species. Most landed small cetaceans are sold to fish traders (75.3%) at the landing beach. In addition, the vast majority of respondents (93.2%) indicated that small cetacean populations are in decline (Table 1).

Table 1
Socioeconomic characteristics of small cetacean bycatch from the response of fishers ($n = 73$ questionnaires).

Variables	Frequency	Percentage (%)
Purposely fish for small cetaceans?		
Yes	28	38.4
No	45	61.6
Do you catch marine mammals?		
Yes	72	98.6
No	1	1.4
Income from small cetacean sale?		
Yes	52	71.2
No	21	28.8
Any market for cetacean meat?		
Yes	66	90.4
No	7	9.6
Any decline noticed in the cetacean populations?		
Yes	68	93.2
No	5	6.8
Major consumer		
Fish traders	55	75.3
Fish processors	18	24.7

Factors affecting bycatch

While respondents agreed that all suggested factors have contributed to small cetacean bycatch, habitat use with fish species (median = 4.0), feeding habitats (median = 4.0) and gear attributes (median = 4.0) were found to be the main factors (Figure 2). Fishing gears, mostly multifilament nylon gillnets and purse-seine nets but also monofilament gillnets, are very strong which makes it difficult for small cetaceans to escape once entangled.

Fishing gear and small cetacean bycatch

The respondents reported three main fishing gears are responsible for small cetacean bycatch: drifting gillnet (DGN); *ali-poli-watsa* (APW); hooks and lines (Figure 3). Multifilament drift gillnets were widely used (57% of respondents), followed by APW (22%) and hook (21%).

Impact of small cetacean bycatch

Respondents were less certain about the suggested impacts of small cetacean bycatch on the activities of fishers. Only damage to fishing gear had a median value above 'neutral' (median = 3.50) while other possible impacts were ranked neutral overall (median = 3.0) (Figure 3).

Landed small cetaceans

Some respondents reported that they either consume the cetaceans as food (27.6%) or use the meat as bait for shark fishing (21.9%). Over half of the respondents (50.5%) sold any small cetaceans caught, although the mean income was smaller (GH¢ 590 ± 186) than income from target fish species (GH¢ 1436 ± 278; Mann-Whitney Test, W -value = 1715, p -value < 0.001).

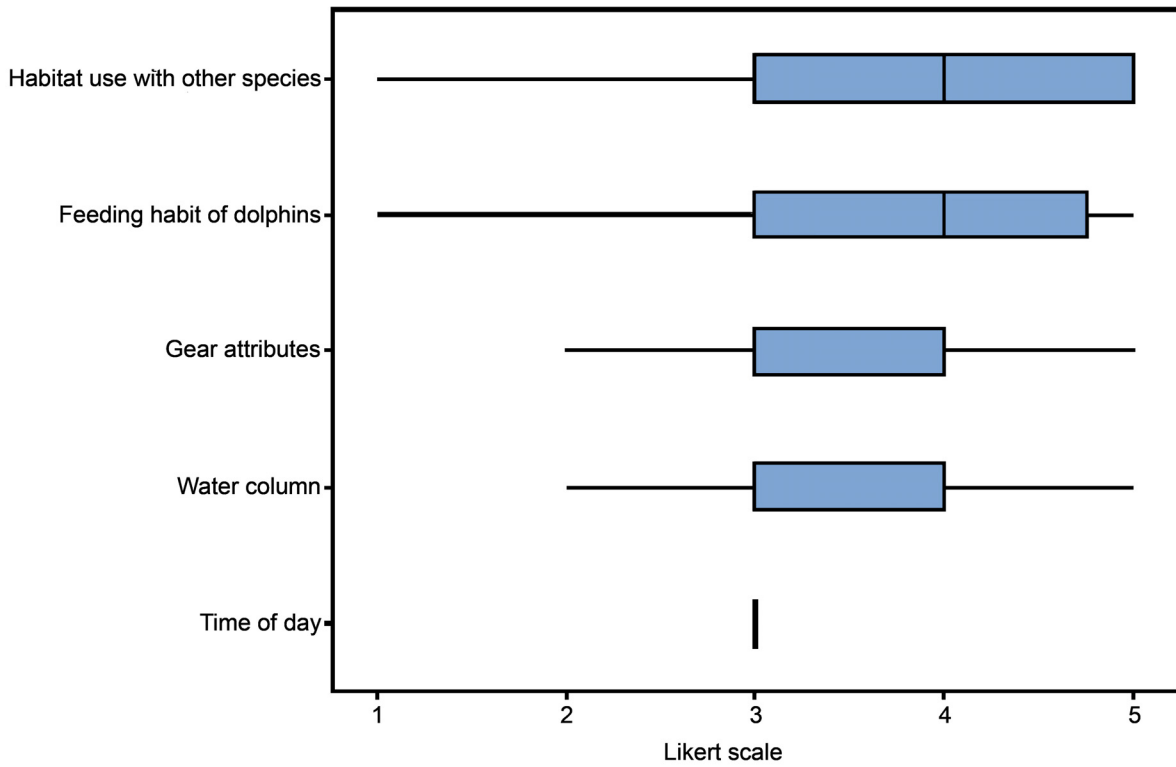


Fig. 2. Box plot shows the distribution of responses to questions on factors affecting cetacean bycatch where the central bar shows the median, the boxes represent quartiles, and the tails represent the range. Likert scale ranges from (1) strongly disagree to (5) strongly agree.

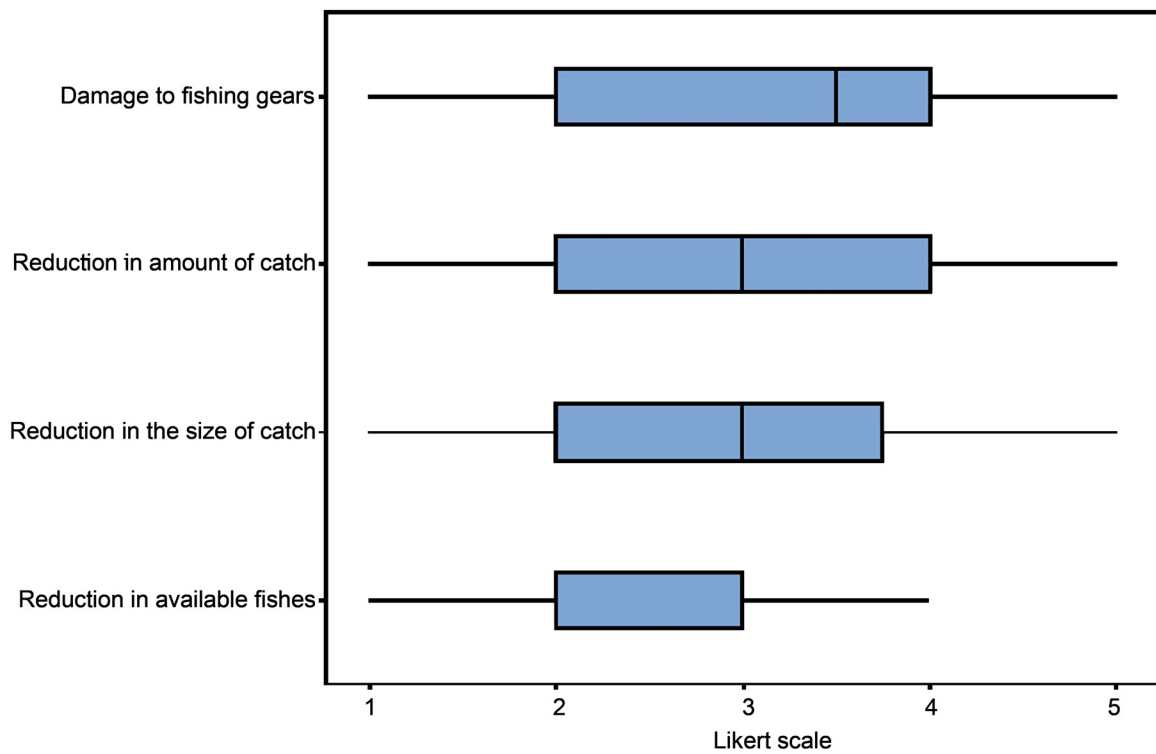


Fig. 3. Box plot shows the distribution of responses to questions on the impact of cetacean bycatch on the Likert scale where the central bar shows the median, the boxes represent quartiles, and the tails represent the range. Likert scale ranges from (1) strongly disagree to (5) strongly agree.

Small cetaceans bycatch from a management perspective

The majority of respondents (67.1%) were unaware of the organisation that decides on small cetacean management issues (Table 2). Most respondents (80.8%) expressed the view that the landing of small cetaceans should not have any implications on the wider ecosystem (Table 2).

Table 2
Small cetacean bycatch from the perspective of existing management options (*n* = 73 questionnaires).

Variables	Frequency	Percent
Any idea of institutions making decisions?		
Yes	49	67.1
No	24	32.9
Is it bad to land small cetaceans?		
Yes	14	19.2
No	59	80.8

Suggested management measures

With the exception of the use of acoustic devices (median = 4.0), respondents remained neutral on the suggested management measures (Figure 4). Small cetacean buyback implies the purchase of landed small cetaceans by relevant authorities.

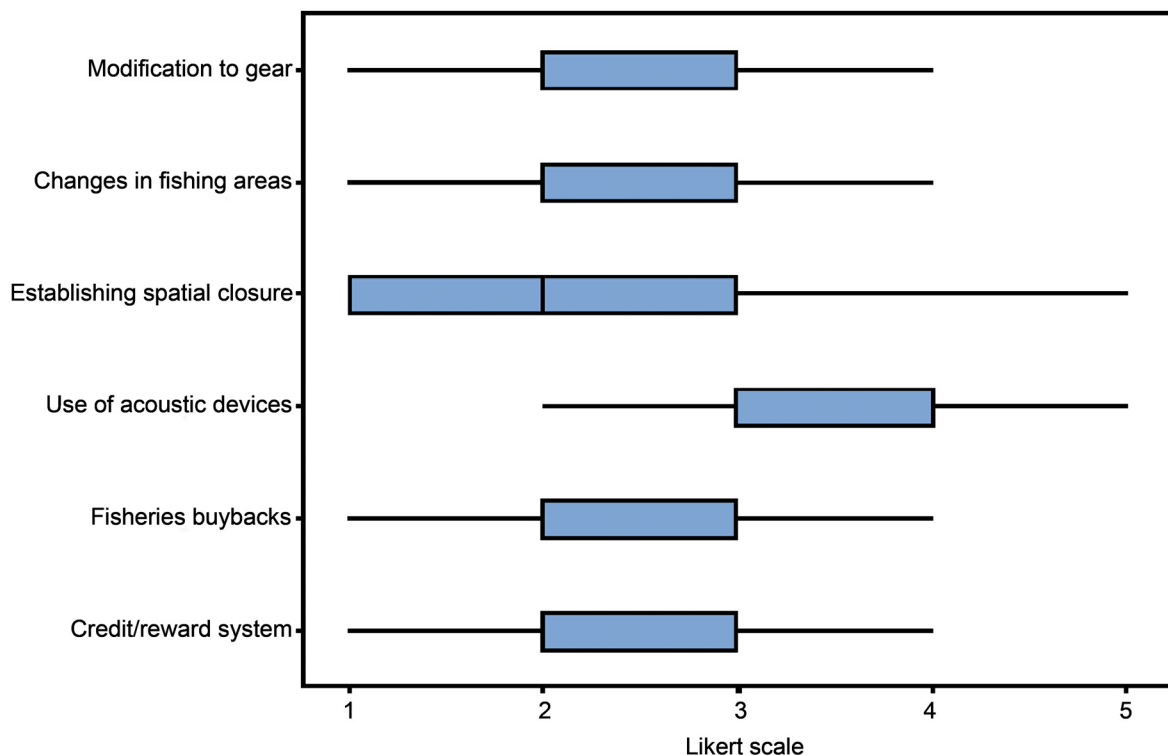


Fig. 4. Box plot shows the distribution of responses to questions on suggested management measures for cetacean bycatch where the central bar shows the median, the boxes represent quartiles, and the tails represent the range. Likert scale ranges from (1) strongly disagree to (5) strongly agree.

Impact of suggested management measures

A large majority of respondents (78.1%) confirmed that suggested measures would affect their livelihoods, particularly the financial stability of their households, but 74% of respondents confirmed their willingness to adhere to these measures if implemented by appropriate fisheries authorities (Table 3).

Table 3
Anticipated impact of suggested management measures on livelihoods
and willingness to adhere to suggested management measures
(n = 73 questionnaires).

Variables	Frequency	Percent
Will conservation measures of cetaceans affect the livelihood of fishers?		
Yes	57	78.1
No	16	21.9
Willing to adhere to these measures?		
Yes	57	74.0
No	16	21.9

DISCUSSION

Small cetacean bycatch from a socioeconomic perspective

Feeding habits and gear attributes were identified by fishers as the main factors which drive small cetacean bycatch in Ghana. The habitat preference of small cetaceans relies on the availability of prey items (Bearzi *et al.*, 2011). Various small cetacean species and large pelagic species, such as tuna, share similar feeding niches because small pelagic species, such as sardines, provide prey for both (Ofori-Danson *et al.*, 2003). Small cetaceans such as *Stenella* sp. generally move with fast-swimming pelagic fish species in search of similar food items and become entangled in drifting gillnets as a result (Ofori-Danson *et al.*, 2003). There is therefore a high likelihood of small cetacean bycatch when fishing for small pelagic species (Jiménez *et al.*, 2018). For example, yellowfin tuna (*Thunnus albacares*) have been linked to some dolphin schools (Xu *et al.*, 2019), which means effort to capture these target species can result in small cetacean bycatch. In Ghana, hook and line is the most effective gear in yellowfin tuna fisheries. Poor fishing gear technology results in a high incidence of bycatch. In reality, a complex ecosystem's trophic structure connects all species and fishing equipment where the interactions occur (Brownell *et al.*, 2019). Predation has an impact on the flow of energy and matter/harvesting operations (Agnetta *et al.*, 2019). Small cetaceans attempting to feed on fish entangled in set gillnets results in entanglement and injury which in turn leads to one or multiple of the following outcomes: (a) death of the mammal; (b) damage to the fishing gear; (c) reduced catch. Bearzi *et al.* (2011) reported that gear damage by small cetaceans is one of the factors that affect seasonal fisheries. Fishers tend to translate fishing gear damage as economic loss. In order to break even, these small marine mammals are harvested for sale so that fishers can afford to repair damaged gear.

Fishers identified drift gillnets as the most dangerous gear for small cetaceans – an observation supported by Zainudin *et al.* (2017), Collins *et al.* (2018) and Brownell *et al.* (2019). In addition, fishers in other fishing communities have suggested that small cetacean meat is well-suited to shark fishing due to its high blood and fat content (Mangel *et al.*, 2010; Barbosa-Filho *et al.*, 2018). Due to the efficacy of small cetacean meat and blubber as bait, some members of fishing communities in Ecuador are willing to pay up to USD75 for a small cetacean carcass as bait in their fishing operations (Castro *et al.*, 2020). The use of small cetaceans as bait is outlawed in many countries, but due to the scarcity of human and financial resources, legal actions are rarely enforced (Barbosa-Filho *et al.*, 2018).

The sale of small cetacean meat is prevalent across coastal communities in Ghana due to the wide range of applications. Ofori-Danson *et al.* (2003) revealed that the consumption of small cetacean meat is widely practised among fishing communities in the western and central regions. The consumption of small cetacean meat has also been identified in other West African countries, including Cape Verde, Senegal, Nigeria, the Gambia and Guinea-Bissau (Van Waerebeek *et al.*, 2003; Leeney *et al.*, 2015). This comes with significant health risks, particularly as small cetaceans accumulate carcinogenic materials, such as mercury and persistent organochlorine pollutants (POPs). The relevant authorities should raise awareness in these fishing communities of the possible health implications. This would help towards SDG Goal 3, 'Good health and well-being', while also contributing towards the conservation of small cetacean species.

Small cetacean bycatch from a management perspective

Effective management will be necessary to maintain sustainable small cetacean populations in the marine ecosystem (Salmin *et al.*, 2019). Many fishers in Ghana share an assumption that the Ministry of Fisheries and Aquaculture Development (MoFAD) through the Fisheries Commission is the main authority entrusted with the management and conservation of small cetaceans, primarily due to the presence of Fisheries Commission officers in fishing communities who record landings of bycaught cetaceans and sea turtles. In fact, the Wildlife Division of the Forestry Commission is responsible for wild mammal conservation in Ghana, in collaboration with the Fisheries Enforcement Unit of the Fisheries Commission. The lack of contact between the Wildlife Division and fishers implies weak adherence to any management measures that may be developed in the future. It is therefore important for the Wildlife Division to develop and implement measures to improve communication with fishing communities. Relevant authorities should create a link with fishing communities and adopt a collaborative management approach to improve adherence to future measures (Ricci *et al.*, 2021). Furthermore, it is worth noting that effective management of small cetacean interactions with fisheries is a very expensive venture, such that it would be economical to embed these measures within a larger management project or fisheries framework (Amir, 2010).

This study also gathered respondents' views on some suggested management measures to mitigate small cetacean bycatch. Results revealed that fishers are most inclined to use acoustic deterrent devices (ADDs) which cover all active sound emitters to reduce marine mammal interactions with fisheries (Dawson *et al.*, 2013). Some ADDs alert the marine mammal to the presence of a fishing net whereas others act to make a particular location so unpleasant that they choose to avoid the area. While some aspects of ADD functionality still remain to be formally tested, there is some evidence for their success in international fisheries where fishers have indicated that ADDs scare dolphins away from nets (Bearzi *et al.*, 2011; Hamilton and Baker, 2019). The use of ADDs is an example of a technological change which reduces the amount of bycatch as a proportion of direct catch (Squire and Garcia, 2014). In contrast, the establishment of spatial closures and changes to fishing areas were less popular among fishers, possibly due to the high incidence of poverty and limited alternative livelihood (Asiedu *et al.*, 2013; Asiedu and Nunoo, 2013), the extent/size of the fishery and limited resources available for maintaining these management measures (Mangel *et al.*, 2013). For the use of ADDs among fishers to be fully implemented, we recommend the following factors are considered: (a) the relevant authorities should be properly resourced; (b) fishers should be allowed to voice their specific concerns for full consideration by the relevant authorities; and (c) fishers are encouraged to participate in mitigation programmes which are intrinsically linked to their wider concerns (Alavraz *et al.*, 2017).

AUTHORSHIP CONTRIBUTION STATEMENT

Samuel K. K. Amponsah: Investigation, Data curation, Formal analysis, Investigation, Visualization, Writing – original draft. Berchie Asiedu: Conceptualisation, Methodology and interpretation, Resources, Writing – critical review & editing, corresponding author. Andrews Apraku and Lesly Ntim: Investigation, Writing – review & editing. Racheal Ackah: Investigation, Writing. William Amekor: Investigation, Writing. Pierre Failler: Conceptualisation, Data analysis, Writing – review & editing. Samuel Henneh: Writing – review & editing. Koen Van Waerebeek: Writing – critical review & editing.

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DECLARATION OF COMPETING INTEREST

The authors declare no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DATA AVAILABILITY STATEMENT

The data which support the findings of this study are available from the corresponding author upon request.

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Appendix 1. Questionnaire

University of Energy and Natural Resources
School of Natural Resources
Department of Fisheries and Water Resources

Dear respondent, this questionnaire is designed to be used for academic research on “Assessing bycatch of small cetaceans in Ghana”. The respondent is assured that the information provided will be treated as confidential. Thank You.

A. DEMOGRAPHICS

1. Gender

Male Female

2. Age

20 or less 21-30 31-40 41-50 61 and above

3. Educational status

Non-Educated Basic Senior High School Vocational School Tertiary

4. Marital status

Married Single Divorced Widow/Widower

5. Years of fishing

1 or less 2-3 3-4 4-5 6 and above

B. Bycatch of small cetaceans

1. Do you catch marine mammals? Y/N

If Yes, what gear do you use in fishing

2. How long have you been fishing for marine mammals?

3. Name at least five (5) species of small cetacean landed by your canoe.

.....

4. What species do you catch during the day?

.....

5. What species do you catch during the night?

.....

6. What species do you catch in shallow waters?

.....

At what depth (in armlength/fathom)?

7. What species do you catch in deep waters?

.....

At what depth (in armlength/fathom)?

8. Do you purposely fish for small cetaceans? Yes/No

If Y/N, why?

9. Rate the following factors which affect the bycatch of marine mammals during fishing from 1 to 5 (**1 = Strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree**).

Factors	5	4	3	2	1
Habitat use with other fishes					
Feeding habit of dolphins					
Gear attributes					
Water column					
Time of day					

10. Rate the following impact of marine mammals on your fishing operations from 1 to 5 (**1 = Strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree**).

Impacts	5	4	3	2	1
Damage to fishing gears					
Reduction in the amount of catch					
Reduction in size of catch					
Reduction in the availability of fishes					

11. Which type (s) of dolphins do you mostly catch?

12. Which type (s) do you rarely catch?

13. Which waters do you mostly catch your dolphins?

14. Averagely, how many dolphins do you catch per trip?

15. What do you do with dolphins you catch?

Eat Sell Discard dead Release alive Other

C. Socio-economics of small cetacean bycatch

1. Do you catch other fishes aside small cetaceans? Yes/No

If yes, name some of these fish species, at least five (5).

2. Do you get more money from the sale of small cetacean than the fish caught? Yes/ No

If Y/N, why?

3. How much do you from get the sale of small cetaceans per trip

4. How much do you get from the sale of the remaining fishes per trip

5. What are the major and minor seasons for small cetaceans landing and what species do you get during these seasons?

Season	Duration or months	Major small cetaceans caught
Major		
Minor		

6. Has the abundance of small cetacean decline over the last decade (since 2012)? Yes/No

If Y/N, why?

.....

7. Is there a market for small cetacean? Yes/No

8. If Yes, who are your major customers?

9. What do these customers use the small cetaceans for?

.....

D. Management of marine mammal bycatch

1. Do you know the organization that makes decision pertaining to marine mammal bycatch management? Y/ N

If Yes, name at least one (1) organization

If No, why?

2. Are you aware of any management measures/rules about harvesting marine mammals?

2a. If Yes, name at least one (1)

Are these rules adhered to by fishermen? Y/N

If No, why?

Are these rules enforced? Y/N

If No, why?

2b. If No, why?

3. Is it a bad practice to land marine mammals? Yes/No

If Yes, why?

If No, why?

4. Do you believe implementing a bycatch law on marine mammal landing will affect your livelihood? Yes/No

If Yes, why?

If No, why?

5. Are you willing to adhere to the marine mammal bycatch mitigation measures? Yes/No

If Yes, why?

If No, why?

6. Rate the following mitigation measures for bycatch of marine mammals from 1 to 5 (1 = Strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree).

Impacts	5	4	3	2	1
Modification to gear					
Changes in fishing areas					
Spatial closures					
Use of acoustic or alerting devices					
Fisheries buybacks					
Credit/reward system					

7. Do you believe implementing any of these mitigation measure will affect your livelihood? Yes/No

8. Are willing to adhere to these measures? Yes/No

THANK YOU FOR YOUR TIME