Commercial and Recreational Angler Conflict with Coastal Wildlife on the Alabama Coast: Protecting Sea Turtles and Dolphins with Greater Awareness

by

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Abstract

Human-wildlife interactions in the Gulf of Mexico fisheries, especially along Alabama's coast, increasingly impact for-hire fishing industries and commercial shrimp industries. Both industries face growing challenges from non-targeted wildlife like dolphins and sea turtles leading to bycatch, depredation, and scavenging, posing significant challenges to fishery sustainability and marine wildlife conservation. Our research characterizes human-wildlife conflicts within Alabama's for-hire fishing industry and commercial shrimp industry, assessing fishermen's perceptions towards dolphins and sea turtles, knowledge of wildlife laws, and willingness to support conservation initiatives through surveys and interviews. Our findings highlight significant concerns about dolphin depredation and scavenging, which disrupt fishing operations and harm marine wildlife. While conflicts between fishermen and sea turtles are rare due to the use of turtle excluder devices, these devices remain controversial among fishermen due to operational challenges and bycatch issues attracting dolphins. This research underscores the need for continued education on wildlife-friendly gear and practices to prevent negative human-wildlife interactions, with implications for broader marine conservation initiatives in other commercial fisheries.

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List of Abbreviations

EEZ Exclusive economic zone

ESA Endangered Species Act

MMPA Marine Mammal Protection Act

BP British Petroleum

NOAA National Oceanic and Atmospheric Administration

ADCNR/MRD Alabama Department of Conservation and Natural Resources, Marine Resource Division

TEDs Turtle excluder devices

NOAA Fisheries National Marine Fisheries Service

MSA Magnuson-Stevens Fishery Conservation and Management Act

Assessing Marine Wildlife Interactions with the Charter Boat Fishing Industry on the Alabama Gulf Coast

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Assessing Marine Wildlife Interactions with the Charter Boat Fishing Industry on the Alabama Gulf Coast

Abstract

Human-wildlife interactions have increased in scale and complexity in the Gulf of Mexico's for-hire fishing industry, particularly off Alabama's coast. These fisheries rely on productive reef fish communities, supporting a consistent, local, and tourist fishing community. However, they also face increasing interactions with non-targeted wildlife like dolphins and sea turtles, leading to challenges such as depredation, scavenging, and accidental gear interactions. This study assesses these conflicts, industry threats, and management challenges through surveys and interviews of Alabama's charter captains and deckhands. Findings revealed low awareness of proper protocols for reporting stranded or injured wildlife but a high willingness to report such incidents. Dolphin interactions were frequent (41% had gear interactions, 51% observed scavenging), while sea turtle interactions were rare (86% never had gear interactions). Qualitative data revealed the complexity of these conflicts, emphasizing the need for targeted education and better enforcement of wildlife protection laws to support sustainable fishing practices.

Keywords: For-hire fisheries, human-wildlife interactions, dolphins, sea turtles, Gulf of Mexico

Introduction

Fishing on a charter is one of the most important forms of outdoor recreation in the Gulf of Mexico, with guided fishing trips forming a major part of local culture and an activity that is

symbolic of the region itself [1], [2]. Saltwater, federally[1]-permitted, for-hire fishing trips are prevalent across the Gulf of Mexico, playing a significant role in the economic development of coastal communities, providing jobs, and having high cultural importance to these same communities [5], [6]. Customers can book fishing trips on smaller charter boats - such as inshore and nearshore charters, or six (pack) passenger charters - defined as for-hire vessels that can carry six or fewer passengers; or larger operations, such as multi-passenger charters or so-called headboats, which are for-hire vessels that are permitted to carry six or more passengers and often have dozens of passengers (hereafter we will refer to all for-hire fisheries as "charter fisheries") [7], [8], [9]. Previous studies on saltwater fisheries found that this fishing industry is predominantly composed of white males [10], [11]. Charter fisheries provide access to fishing for individuals who lack expensive equipment like boats and tackle, expertise, or regular accessibility to fishing coastal waters. Importantly, charter fishing can increase public interest in conservation by increasing access to recreational opportunities that depend on healthy populations of targeted species. Charter fishing can also spark the desire to learn more about natural resources and marine wildlife in order to improve fishing abilities [12].

The ever-increasing popularity of charter fishing in the Gulf of Mexico has also resulted in an increase in human-wildlife conflict, defined as a circumstance where wildlife has a negative impact on humans - physically, psychologically, or economically - or the reverse, where humans have a negative impact on wildlife [13]. The three most important forms of human-wildlife conflict in the charter fishing sector include *depredation* (the removal of a caught fish or

[1] In the United States, commercial, recreational, and for-hire anglers are subject to both state and federal laws, depending on the location point of the harvested fish. In many states, state-controlled waters generally extend from the shoreline to 3 nautical miles from shore, whereas federal waters generally extend from 3 nautical miles to the limits of the exclusive economic zone (EEZ) at 200 nautical miles. For-hire fishing boats are permitted by federal regulators and are subject to state and federal laws [3], [4].

bait from an angler's line), *scavenging/illegal feeding* (when wildlife feed on discarded fish that boat passengers release because the fish are either out of season, undersized, unwanted, or dead), and *accidental gear interactions* (unintentional contacts where fishing gear is not noticed by wildlife or intentional contacts due to curiosity, foraging, or exploration of a new object) [14], [15], [16], [17], [18]. Human-wildlife conflict brings with it negative consequences for marine wildlife and charter fisheries alike; examples can include injury or mortality of marine wildlife due to entanglement with fishing gear, accidental hooking, ingestion of gear, or vessel strikes [18], [19]. Increasing understanding of the challenges of human-wildlife conflict and charter fishermen is urgent because, in extreme cases, this stakeholder group has been responsible for harming and even killing wildlife perceived as interfering with their livelihoods [20], [21].

The human-wildlife conflict that charter fishermen may experience has been observed with several species of high cultural importance to Gulf of Mexico communities, including bottlenose dolphins (*Tursiops truncatus*), green sea turtles (*Chelonia mydas*), loggerhead sea turtles (*Caretta caretta*), and Kemp's ridley sea turtles (*Lepidochelys kempii*) (hereafter "dolphins" and "sea turtles"). Decision-makers are interested in better understanding human-wildlife conflict for dolphins and sea turtles because they are subject to federal legal protections from the Endangered Species Act (ESA), the Marine Mammal Protection Act (MMPA), and Marine Life Viewing Guidelines [22], [23], [24]. After the British Petroleum (BP) oil spill in 2010, these species became of interest to regulators working on clean-up and restoration [25], [26], [27]. The BP oil spill also unlocked research dollars for a better understanding of these particular species [26], [28]. For example, the funds for this study were made available through the subsequent Natural Resource Damage Assessment process [29].

Human-wildlife conflicts, especially with dolphins and sea turtles, are becoming more frequent in the Gulf of Mexico [14], [17]. Several other studies have examined human-wildlife conflict, specifically on the issues of scavenging/illegal feeding, depredation, and gear interactions in the Gulf of Mexico, but to our knowledge, charter fishermen have not been the focus of research, a gap which this research will fill. Beginning with scavenging/illegal feeding, Duda et. al 2013 studied the perceptions of coastal recreationists (including charter fishermen) and wildlife viewing trip operators in Florida, with scavenging and illegal feeding very commonly observed. While coastal recreationists have high levels of concern for dolphin conservation, they also have little knowledge of the specifics of legal protections preventing dolphin feeding and interactions [15]. Our research builds on Duda et al. 2013 to focus on a nearby geographical location that has not been systematically studied despite having a high potential for human interactions with dolphins. Additionally, we added in additional human-wildlife conflict species (sea turtles) and forms of conflict (depredation and accidental gear interactions) in Alabama.

Human-wildlife conflict is hazardous to the long-term survival of marine wildlife populations because when anglers feed wildlife illegally, this can condition species that are reliant on fish for their diet to associate anglers and boats with food [30], [31]. Depredation interactions can also occur when dolphins and sea turtles, attracted to the bait, can get caught on the hooks [17], [32], [33]. Sea turtle interactions with recreational charter fishing gear in the Gulf of Mexico are poorly understood but are thought to be increasing and as such, important to better understand [14]. To prevent severe injury or reduce bycatch of marine wildlife with hooks, circle hooks have been shown to reduce these negative interactions compared to the traditional “J”

shaped hooks [34], [35]. For the state of Alabama, non-stainless steel circle hooks are required when fishing for sharks and gulf reef fish when natural bait is used [36], [37].

Finally, research on accidental gear interactions shows that the Gulf of Mexico is particularly susceptible to this type of conflict involving dolphins and sea turtles [38]. These marine species are seriously threatened by the complex web of fishing gear and marine debris in this area leading to higher chances of accidental interactions with gear, which can cause entanglement problems that have detrimental effects on these populations [16]. The state of current knowledge on marine human-wildlife conflict is summarized in Table 1 below. Our research question asks what behaviors charter fishermen would adopt voluntarily to reduce human-wildlife conflict with marine wildlife under federal protection.

Table 1: Current Knowledge of Human-Wildlife Conflict of Dolphins and Sea Turtles

Type of human-wildlife conflict	**Publication**	**Findings**	**Whether the publication studied charter fishermen**
Scavenging/Illegal feeding	Duda et al., 2013	This study found that people who care about protecting wild dolphins may not be aware of or obligated to follow the law put in place to protect them. NOAA has carried out different outreach to inform the public about the law and safe	Yes

		ways to see dolphins in the wild. However, the illegal feeding of dolphins persists.	
Depredation	Grewal et al., 2023	Fisheries interactions, specifically rod and reel fisheries, typically occur when small cetaceans depredate (remove captured fish or bait) or scavenge (feed on released live or dead fish). These interactions are becoming more common in the eastern Gulf of Mexico and have negative consequences for cetaceans and fishermen.	Yes
Accidental gear interactions	Adimey et al., 2014	Fishery gear interactions from Florida, U.S. were reviewed with dolphins, sea turtles, and manatees. Interactions can be caused by accidental encounters, opportunistic occasions, or deliberate situations from the investigation of gear. Overall gear interactions were from hook/line, trap pots, and fishing nets and cases have increased.	No

Our research is of general interest to both resource managers as well as coastal users because it tests the theory that those who are reliant on wildlife for their livelihood are more likely to take voluntary measures to ensure the overall sustainability of the wider ecosystem [39]. In the case of charter fisheries, sustainable recreational fish stocks are desired by charter fishermen, but to protect the wider ecosystem, we hypothesize that charter fishermen may be willing to adopt voluntary behavior changes to protect wildlife, such as stopping illegal feeding or adopting gear modifications that are less likely to harm wildlife [40]. To test our hypothesis, our research aims to achieve the following objectives: 1) to understand what charter fishermen know about conservation laws protecting wildlife, 2) to assess their knowledge of required or recommended actions during human-wildlife conflicts, and 3) to explore the extent of their willingness to modify behaviors to reduce the likelihood of such conflicts. To answer our question, we study charter fisheries of the Gulf of Mexico, specifically in the state of Alabama, where charter fisheries are a significant source of livelihood and economic development in coastal communities [41].

Methods

2.1 Survey Area

We adopt the survey area of coastal Alabama, an American state with a rapidly growing inshore and offshore charter fishery, enhanced by its productive artificial reef system [42]. Alabama has the largest artificial reef programs in the U.S. and has been very successful in increasing the biomass of the most popular reef fish populations targeted by anglers, including red snapper (*Lutjanus campechanus*), gray triggerfish (*Balistes capriscus*), sheepshead (*Archosargus probatocephalus*), and gray snapper (*Lutjanus griseus*) [43]. This region is also

considered a “hotbed” of human-wildlife conflict due to its popularity with tourists [44]. The major cities of Gulf Shores and Orange Beach - coined as the “Red Snapper Capital of the World” - are both popular tourist destinations for water-based activities, especially recreational fishing [42], [45]. As of 2020, Orange Beach had more than 100 charter fishing captains [46]. The four types of charter fishing trips available include inshore and nearshore fishing - which includes fishing the bay, bayou, or Gulf - six-pack deep sea charters, multi-passenger deep sea fishing charters that allow for six or more individuals, and headboats with a capacity range of 25 to 62, with the average capacity being 32 individuals [46]. A majority of charter companies use rods and reels as their main gear, with a variety of hooks being available.

Mobile Bay is an inlet part of the Gulf of Mexico and occurs along the coast of Alabama. Mobile Bay plays a significant role in the success of the coastal region of Alabama, as it is the center of the regional economy [45]. Alabama is renowned for its marine recreational and commercial fishing opportunities, which is a significant industry in the Mobile Bay region [45]. Figure 1 shows the state waters with Mobile Bay being the center of the cities along the coast. Some of the coastal cities of Alabama that support the recreational and commercial fisheries consist of Dauphin Island, Bayou La Batre, Spanish Fort, Fairhope, Bon Secour, Gulf Shores, and Orange Beach. To characterize perceptions of those who participate in recreational and commercial fishing on the Alabama coast, surveys and interviews were utilized. By targeting charter fisheries, we aim to achieve a representative sample of current commercial fishing license holders on the coast of Alabama.

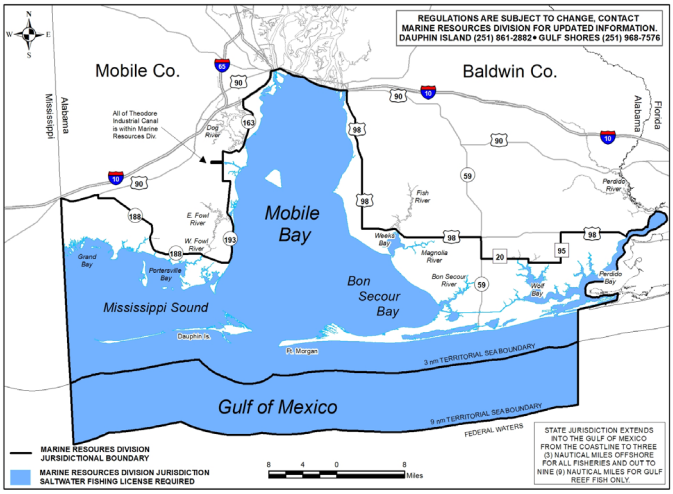

Figure 1. Map from the ADCNR/MRD depicting the coast of Alabama and the surrounding cities and jurisdictional boundaries [47].

2.2 Survey Design and Implementation

Surveys and interviews consisting of the same questions were used to gather information on the Alabama commercial fishing operations, specifically charter fishing operations (see Appendices). The purpose of the survey was to assess the current perceptions of charter boat captains and deckhands toward marine wildlife, with a focus on dolphins and sea turtles. IRB approval was obtained through Auburn University, IRB protocol number 22-502 EX 2211. The questions were co-designed collaboratively by interdisciplinary experts in the social and marine biological sciences from Auburn University, NOAA Fisheries, and the Alabama Department of Conservation and Natural Resources, Marine Resource Division (ADCNR/MRD).

The survey was distributed via Qualtrics and totaled 33 questions, including multiple-choice questions, text-entry, and 5-point Likert questions with themes of demographics, wildlife laws, wildlife ecology, wildlife interactions, willingness to change behavior, wildlife attitudes, and educational materials and outreach. A section with six questions assessed respondents'

knowledge of dolphin and sea turtle conservation policy and biology. Knowledge was scored as the percentage of correct answers to these questions. The survey was available to those over the age of 18, and respondents were able to start the survey and complete it at a later time if needed. Participation was completely voluntary, and all answers were confidential and kept anonymous. The finalized survey was made available from June 2023 to August 2023. A QR code and link to the survey were sent via email to current commercial fisheries license holders registered with the ADCNR.

2.3 Interview Design and Implementation

The interview questions were drawn from the 33 commercial fishermen survey questions mentioned above, with the opportunity for additional follow-up questions based on the interview responses and related increased opportunities for engaging with target respondents in person. The Alabama Charter Fishing Association 2023 Charter Boat Directory and other online fishing charter directories were used to contact charter boat owners and deckhands to schedule interviews. Interviewers also gathered opportunistic interviews at marinas, docks, and boat ramps. Prior to the start of the interview, interviewers read a statement that included a brief description of the project, funding sources, a potential incentive, and the researcher's contact information. Respondents were advised the interview would take roughly 5 to 10 minutes. Respondents were asked if interviewers could record the interview for transcription; all interviews were transcribed directly afterward. Thirty-five interviews were completed with charter captains and deckhands, either in person or over the phone during July and August of 2023, and were combined with 16 online responses from the surveys mentioned above. Demographic information such as age, race, gender, and state residency were collected as part of

the surveys and interviews to obtain information on the general charter fisheries population occurring along the coast of Alabama.

2.4 Analysis

Following data collection, we cleaned the survey information by downloading raw data from Qualtrics and then transferred all survey responses to a single electronic data file using Google Sheets. Any responses that were 25% or less completed or that didn't meet other respondent criteria (i.e., under 18 years old) were removed. Any errors, either in the downloading process or respondent error, were accounted for. Next, word embedding, or transforming text into numbers, was completed for compatibility with R for future analysis. After all the word responses from the surveys were turned into a numerical format, binary coding was used (e.g., 0=male, 1=female) to facilitate analysis. Descriptive statistics of respondents' demographics were gathered and put into tables with percentages to summarize the distribution of Alabama's charter fishermen.

Binomial generalized linear models were used to analyze the relationship of two independent variables: education level [0= less educated: Did not graduate HS/no GED, HS/GED, Technical/Vocational School, 1= more educated: Some College/AA or AS (2-year degree), College Graduate/BA or BS (4-year degree), or Graduate or Professional School] and percent correct on six knowledge questions on dolphin/turtle conservation policy and biology with a person's willingness to change a specific behavior. The original willingness to change behavior questions, initially on a 5-point Likert scale (Very unwilling, Unwilling, Neutral/I do not know, Willing, Very willing), were converted into a binomial variable. Responses of 'Neutral/I do not know' were excluded, resulting in categories of 0= less willing (Very unwilling, Unwilling) and 1= willing (Willing, Very willing). We calculated the variance inflation factor to

evaluate the degree of multicollinearity among the independent variables in our model, and all values were less than 2. Odds ratios were calculated, which measure and quantify the strength and direction of the relationship between the independent variables and respondents' willingness to change behavior.

An inductive methodology known as grounded theory involves obtaining, combining, evaluating, and conceptualizing qualitative data to construct a theory [48], [49]. By using this method, one can develop theories from observations and interviews that better reflect reality. The interviews were coded thematically using grounded theory, allowing us to capture the current state of the three identified human-wildlife conflicts in the charter fishing industry: depredation, scavenging/illegal feeding, and accidental gear interactions.

Results

3.1 Demographics: Who are the charter fishing boat operators on the Alabama coast?

Part of the survey's intention was to characterize the charter fishing industry on the coast of Alabama. Across online (16) and in-person (35) distributions, 51 survey responses were received from charter captains and deckhands with demographics summarized in Table 2. A majority of respondents (52%) possessed a 4-year college degree.

Table 2

Descriptive statistics of Charter Captains and Deckhands

Variable Names			
Demographics	Specific Category	Count	%
Gender	Male	48	96.00

	Female	1	2.00
	Other	0	0.00
	Prefer not to answer	1	2.00
	Total count	**50**	
Race	White	45	91.84
	Native American	2	4.08
	Black or African American	0	0.00
	Asian	0	0.00
	Other	1	2.04
	Prefer not to answer	1	2.04
	Total count	**49**	
Alabama Resident	From Alabama	45	91.84
	From elsewhere	4	8.16
	Total count	**49**	
Age Ranges	19-24	1	2.08
	24-35	14	29.17
	35-44	11	22.92
	45-54	7	14.58
	55-64	8	16.67
	65+	7	14.58
	Total Count	**48**	
Education Level	Did not graduate HS/no GED	0	0.00

HS graduate/ GED	9	19.57
Technical/vocational school	1	2.17
Some college/AA or AS (2 year degree)	10	21.74
College grad/BA or BS (4 year degree)	24	52.17
Grad or professional school	2	4.35
Total count	**46**	

Reef fish was the most targeted species, accounting for 49% of responses, followed by mackerel at 29%. Other targeted fish included mullet, blue crab, and shrimp, summarized in Table 3. The predominant fishing gear used was hook and line, utilized by 98% of respondents. Trawls were only used by 2% of respondents. No instances of gillnets, skimmers, or trap pots were reported. Most fishermen were targeting reef fish (Table 3), which in the Gulf of Mexico include, but are not limited to, gray snapper (*Lutjanus griseus*), gray triggerfish (*Balistes capriscus*), greater amberjack (*Seriola dumerili*), lane snapper (*Lutjanus synagris*), red snapper (*Lutjanus campechanus*), vermillion snapper (*Rhomboplites aurorubens*), and yellowfin grouper (*Mycteroperca venenosa*) [50].

Table 3

Fisheries information of charter fishermen

Variable	Specific Category	Count	%
Targeted Fish	Reef fish	22	48.89
	Mackerel	13	28.89
	Mullet	3	6.67

	Blue crab	1	2.22
	Shrimp	2	4.44
	Total count	**45**	
Fishing Gear	Hook and line	50	98.04
	Trawls	1	1.96
	Gillnet	0	0.00
	Skimmer	0	0.00
	Trap pots	0	0.00
	Total count	**51**	

3.2 What do charter fishermen do when interacting with federally protected wildlife?

According to NOAA, when charter fishermen see an injured dolphin, they should report it to the Marine Mammal Stranding Hotline [51]. Table 4 displays the percentage of respondents who answered this question correctly (34% knew to call the Marine Mammal Stranding Hotline) compared to the incorrect options (Police, Coast Guard, and ADCNR). Despite low levels of awareness of what to do when encountering protected wildlife, the overwhelming majority of respondents, 82%, expressed a definite willingness to report an injured dolphin, while 11% indicated they would probably report it (Table 4). These results suggest that although awareness is low, a willingness to engage in desired behaviors (reporting injured wildlife) is high.

Table 4

Knowledge of what to do when encountering injured dolphins

Variable	Specific Category	Count	%
Where to report an injured dolphin	ADCNR	20	57.14
	Marine Mammal Stranding Hotline	12	34.29
	Coast Guard	2	5.71
	Police	1	2.86
	Total count	**35**	
Willingness to report an injured dolphin	Yes	36	81.82
	Probably yes	5	11.36
	Unsure	0	0.00
	No	2	4.55
	Probably no	1	2.27
	Definitely no	0	0.00
	Total count	**44**	

According to NOAA, when charter fishermen see an injured sea turtle, they should report it to the Alabama Sea Turtle Stranding and Salvage Network Hotline [51]. Table 5 displays the percentage of respondents who answered this question correctly (32% knew to call the Alabama Sea Turtle Stranding and Salvage Network Hotline) compared to incorrect options (Police, Coast Guard, and ADCNR). The overwhelming majority of respondents (86%) expressed a definite willingness to report an injured sea turtle, while 11% indicated they would probably report it

(Table 5). Therefore, similar to encounters with injured dolphins, awareness is somewhat low with only 32% knowing the correct procedure, but a majority being willing to make such a report.

Table 5

Knowledge of what to do when encountering injured sea turtles

Variable	Specific Category	Count	%
Where to report an injured sea turtle	ADCNR	21	56.76
	Alabama Sea Turtle Stranding and Salvage Network Hotline	12	32.43
	Coast Guard	3	8.11
	Police	1	2.70
	Total count	**37**	
Willingness to report an injured sea turtle	Yes	38	86.36
	Probably yes	5	11.36
	Unsure	1	2.27
	No	0	0.00
	Probably no	0	0.00
	Definitely no	0	0.00
	Total count	**44**	

3.3 Characterizing human-wildlife conflict with dolphins

We asked respondents about the three types of human-wildlife conflict with dolphins: depredation (the removal of a caught fish or bait from an angler's line), scavenging/illegal feeding (when wildlife feeds on discarded fish that boat passengers release live, unwanted, or dead), and accidental gear interactions (unintentional contacts where fishing gear is not noticed or intentional circumstances due to curiosity, foraging, or exploration of a new object). Results are summarized in Table 6. We found that 41% of respondents had frequently experienced accidental gear interactions, 28% engaged in feeding dolphins bycatch, 13% had experienced depredation frequently, and 51% had frequently experienced dolphins scavenging on thrown-back, undersized, or out-of-season fish.

Table 6

Frequency of interactions with dolphins

Variable	Specific Category	Count	%
Accidental gear interactions	Never	17	38.64
	Rarely	4	9.09
	Sometimes	5	11.36
	Frequently	18	40.91
	Total count	**44**	
Feeding bycatch	Never	17	47.22
	Rarely	5	13.89
	Sometimes	4	11.11
	Frequently	10	27.78

	Total count	**36**	
Depredation	Never	10	25.00
	Rarely	10	25.00
	Sometimes	15	37.50
	Frequently	5	12.50
	Total count	**40**	
Scavenging	Never	4	9.76
	Rarely	2	4.88
	Sometimes	14	34.15
	Frequently	21	51.22
	Total count	**41**	

3.4 Characterizing human-wildlife conflict with sea turtles

Table 7 shows the frequency with which charter fishermen interacted with sea turtles: 20% of respondents encountered sea turtles monthly, while 16% of respondents encountered them once a week, suggesting that interactions are not common. Human-wildlife conflict interactions with sea turtles getting accidentally hooked on fishing gear were reported to be a rare occurrence with 86% of respondents stating that they never experienced such interactions. Comparatively, 14% of respondents reported rare occurrences of accidental gear interactions.

Table 7

Frequency of interactions with sea turtles

Variable	Specific Category	Count	%
Frequency of encountering sea turtles	Daily	5	11.11
	Once a week	7	15.56
	Once a month	9	20.00
	Other	24	53.33
	Total count	**45**	
Accidental gear interactions	Never	37	86.05
	Rarely	6	13.95
	Sometimes	0	0.00
	Frequently	0	0.00
	Total count	**43**	

3.5 Logistic Regression: Assessing Willingness to Change Behavior

We ran logistic regression models predicting the willingness to change behavior (for 5 different behaviors) as a function of education level (0= less educated, 1= more educated) and prior knowledge about conservation policies, where knowledge was scored as the percent of correct answers to the six questions on dolphin/turtle conservation policy and biology. Other variables from our data were not included due to a lack of variation in responses. We hypothesized that education and knowledge levels on wildlife policy and biology would have positive relationships with voluntary willingness to adopt wildlife-friendly behaviors. The 5 behaviors examined included willingness to change bycatch feeding behaviors (Table 8), willingness to change bait to be safer for sea turtles (Table 9), willingness to use non-stainless steel hooks (Table 10), willingness to pull gear out of the water when dolphins come nearby

(Table 11), and willingness to relocate to a different location where there are no dolphins (Table 12). Neither of these independent variables were significant predictors of willingness to change any of these behaviors (See Table 8-12). For this reason, we opted to explore qualitative data to determine the rationale behind the lack of willingness to adopt certain behaviors relating to wildlife. However, certain models had large effects, suggesting that these results could be important, and more research is necessary to see if the estimated effect holds with bigger sample sizes. For example, in model 1, more educated individuals were 2.26 (0.059-100.95, 95% C.I.) times as likely to be willing to change their behavior of feeding dolphins bycatch than less educated individuals (p= 0.635) (Table 8). In model 3, more educated individuals were 1.75 (0.067-28.98, 95% C.I.) times as likely to be willing to use non-stainless steel hooks than less educated individuals (p= 0.690) (Table 10).

Table 8

Model 1 displays the logistic regression odds ratio for models of factors explaining charter fishermen's willingness to stop feeding dolphins bycatch

	Odds ratio	*Confidence limits*	*z value*	*P-value*
Intercept	3.092872	0.07399809- 464.5262	0.573	0.566
Education level (binary)	2.258272	0.05937987- 100.9499	0.474	0.635
Percent correct	0.2818163	2.976587e-05- 5181.801	-0.293	0.770

Note: Significance notes as *p<0.05, **p<0.01, ***p<0.001. Odds ratios can be calculated by exponentiating the beta.

Table 9

Model 2 displays the logistic regression odds ratio for models of factors explaining charter fishermen's willingness to change bait to be safer for sea turtles

	Odds ratio	*Confidence limits*	*z value*	*P-value*
Intercept	0.973926	0.0555935- 16.13892	-0.020	0.984
Education level (binary)	0.2836625	0.01735227- 3.762915	-0.965	0.335
Percent correct	1.094798	0.00184194- 970.6423	0.029	0.977

Note: Significance notes as *p<0.05, **p<0.01, ***p<0.001. Odds ratios can be calculated by exponentiating the beta.

Table 10

Model 3 displays the logistic regression odds ratio for models of factors explaining charter fishermen's willingness to use non-stainless steel hooks

	Odds ratio	*Confidence limits*	*z value*	*P-value*
Intercept	6.204656	0.5259792- 224.4038	1.277	0.202
Education level (binary)	1.749273	0.06700228- 28.98423	0.399	0.690
Percent correct	0.2143168	0.0004321839- 73.85384	-0.532	0.595

Note: Significance notes as *p<0.05, **p<0.01, ***p<0.001. Odds ratios can be calculated by exponentiating the beta.

Table 11

Model 4 displays the logistic regression odds ratio for models of factors explaining charter fishermen's willingness to pull gear out of the water when dolphins come nearby

	Odds ratio	*Confidence limits*	*z value*	*P-value*
Intercept	15.30072	1.931195- 424.4708	2.124	0.0337*
Education level (binary)	0.4832602	0.0214337- 4.930973	-0.579	0.5627
Percent correct	0.03728366	0.0002838336- 2.279767	-1.482	0.1383

Note: Significance notes as *p<0.05, **p<0.01, ***p<0.001. Odds ratios can be calculated by exponentiating the beta.

Table 12

Model 5 displays the logistic regression estimates for models of factors explaining charter fishermen's willingness to relocate to a different location where there are no dolphins

	Odds ratio	*Confidence limits*	*z value*	*P-value*
Intercept	10.21135	1.433347- 233.1707	1.937	0.0527*
Education level (binary)	0.529247	0.02364494- 5.141182	-0.511	0.6097
Percent correct	0.1714095	0.001706206- 11.08671	-0.814	0.4155

Note: Significance notes as *p<0.05, **p<0.01, ***p<0.001. Odds ratios can be calculated by exponentiating the beta.

3.6 Qualitative data characterizing human-wildlife conflicts for dolphins

From coding the three human-wildlife conflicts for dolphins, the findings suggest a complex interplay between fishing activities and dolphins, with potential consequences for both (Table 13). Accidental gear interactions, depredation, and scavenging all contributed to the intricate dynamic of human-wildlife conflicts occurring with dolphins in the charter fisheries. Accidental gear interactions have been defined by previous literature as unintentional encounters where equipment is not noticed, opportunistic situations where equipment is mistaken for

appropriate natural objects, or intentional situations from curiosity, foraging, or exploration [14]. Accidental gear interactions were interpreted differently by respondents, which led to the themes of interactions with dolphins being rare and having an impact on the fishing industry. For both depredation and scavenging, both conflicts are common and increasing in nature and can alter dolphin behavior. The absence of depredation and scavenging in sea turtles indicates a potential difference in the nature of human-wildlife conflicts between fishermen and sea turtles compared to dolphins.

Table 13

Codes and themes for human-wildlife conflicts with dolphins

Human-wildlife Conflict	Theme	Example
Accidental gear interactions [14]	Dolphin accidental gear interaction is rare to never	"I would say that at least half the time or over half the time you'll have dolphins around and hardly interact with the gear and you can stay catching [fish], like several times."
Depredation (e.g. dolphin consumes live fish hooked on the line before the angler can reel it in)	Dolphins are eating fish/bait off the hook	"Almost daily. Typically the most common interaction is when we are fishing for the vermillion snapper, they have a soft mouth, and the vermillion do, soft enough where the dolphins can carefully grab them from the back end and pull, we keep the hook and they keep

		the fish."
	Harmful to dolphins by impacting their natural behavior	"We aren't purposely feeding them. Sure, I mean they aren't using their natural instinct, they are waiting for us to throw them [fish] off the side of the boat. So they are not technically hunting."
	Depredation is becoming more frequent	"Occasionally, and this has started in the past, I've been doing this for the past 10 years now and this has started in the past 2 to 3 years now and it's progressively gotten worse."
	Interactions with dolphins are impacting the fishing industry	"And then a lot of your dolphin interactions whether or not they bite your bait off or something, you will have dolphins come up and they will shut the bite down. You have to fish harder. We never catch a fish when the dolphins are around."
Scavenging (e.g. dolphins consume dead fish such as unused bait, or fish that is required by law to be thrown back)	Dolphins behavior has changed to following the boats	"Most days they follow the boat but they don't really, well they will eat the fish you throw back, they don't necessarily get it off the line all that often."

Fishermen lack agency over whether this happens because throwing certain species back is required by law	"Well I don't feed them but the law requires that we throw them back and they eat what we throw back. Triggerfish, V-liners, amberjack, red snapper, they eat it all. We take the time to vent the fish and the dolphins eat them."
Fishermen's best option is to move on because dolphins scare the fish	"Everyone does to their best ability stay away from the dolphins they just kind of chase you and like I said before if it gets to a point where they start messing with anything, getting too close to the boat, eating the bycatch we will go all the way to the extent of trying to get away from them, I don't know if they get tired or give up following us."

3.7 Qualitative data characterizing human-wildlife conflicts for sea turtles

We used our three-part framework to code our data to better understand human-wildlife conflicts for sea turtles. We found that accidental gear interactions are infrequent, with respondents expressing how rare these occurrences were over various types of fishing experiences. Despite the rarity of such interactions, one form of gear interaction that does occur, albeit infrequently, is accidental hooking. Respondents frequently described their interactions with sea turtles as witnessing "timidness" where sea turtles avoid proximity to boats, which

suggests a certain level of awareness and avoidance of fishing activities by sea turtles. As for depredation and scavenging being mentioned by respondents, these two conflicts were not observed among fishermen. Thus, our interviews show a low occurrence of human-wildlife conflicts with sea turtles in the charter fisheries (Table 14).

Table 14

Codes and themes for human-wildlife conflicts with sea turtles

Human-wildlife Conflict	Theme	Example
Accidental gear interactions	Sea turtle accidental gear interaction is rare to never	"Because I know that the interaction is so rare that I have never in ten years of fishing, or twenty years doing this every day never hooked a sea turtle."
	Sea turtle accidental gear interaction: hooking	"Yeah, we caught one about three years ago accidentally hooked it snapper fishing. The hook wrapped around its left flipper and it got lounged in its flipper. We brought it up, unhooked it, it wasn't hurt, we let it go."
	Sea turtles are timid	"They are boat shy. They don't usually come to the boat voluntarily, you just see them. They will maintain their distance of between 25 to 50 yards, they don't come to

boats usually."

Discussion

This research aimed to fill a gap in the existing literature by focusing on human-wildlife conflict with dolphins and sea turtles in charter fisheries in the Gulf of Mexico, specifically along the Alabama coast. The Alabama coast has a historical charter fishing industry that is expanding with the help of its productive and nationally renowned artificial reef systems. Unfortunately, this expansion has led to a rise in human-wildlife conflict with wildlife species. This issue is of increasing importance as both dolphins and sea turtles are charismatic species that serve as symbols of the ecosystems that they inhabit, leading to attention and funding, particularly in the wake of the BP oil spill disaster. Understanding the perceptions and knowledge of charter fishermen will help coastal managers implement effective management strategies. Previous studies have looked at human-wildlife conflicts in other key marine industries, such as commercial fishing or wildlife tourism, but not in the context of charter fishing in the state of Alabama. In the case of a study by Arthur et al. 2013, which discussed the human-wildlife conflict between green sea turtles and a local fishing community in India, the findings indicated that fishermen associated the increase in sea turtle populations with declining fish catches, leading to the targeted killing of sea turtles [52]. Our research stands in contrast to that case study, where interactions with sea turtles are seen as rare, and sea turtles are perceived as timid. Barnhill et al. 2022 provided an overview of human-wildlife conflict with dolphins within wildlife tourism, commercial fisheries, and ocean recreation highlighting the complexity of such interactions as they can be planned or opportunistic. Specifically in commercial fisheries, conflict between fishermen and dolphins occurs when both are targeting the same fish [53]. This was also the case in our findings with depredation and scavenging behaviors in dolphins leading

to human-wildlife conflicts with charter fisheries as they both target the same fish in the Gulf of Mexico.

Our findings provide insights into the current demographics, fishing practices, and interactions of the charter fishing industry on the Alabama coast. The predominantly male (96%) and white (91.84%) demographics of charter fishermen align with the existing literature on saltwater fishing industries [10], [11]. With 79% of our respondents having some college background, either 2-year degrees, 4-year degrees, or graduate school, the acquisition of higher education in this group suggests that the charter fishing industry workforce may be well-educated.

Charter fishermen play a crucial role in mitigating human-wildlife conflict by voluntarily complying with key wildlife laws and providing de facto enforcement of those laws with residential and non-residential tourists that they take on their vessels to fish. Further, because charter fishermen spend an extensive amount of time in the marine environment, they have the opportunity to be some of the first individuals to respond to and report marine wildlife that is in distress or deceased to stranding networks or hotlines. However, the effectiveness of these networks is largely dependent on individual willingness to report, including charter fishermen, which may be influenced by variables like their perceptions and knowledge of wildlife species. In a study looking at compliance with the MMPA in the commercial gillnet fishing industry, compliance was related to an individual's knowledge and perceptions toward an issue as well as social, economic, and cultural factors [54].

Our research contributes to the scholarship characterizing whether anglers report injured wildlife correctly, showing that only around one-third of fishermen know the correct procedure (34% answering Marine Mammal Stranding Hotline, 32% Alabama Sea Turtle Stranding and

Salvage Network Hotline). We found that anglers' willingness to report both was high, with 82% saying yes to reporting an injured dolphin and 86% saying yes to reporting an injured sea turtle. This disparity between awareness and willingness to report highlights a current challenge in wildlife conservation efforts, as even though the charter fishermen may be very willing to report these species, they do not know the correct procedures or agency to contact. This presents an opportunity for targeted educational initiatives to enhance awareness and knowledge amongst charter fishermen on who to contact in the event of encountering injured marine wildlife. Considering the interactions with dolphins were perceived to be impacting the fishing industry, charter fishermen are still willing to report injured dolphins. This confirms our hypothesis that those who are dependent on fisheries as a source of income are more likely to take actions that protect surrounding ecosystems and their wildlife [40].

In the case of charter fishermen, this stakeholder group may be willing to adopt behaviors that reduce human-wildlife conflict with dolphins and sea turtles, such as stopping feeding bycatch or reporting injured marine wildlife. We hypothesized that education levels and knowledge of sea turtle and dolphin biology and conservation policy would result in higher levels of willingness to enact behaviors that would voluntarily reduce human-wildlife conflict. Behaviors that we asked about included, for instance, fishermen voluntarily stopping feeding dolphins bycatch, changing the type of bait used to protect sea turtles, changing to non-stainless steel hooks, possibly pulling gear out of the water when dolphins are nearby, or relocating their fishing spot for the day to areas without dolphins. Yet, our hypothesized independent variables were not significant predictors of willingness to adopt wildlife-friendly behavior change. Human-wildlife conflict can take many forms, and using the literature we devised a framework

for the most common forms of human-wildlife conflict that were relevant to this study, including accidental gear interactions, depredation, and scavenging.

Since our hypothesized relationships in the models did not materialize, we turned to our qualitative interview data to gain a deeper understanding of human-wildlife conflict. There we learned that fishermen were unwilling to change certain actions on the water due to what they saw as the rarity of certain forms of human-wildlife conflict amongst sea turtles and dolphins for gear interactions, and perceptions that sea turtles are timid on the water and avoid charter fishermen. A previous study investigating commercial and recreational fishery gear interactions with Florida manatees (*Trichechus manatus latirostris*), dolphins, and sea turtles observed hook and line as the most commonly observed fishery gear to cause entanglement in Florida waters. Specifically, 75.2% of interactions with sea turtles were from hook and line and 73.5% for dolphins [14]. Our results are aligned with existing findings from Grewal et al. 2023, which analyzed data collected by observer programs in Florida charter fisheries observing an increase in depredation and scavenging in bottlenose dolphins [17]. From a conservation perspective, depredation and scavenging conflicts with dolphins present the greatest challenge for wildlife managers. Dolphin depredation of fish that are hooked on the line is, according to fishermen, becoming more frequent, and causing negative changes to wildlife behavior. Scavenging presents its own problem as fishermen are required by law to throw back certain species of fish, a phenomenon that is also changing dolphin behavior. Further study is needed to review ways that commercial fisheries managers have reduced wildlife behavior change caused by depredation and scavenging to inform educational outreach aimed at charter fishermen with these emerging concerns.

A few limitations of our study arose despite its insights for managers. Although the sample is representative of the charter fishing industry on the Alabama coast, it might restrict how broadly the results can be applied elsewhere. Additionally, collecting self-reported data can potentially introduce response bias. Building on our research, future studies could examine how well educational interventions work to raise awareness and reduce human-wildlife conflicts, aiming for larger and more diverse samples in other states and countries. This study sheds light on the current characteristics and interactions of the charter fishing industry on the Alabama coast while adding to the growing body of literature on human-wildlife conflict in marine settings. Sustainable coexistence in the charter fishing industry should be a goal of effective management strategies, which take into account the dynamic interactions with dolphins, sea turtles, and other marine wildlife that are experiencing human-wildlife conflicts. By understanding charter fishermen's perceptions, knowledge, and willingness to adopt conservation-based actions, future management actions can support a sustainable fishery and healthy fish and wildlife populations. Through our study, we can contribute to the existing knowledge in the field of human dimensions, particularly in the growing charter fishing industry, with the aim of reducing human-wildlife conflict.

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An Analysis of the Marine Wildlife Interactions with the Commercial Shrimping Industry on the Alabama Gulf Coast

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An Analysis of the Marine Wildlife Interactions with the Commercial Shrimping Industry on the Alabama Gulf Coast

Abstract

Our study offers an in-depth, qualitative analysis characterizing human-wildlife conflict in one of the most culturally, historically, and economically important commercial fishing operations in the Gulf of Mexico: shrimp fisheries. Human-wildlife conflict can negatively impact both marine wildlife and the industry's longevity, but to date, conflicts have not been analyzed in-depth for two key groups of marine wildlife: sea turtles and dolphins. Our research found that human-wildlife conflict with dolphins is increasing and commonly takes the form of depredation (dolphins eat live shrimp by making holes in nets) and scavenging (dolphins follow shrimp boats to consume unwanted bycatch thrown overboard). The human-wildlife conflict between shrimpers and dolphins is changing dolphin behavior. The human-wildlife conflict between shrimpers and sea turtles is rare, thanks to the widespread adoption of wildlife-friendly shrimping gear in the form of turtle excluder devices or TEDs. That said, some bycatch does happen, requiring shrimpers to have some working knowledge of handling sea turtles. TEDs remain polarizing to commercial shrimpers due to their cumbersome nature, which can cause a large collection of fish bycatch to accumulate in the device, attracting scavenging dolphins. Our research suggests that resource managers can reduce human-wildlife conflict with key marine species by continuing education programs on wildlife-friendly gear and pursuing technological advances to prevent dolphin scavenging.

Keywords: Commercial shrimping, human-wildlife interactions, dolphins, sea turtles, Gulf of Mexico

Introduction

The Gulf of Mexico commercial shrimp industry is a key component of commercial fisheries in the U.S. [55], [56], [57]. In 2022, over 75.5 million pounds of shrimp were landed in the Gulf of Mexico, constituting a significant source of economic activity and food for the region [58]. Commercial shrimping is especially prevalent on the coast of the state of Alabama, with commercial fishing and seafood production being a significant economic driver, providing more than 12,000 jobs and $555 million in sales in general profits annually [45], [59]. Both historically and currently, Alabama's seafood industry has been primarily reliant on shrimp, with an average of 1.3 million pounds landed for the state [60], [61]. This success is attributed to the states' management strategies for protecting vital habitats for shrimp throughout all life stages, such as bays and marshes [62]. The main fishing ports that land Alabama's shrimp are the culturally important communities of Bayou La Batre, coined as the "Seafood Capital of Alabama," and Bon Secour, both of which have played a role in the state's economy for centuries [60], [63], [64].

Commercially licensed shrimp boats are considered to be any vessel capturing or attempting to capture shrimp by any trawl(s) that exceed 16 feet as measured along the main top line or any trawl 16 feet or less licensed as a commercial shrimp boat [65]. Specifically for the state of Alabama, in inshore waters, trawls cannot exceed 50 feet, whereas there are no restrictions on trawl size offshore [65]. A variety of gear is used in the Gulf of Mexico commercial shrimp fishery and can be divided into two categories: shrimp trawls and other

trawls, like otter trawls, mongoose trawls, skimmer trawls, and butterfly nets [56], [66]. The haul times for pulling a shrimp net vary depending on gear type, season, and location [67], [68], [69].

Our study investigates the human-wildlife conflicts encountered by commercial shrimpers in Alabama, specifically regarding the nature of the negative interactions with two groups of marine wildlife that hold immense cultural importance in this region and all over the world: dolphins and sea turtles. Human-wildlife conflicts are defined as situations in which wildlife has a negative impact on humans physically, economically, or psychologically, or when humans negatively impact wildlife [13]. Human-wildlife conflict is not a new topic in commercial fisheries and can have detrimental effects on marine wildlife as well as the longevity of the industry [67]. The forms of human-wildlife conflict that are most prevalent in the commercial shrimp fishery include 1) bycatch, or the accidental capture of non-targeted species; 2) depredation, or when wildlife species remove captured fish or bait from fishing gear; and 3) scavenging, when wildlife feeds on fish that are discarded because they are either out of season, undersized, unwanted, or dead [17], [18], [70], [71].

Our study holds significance for both resource managers and the American commercial fishing industry as it establishes the first in-depth analysis of human-wildlife conflicts encountered by commercial shrimpers, specifically involving sea turtles and dolphins in Alabama waters. Characterizing human-wildlife conflict in this case can be generalized to the entire Gulf of Mexico region of the U.S., the nation's fastest-growing coastal region and a region of increasing economic importance [72], [73], [74]. The Gulf of Mexico area shares similar ecological and economic traits. Commercial shrimp fisheries across the Gulf states, including Texas, Louisiana, Mississippi, Alabama, and Florida, operate under comparable environmental

conditions and regulatory frameworks, including similar shrimp species, types of fishing gear, and common target and bycatch species [75], [76].

There is currently a gap in the human-wildlife conflict literature covering interactions between commercial fisheries and sea turtles and dolphins in Alabama waters. Following the British Petroleum (BP) oil spill in 2010, there has been a surge in interest surrounding human impacts on wildlife, especially dolphins and sea turtles, as they are both federally protected species [25], [26], [27]. By using a qualitative, interview-based approach with our research, we seek to fill a crucial gap in a comprehensive study of human-wildlife conflicts within the context of Gulf of Mexico commercial shrimping, particularly in the state of Alabama, where shrimp fisheries are a significant source of livelihood and growth for coastal communities. Our findings are of general interest to fish and wildlife managers tasked with balancing tradeoffs between wildlife protection and a thriving commercial fisheries sector. By better characterizing human-wildlife conflict trends in commercial fisheries and stakeholder-driven perceptions, we can better understand challenges and opportunities for more wildlife-friendly fisheries in the wake of environmental disasters like the BP oil spill disaster.

Literature Review: Human-Wildlife Conflict and Commercial Fisheries

Human-wildlife conflicts can be destructive to commercial fishing livelihoods due to the loss of bait, damage to gear, and diminished catch of target species, while also negatively impacting marine wildlife populations [71]. With commercial shrimping trawls pulling nets for extended periods of time, non-targeted species could be fatally injured or drowned [67]. In a review done by Moore et al. 2009, bycatch was found to be a growing concern for sea turtles, dolphins, and sea birds and a significant management issue pertaining to U.S. commercial

fisheries [4], [71]. The National Marine Fisheries Service (hereafter "NOAA[2] Fisheries") plays a critical role in overseeing marine fisheries within the U.S. Exclusive Economic Zone (EEZ)[3], aiming to promote sustainable fisheries management by reducing bycatch [71], [77]. The management of bycatch is guided by several foundational pieces of legislation that govern the management of U.S. fisheries, which, in part aid in the reduction of bycatch, including the Magnuson-Stevens Fishery Conservation and Management Act (MSA), the Marine Mammal Protection Act (MMPA), the Endangered Species Act (ESA), and the Marine Wildlife Viewing Guidelines [23], [24], [77], [78].

For our study, we focus on the human-wildlife conflict between two of coastal Alabama's charismatic and highly cultural animals: dolphins and sea turtles. Specifically, we examine human-wildlife conflict issues in commercial shrimping impacting bottlenose dolphins (*Tursiops truncatus*), green sea turtles (*Chelonia mydas*), loggerhead sea turtles (*Caretta caretta*), and Kemp's ridley sea turtles (*Lepidochelys kempii*) (hereafter "dolphins" and "sea turtles"). These human-wildlife conflicts occur in a variety of ways. For dolphin interactions with shrimping gear, dolphins are attracted to shrimp trawling operations as a means to exploit fish resources and discarded fish bycatch for opportunistic feeding when shrimpers throw these fish back as they were not the target of the shrimpers [79], [80]. Bottlenose dolphins have been known to exhibit scavenging behavior as they wait alongside fishing vessels for discarded bycatch [79], [81]. In this case, dolphins may modify their normal foraging behavior to take advantage of this anthropogenic food source, increasing their likelihood of following vessels and becoming desensitized to human activities [79], [82]. Dolphins have also been known to bite and rip nets to

[2] The National Oceanic and Atmospheric Administration (NOAA) is a federal agency responsible for commercial and limited recreational fishery management in the U.S.

[3] The Economic Exclusive Zone is the region where natural resources are under the authority of the U.S. and other coastal nations; the U.S. EEZ extends 200 nautical miles [28].

release and catch the captured fish, displaying depredation behaviors [83]. These behaviors from dolphins may increase the chance of vessel strikes or becoming entangled in gear, resulting in severe injuries or death [84].

Shrimp nets have also been associated with the bycatch of sea turtles [71], [85], [86]. If sea turtles are caught underwater in nets or on lines, they risk drowning if they are unable to reach the surface for air after a long period of time [87]. After six out of the seven sea turtle species were listed as endangered or threatened under the ESA during the 1970s, sea turtle bycatch became a management concern for the U.S. southeast shrimp trawl fishery [88], [89]. While all six species of sea turtles that inhabit U.S. waters are susceptible to shrimp trawls, the two most vulnerable species are the loggerhead and Kemp's ridley, which is the most endangered sea turtle species [88], [90]. In 2016, the estimated number of sea turtles captured in the Gulf of Mexico and southeastern U.S. Atlantic coast shrimp otter trawl fisheries was 111 Kemp's ridleys, 139 loggerheads, 86 green sea turtles, and 168 sea turtles of a different species [87].

To help reduce bycatch associated with shrimping gear, regulatory measures, such as the use of turtle excluder devices (TEDs) and bycatch reduction devices, have been implemented in certain areas; however, enforcement varies [66], [86], [91]. TEDs were developed in the early 1980s by NOAA Fisheries and are metal grid bars that are fitted into the necks of trawl nets [92], [93]. Since their development, TEDs have become a standard part of offshore shrimping trawls, coming in a variety of designs that increase the likelihood of non-targeted species escaping [70]. Currently, skimmer trawl vessels 40 feet or smaller in length are not required to have TEDs [66]. Any sea turtle that falls victim to bycatch during fishing operations must be handled, and release gear must be used, in accordance with NOAA Fisheries' careful handling, resuscitation, and

release protocols [94]. According to NOAA Fisheries, the current TED designs are determined to have 97% efficacy in excluding sea turtles from shrimp trawls and are required under the ESA (50 CFR 223.206) [91], [95].

Research has shown that TEDs significantly reduce the bycatch of large marine wildlife on shrimp trawls but still require improvements when it comes to reducing the capture of smaller wildlife [96]. Gear regulations such as TEDs directly impact commercial shrimpers through the modification and maintenance of gear and can be financially costly and time-consuming for fishermen, who may have to replace or repair expensive gear [65]. Unfortunately, the clogging of shrimp nets with debris due to TEDs can lead to significant economic losses [56]. In a study done with Georgia shrimpers, the adoption of TEDs highlighted the willingness to accept new technology and fishing practices where they were included in the development process [97]. However, commercial fishermen are not always included in the fisheries management dialogue, which can lead to negative perceptions of both the wildlife and conservation policies in place to reduce bycatch.

Negative interactions in commercial fisheries have the potential to influence fishermen's perceptions of marine wildlife [82]. These interactions can impact how they operate their vessels and gear, which gear they adopt that can aid in wildlife conservation, how they respond to bycatch, and how they obtain information regarding marine wildlife policies such as the MSA, ESA, MMPA, and Marine Wildlife Viewing Guidelines. To effectively address human-wildlife conflict in the commercial shrimping industry, a multifaceted approach that considers the needs of both fishermen and marine wildlife is needed. To meet this objective, we use interviews to capture Alababma's shrimpers' experiences while assessing their knowledge of pertinent policies protecting sea turtles and dolphins.

Methods

2.1 Survey Area

Situated along the coast of Alabama, Mobile Bay holds a significant role in the success of the coastal region [45]. Coastal Alabama possesses a renowned reputation for its rich commercial fishing industry, which is a notable industry in the Mobile Bay region [45]. Figure 2 illustrates the geographical location of Mobile Bay and the surrounding inshore waters and cities. Some of the coastal cities in Alabama that support commercial fisheries are Bayou La Batre and Bon Secour, both of which have multiple wholesale seafood markets and distributors. One of Alabama's leading fishing industries is its commercial shrimp industry, with Alabama's water containing roughly 22 species of shrimp, with three found in commercial quantities: brown (*Farfantepenaeus aztecus*), white (*Litopenaeus setiferus*), and pink (*Farfantepenaeus duorarum*) [62]. By targeting commercial shrimpers, we aim to achieve a representative sample of current commercial fishing license holders on the coast of Alabama.

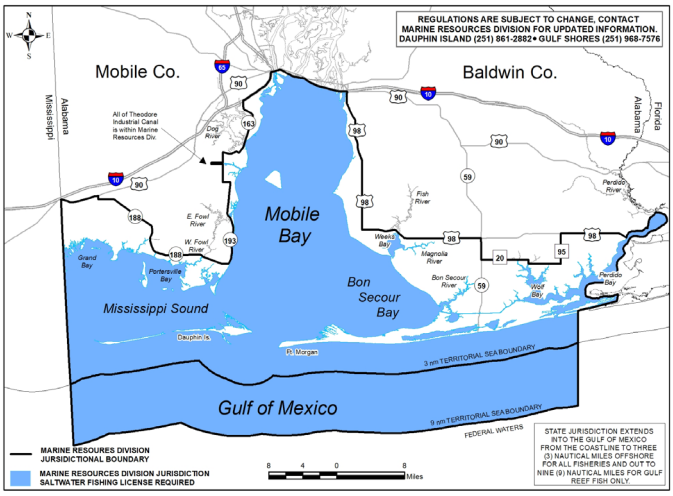

Figure 2. A map from the ADCNR/MRD depicting the coast of Alabama and the surrounding cities and jurisdictional boundaries [47].

2.2 Interview Design and Implementation

Information on Alabama's commercial fisheries, particularly those involved in commercial shrimping, was gathered through interviews. With an emphasis on sea turtles and dolphins, the interviews were conducted to gauge the commercial shrimpers' current attitudes, desires, and concerns regarding marine wildlife. Interdisciplinary experts in the social and marine biological sciences from Auburn University, NOAA Fisheries, and the ADCNR/MRD helped with the creation of the interview questions. The Auburn University Institutional Review Board accepted the interview questions and process, which adhered to its rules and specifications (22-502 EX 211).

The interview questions were based on Olivas Et Al. 2023 commercial fishermen survey questions, totaling 33 questions (see Appendices). Based on the interview and respondents' answers, there was an opportunity to ask additional follow-up questions. Opportunistic sampling was done at wholesale seafood markets located in Bayou La Batre and Bon Secour, both of which are commercial fishing-based areas on the coast of Alabama. Before conducting the interview, interviewers provided respondents with a statement that contained a brief project description, funding sources, a potential incentive, and the researcher's contact details. Interviewers advised respondents that the interview would take approximately 5 to 10 minutes and asked if they could record the interview for transcription; all interviews were transcribed directly afterward. Fourteen interviews were completed either in person or over the phone with the commercial shrimpers during July and August of 2023 and were coded thematically. Demographic information, including age, race, gender, and state residency, was collected to

determine the commercial fishing population along Alabama's coast. The responses from the interviews reached the point of information saturation, where the answers were similar and matched one another [98], [99].

For the analysis of qualitative data, we used an inductive approach where the use of the speaker's own words was used to form our codes using the process of grounded theory methods. Grounded theory is an inductive methodology that involves obtaining, combining, evaluating, and conceptualizing qualitative data to construct a theory and aids in exploratory research [48], [49], [100]. These grounded theory methods were used to identify the key themes and develop a comprehensive theory centered on the interaction between commercial shrimpers and wildlife.

Results

3.1 Demographics: Who are the commercial shrimpers on the Alabama coast?

Fourteen interviews were completed either in person or over the phone with the commercial shrimpers during July and August of 2023 and were coded thematically. Of the 14 respondents, all (100%) were white males, from Alabama (100%), and ranged in age from 19 to 65. Educational levels varied, with a majority of respondents (63%) having graduated high school or obtained a GED. The obtained sample of shrimpers is representative of most Alabama shrimpers [101].

3.2 Characterizing human-wildlife conflicts for dolphins in the Gulf of Mexico

Commercial shrimper respondents identified two types of human-wildlife conflicts involving dolphins that had major impacts on livelihoods and changing behaviors of dolphins: depredation and scavenging. Respondents described a complex relationship between shrimping

operations and dolphins, with potential consequences for both wildlife and fishermen, with example quotations from interviews described in Table 15. Both types of human-wildlife conflicts are, according to our interviews, common and increasing.

Depredation behavior was described by respondents as commonly taking the form of dolphins removing captured fish by tearing holes into the shrimping nets. Respondents emphasized that their most important livelihood challenge was a lack of effective ways to deter dolphins from exhibiting depredation behavior and that technological advances in this area would benefit them. Shrimpers noted repeatedly that dolphin numbers have increased in recent years, with their belief that perceived increases in dolphin populations come from increased evidence of depredation, such as increased holes in their nets made by dolphins. Shrimpers noted that depredation behaviors can be an intense experience out on the water, causing their boats to rock forward when nets are being pulled from the water as dolphins repeatedly try to make these holes in the nets. Likewise, our respondents believe that because of what they perceive as recent increases, the depredation type of human-wildlife conflict is altering dolphin behavior, where instead of hunting naturally, they make holes in nets and consume shrimp. This suggests that depredation is harming commercial fishing operations and wildlife.

Respondents also identified scavenging as an important type of human-wildlife conflict with major livelihood impacts. Respondents described scavenging as a process where dolphins consume released and unwanted fish that fishermen throw back, which leads to dolphins following the shrimp boats as a means to exploit food resources. Respondents clarified that the law requires them to release out-of-season, undersized, unwanted, or dead fish; they are not intentionally feeding the dolphins. Respondents emphasized that scavenging behaviors were the most common form of human-wildlife conflict, with it happening every night. Fishermen said

that dolphins associated them with food, akin to a floating "buffet" because of the requirement to throw back unwanted fish. They also noted that wildlife-safe fishing gear in the form of a TED results in increased numbers of dead and unwanted fish being released from the nets, thereby increasing the amount of scavenging that occurs.

Both types of human-wildlife conflicts between commercial shrimpers and dolphins lead to an increased reliance on artificial food sources for the dolphins coming from shrimp boats and nets. Respondents noted that this behavior can negatively impact the commercial shrimping industry and the overall health of dolphin populations, increasing the chances of entanglement. Shrimpers noted that they have to pick up their nets and move when they see dolphins depredating and scavenging because this helps them secure a better catch. This choice costs them time and money, but it does result in an intentional lessening of human-wildlife conflict.

Table 15

Codes and themes for human-wildlife conflicts with dolphins found in commercial shrimper interviews. Interviews were transcribed verbatim, and colloquialisms were kept as is.

Human-wildlife Conflict	Theme	Example
Depredation (e.g. dolphins consume live fish from nets)	Dolphins tear holes in nets to get fish	● "They [dolphins] will come up and tear my shrimp net open to get the fish to come out of it so they can eat them. They [dolphins] are trying to tear small holes, trying to get the fish half in and half out of the net itself, but when I'm pulling my shrimp net, you can feel the boat surging backward

from the dolphins grabbing my net and pulling on it. That's when I'm shrimping. That's about every time I go shrimping, I have dolphins biting at my net."

- "Dolphins eat a bunch of the fish caught in my nets, yes."
- "Dolphins snap a hole in my gear every so often. There is no harm from the dolphins. Sharks are a bigger problem. They feed and snatch at the gear."
- "Dolphins, from what the fishermen tell me, can be a nuisance. They [dolphins] will bite holes in the net from time to time. They tell me they have untied the tail bags when you tie your net up to keep your shrimp and fish in. They are down there with the fish and they are wanting to eat them because they eat their body weight a day or something. So they are naturally wanting to get that easy catch and eat them."
- "They [dolphins] usually bite at the net, trying to get ahold of shrimp."

		• "They [dolphins] try to bite the holes in the nets, they try to get the fish out, but that is normal, they have to eat. Just like sharks, they have to eat."
	There are no effective ways to deter dolphins from nets	• "You can definitely tell when there were more dolphins, there were more holes. We put zip ties but I don't think they helped. In Florida, we put chains, but they still ripped the tail bag." • "Respondent: "I have been told that if you put zip ties on your net and leave the zip ties unsnipped that will discourage dolphins from doing that. That's what I have on my net now." Interviewer: "Have you noticed a difference with them?" Respondent: "I have not, they [dolphins] tear it open still."
Scavenging (e.g. dolphins consume released fish that is out-of-season, undersized, unwanted, or dead that is	Dolphins follow shrimp boats for fish	• "I got about 30 dolphins following me a night. All night long, they come up right beside the boat and eat the fish right off the top of the net." • "Even when you drag, you still see them

required by law to be thrown back)	[dolphins], so you pick your gear and your nets up, you see more of them. They [dolphins] are probably feeding off of the bycatch coming from the nets, who knows. Or better yet, you probably see bycatch that comes out of the TEDs and the fish eaters. Because we lose a lot of percentages that they [dolphins] are probably feeding on when it comes out of the TEDs." ● Trust me, they [discarded fish] don't go to waste, because when I'm shrimping the dolphins, I've got lots of dolphins, I'm a floating buffet to the dolphins when I'm shrimping." ● "No, I mean, I have my net down there, I'm trawling and we are catching shrimp but also catching fish, and dolphins want those fish." ● "4 to 5 dolphins will follow me out of nowhere. Dolphins eat the live bait and will follow the shrimp boat." ● "They [dolphins] got used to being fed and

		have stopped hunting."
	Shrimpers are not intentionally feeding dolphins	● "We don't 'feed the dolphins bycatch', what we do is pick out our net, and I make it very clear to the people I take that shrimping that it is unlawful to feed the dolphins. We don't taunt them, we don't dangle fish over their mouth, we don't do anything like that. But we do pick out our net, we put the catch in bowls and we pick out and throw the fish overboard, and dump the shrimp in an ice chest. Truth be told, a lot of times there is twenty to thirty hungry dolphins hanging around my boat waiting for those little fish to hit the water, but we are not intentionally feeding the dolphins; we are picking our catch out. And I am very careful to make sure they [customers] aren't doing anything that looks like they are feeding a dolphin." ● "Yes, I would never feed them [dolphins] personally out of my hand, none of that because you wouldn't want them getting used to a human being so close."

- “I need to make sure you understand I’m not feeding dolphins bycatch; they are just eating the bycatch we are throwing overboard. I just want to make sure it’s understood, I’m not feeding them; they just happen to be there eating what goes in the water.”
- “I have seen dolphins numbers do nothing but grow and I can’t see where that has been a detriment to them in any way. That being said, I am very strict, no matter how bad people want to pet them, absolutely not. If they want to dangle a fish over their mouth, absolutely not. If they want to aim a fish and toss a fish to a dolphin with its mouth open, absolutely not. You have to pick out and simply throw the fish overboard and if the dolphins get them, then they get them. But most of the time we are picking out when we are underway, the dolphins stay there right with us. At that time, we are floating moving buffet instead of a floating buffet standing still.”

- "We didn't feed the dolphins intentionally; however we did have to throw back our bycatch. We didn't throw the fish directly to the dolphins, but the dolphins always managed to eat the fish."

3.3 Characterizing human-wildlife conflicts for sea turtles in the Gulf of Mexico

Contrary to dolphins, our interviewees noted that sea turtles did not exhibit depredation and scavenging behaviors with shrimping gear. Given the different nature of sea turtle interactions, we altered our data coding process to accurately capture the current human-wildlife conflicts for sea turtles (Table 16). We found that, unlike with dolphins, human-wildlife conflict rarely occurs, according to interviewees. Respondents noted that human-wildlife conflict has been significantly reduced to near zero due to TEDs. For example, one respondent said, "Occasionally out on the Gulf beach when we were dragging the trawls, I could remember 3 times that we caught a big sea turtle because way back then we didn't [have] TEDs [on our nets]. We caught a big sea turtle, the first time I had ever seen one." Another respondent mentioned a lack of sea turtle encounters in the habitats where they commonly fish, "In the Bay, we never see sea turtles in Mobile Bay. I haven't seen one in years. You do see them in the Mississippi Sound sometimes, when I say see them, I don't mean catching them; I mean seeing them in the water."

Human-wildlife conflict in the form of bycatch, or the unintentional capture of a non-targeted species, still does happen, albeit much more rarely than in years prior due to the widespread adoption of TEDs. When sea turtles aren't successfully released by a TED, some fishermen take action to try and help the sea turtle. In one interview, the respondent explained,

"On rare occasion, [when the TED fails] you put them upside down, give them CPR, and they will squirt that water out of their mouth, you let them lay there for a minute, all of a sudden their feet will start flopping, flip him black over, and put him overboard. They take off swimming."

Despite the success of TEDs, respondents expressed polarized opinions over their efficacy, saying that TEDs are either effective or cause a disruption to their livelihood. In support of TEDs, a respondent mentioned, "[TEDs] are pretty effective, I mean, you'll catch one [a sea turtle] every now and then. You just put them overboard. Sometimes they will get caught in the bars. They will get caught in between, but this is a rare event." Contrary to this, a different respondent criticized TEDs, saying, "I have TEDs, they are a hassle, cost money. I started [using] them last year. They are dangerous. About 15% of the shrimp catch is lost because of TEDs. In Mobile Bay, you can catch anything which clogs the TEDs, that leads to time loss. Jellyfish also clog the TEDs at certain times of the year." In other words, TEDs have an unintended consequence of causing accidental loss of fish and shrimp, which in turn, leads to the scavenging problems described above for dolphins. This suggests technological advances may be needed to improve the design of TEDs and reduce the loss of catch and the accidental discarding of unwanted species that increase conflict with dolphins.

Table 16

Codes and themes for human-wildlife conflicts with sea turtles found in commercial shrimper interviews. Interviews were transcribed verbatim, and colloquialisms were kept as is.

Human-wildlife Conflict	Theme	Examples
Bycatch	Bycatch of sea turtles is infrequent	● Interviewer: "You said you don't typically see sea turtles when you're inshore, but do you ever

		have accidental gear interaction when you're offshore with sea turtles?" Respondent: "No, because I don't use any of my shrimping gear offshore, and when we are fishing, we only see the sea turtles as we are on our way to or from one of our sites." ● "Occasionally out on the Gulf beach when we were dragging the trawls, I could remember 3 times that we caught a big sea turtle because way back then we didn't pull TEDs. We caught a big sea turtle, first time I had ever seen one." ● "I would say I catch about 8 in the span of my shrimping. They were smaller sea turtles. All of them were alive and swam away. I had one with fishing line, we cut it off." ● "In the Bay, we never see sea turtles, in Mobile Bay. I haven't seen one in years. You do see them in the Mississippi Sound sometimes, when I say see them, I don't mean catching them; I mean seeing them in the water."
	Bycatch of sea turtles can happen at any time but changes in gear	● "Anybody is subject to catching a turtle. You can catch them anytime. We used to catch 4 or 5 a night before a TED."

	(TEDs) have made this rarer	
TEDs	TEDs are effective	• "The shrimp boats catch shrimp, and of course, they have the TEDs and the nets to shoot the turtles out and also the bigger fish out." • "TEDs have led to an increase in the sea turtle population, it does decrease the catch due to the debris caught in the TEDs, around 5% of the catch is lost because of TEDs." • "They [TEDs] are pretty effective. I mean, you'll catch one [sea turtle] every now and then. You just put them overboard. Sometimes they will get caught in the bars. They will get caught in between." • "They [TEDs] don't really hurt us. We lose probably 10 to 20 pounds a night if we don't catch anything in them compared to what we normally catch without TEDs. We got so used to pulling them, we figured out how to make them work better."
	TEDs are disrupting the shrimp quota	• "I have TEDs, they are a hassle and cost money. I started pulling them last year. They are dangerous. About 15% of the catch is lost

because of TEDs. In Mobile Bay, you can catch anything which clogs the TEDs, that leads to time loss. Jellyfish also clog the TEDs at certain times of the year."

- "Except TEDs, I don't agree with that. We leave them [sea turtles] alone, we don't catch them, it wasn't ever a big problem. They [resource managers] don't want us to catch anything."
- "TEDs, from what they tell me over the years, is TEDs will knock down the shrimp production at least 15% to 20% percent. That is another thing; back in the day, they didn't have to pull TEDs, now they do. People don't realize if they catch a log or a crab trap or anything else that is down there in the water that is big and they catch it and it gets hung up in their TEDs then it messes up everything for that hour drag or however long they have that net on the bottom. So they may not catch anything in that net for that period of time. It is a lot of things that is the nature of the beast."
- "They [TEDs] will clog and spin, and you can't

		catch anything if they spin over. You got to dump your whole bag."
Sea Turtle Handling	Shrimpers have different ideas about what one should do when they encounter a sea turtle	● "The first thing my dad did was flip the turtle upside down because they had been dragging the turtle for possibly about an hour or an hour and a half. So it had water in its lungs, they [shrimpers] would literally flip the turtle upside down and give it CPR until it regurgitated or started breathing. They flipped it back over, they picked it up and pulled it in the water, and it would swim off." ● "We make sure there wasn't any line on them [sea turtles] that there wasn't anything broken. We put them right up, let them get their strength back, and make sure their back legs weren't broken. We let them run on the boat for about 20 to 30 minutes and then throw them." ● "I'm sorry, if I would catch a turtle what should I do with it? First off, you don't throw him back overboard because he would drown. As far as I know, we don't have any literature on the proper way to turn them upside let them sit for so many minutes I don't know, but like I've

said I have never caught one. I don't know what to tell you about that. But I would love to have paperwork on that to better a procedure telling me what to do with him."

- "99.99%. You pick them [sea turtles] upside down, give them CPR, they will squirt that water out of their mouth, you let them lay there for a minute, all of a sudden their feet will start flopping, flip him black over and put him overboard. They take off swimming."
- "If we caught a sea turtle, he would just drop out of the net and be lively."
- "If a gill netter or a shrimper was to catch a turtle or a dolphin, which they [fishermen] hardly ever do, then they [marine wildlife] may have a hook in their mouth possibly, especially a turtle, I would think or somewhere. Most of the guys they would have a pocketknife and pliers of some sort."

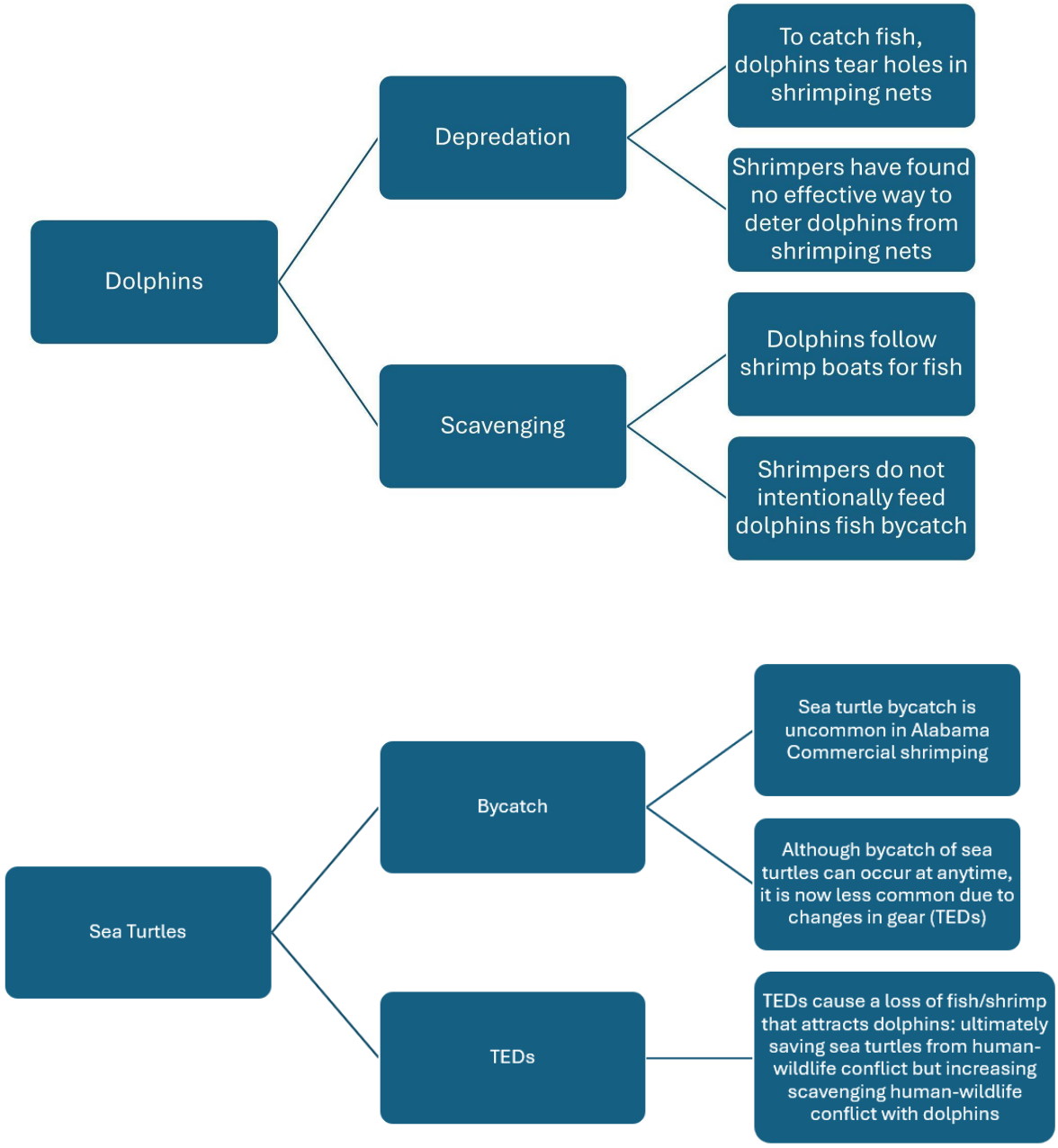

Figure 3. Tree diagrams illustrating the perceptions of human-wildlife conflict for sea turtles and dolphins from Alabama commercial shrimpers. The figure categorizes key themes contributing to human-wildlife conflict for each species, highlighting the contrasting nature of how marine wildlife interacts with fishing operations.

Discussion

This study aimed to fill a gap in the human dimensions literature characterizing human-wildlife conflict occurring with dolphins and sea turtles in the Gulf of Mexico commercial shrimp fisheries, particularly along the coast of Alabama, but relevant to the entire Gulf. A wide variety of studies have examined commercial shrimp fisheries and their interaction with marine wildlife in a global context and the narrow context of the Gulf of Mexico. However, there have been limited studies that characterize the human-wildlife interactions with the commercial shrimp industry, one of the most important sources of economic revenue in the region, and its impacts on dolphins and sea turtles along the Gulf Coast.

Our study clarified and categorized the human-wildlife conflict interactions between commercial shrimpers and dolphins, including accidental gear interactions, depredation, and scavenging behaviors. Our study aligns with Greenman et al. 2014 and Fertl et. al. 1997, as both their work and ours emphasize increased dolphin interactions with commercial shrimp nets since the 1970s [67], [79]. Commercial fishermen commonly identify the most important form of human-wildlife conflict occurring with dolphins that is impacting their livelihoods: depredation. Depredation forms of human-wildlife conflict present challenges for commercial shrimpers. These challenges include: 1) dolphins tearing holes in nets to get to fish, and 2) there being no effective ways to deter dolphins from nets. Similar to our findings, other studies from across the globe have found depredation to be an international-scale problem. Bonizzoni et al. 2021 analyzed dolphin interactions in the north-western Adriatic Sea, highlighting that depredation is the most prevalent and thoroughly researched form of dolphin adaptation to human activities [102], [103]. Alabama shrimpers shared their ongoing struggle with dolphins interacting with their shrimping gear. Dolphins were observed damaging shrimp nets and tearing holes in

attempts to exploit the fish resources and consume a large portion of their catch. Commercial fishermen attempt to deter dolphins from depredating on their catch by adding informal adjustments to their gear, like zip ties or chains, yet dolphins continue to pursue the fish despite attempts to discourage this negative interaction. This suggests technological advancements are needed to deter dolphins from damaging gear, especially as dolphins become more numerous when conservation laws have their desired impact.

Commercial shrimpers also emphasized the challenges created by scavenging behaviors in dolphins, citing the following challenges as among the most pressing: 1) dolphins follow shrimp boats for fish, and 2) shrimpers are not intentionally feeding dolphins. A study carried out in the Gulf of Mexico's Mississippi Sound presents data suggesting that dolphins tend to scavenge discarded fish in the presence of both active and non-active shrimp trawlers, meaning they know what they are looking for and are changing their behavior [103]. In the case of Alabama, shrimpers frequently witness dolphins trailing behind their vessels while dolphins consume fish either from the net or thrown overboard. The shrimpers, however, did stress that they discard the bycatch fish only and, according to the law, the bycatch that the dolphins scavenge, rather than engaging in the intentional feeding of dolphins. They also emphasized their awareness that feeding the dolphins can lead to dolphins becoming accustomed to human interactions and that they'd prefer dolphins remain at a distance as they impact catch success.

Interactions between sea turtles and the commercial shrimp industry show contrasting dynamics, particularly because sea turtles have demonstrated passive interactions in previous studies. This is where an animal is swimming freely without actively interacting with fishing operations and becomes entangled with fishing gear [14]. These passive behaviors might discourage sea turtles from depredating and scavenging shrimp gear. In our study, the most

important form of human-wildlife conflict associated with sea turtles and shrimping operations is bycatch. However, our shrimper interviews showed consensus that accidental bycatch of sea turtles is infrequent because of the widespread adoption of TEDs. Moore et al. 2009 reviewed available information, such as observer programs, estimates, and regulations for bycatch of sea turtles, marine mammals, and sea birds in fisheries in the U.S., highlighting that the Atlantic and Gulf of Mexico shrimp trawl fisheries are some of the most problematic for bycatch of sea turtles [71]. In contrast, most of our respondents expressed that accidental gear interactions are now rare, suggesting some preliminary improvements in human-wildlife conflict in recent years. In our interviews, the shrimpers noted that they usually do not encounter sea turtles near shore, with rarity in such interactions due to gear changes like the inclusion of TEDs. However, they explained that there is still potential for commercial fishing vessels to accidentally capture sea turtles and that TED's design could be improved.

Shrimp fishermen play a critical role in reducing human-wildlife conflict by adhering to key wildlife laws and implementing conservation-focused gear such as TEDs. The perspectives on the effectiveness of TEDs vary, as indicated by our respondents, resulting in divided views: TEDs are considered to be effective in protecting wildlife while disrupting the shrimp harvest. Respondents described that while sea turtles are occasionally still caught in shrimping nets, TEDs are recognized as a useful adaptation to gear for reducing the bycatch of sea turtles. Nevertheless, concerns were expressed regarding the decline in catch efficiency due to live fish debris getting trapped in the TEDs, which, from their experience, could result in a 5% to 15% loss of catch.

Though TEDs come at a cost and can cause inconvenience to the shrimpers because they are heavy and cumbersome to tow, they are seen as an essential conservation strategy. Overall,

TEDs were acknowledged for their conservation benefits but described as presenting difficulties in shrimping operations. In a study looking at fisheries education and extension programs, the use of principles of diffusion theory, which implement innovation, communication, channels, time, and the social system, aided in the successful adoption of TEDs with U.S. shrimpers [40]. This study highlighted that personal interactions with resource managers, providing assistance in installation, and offering personal instruction on TEDs can all increase voluntary adoption from shrimpers. This was also seen in Georgia shrimpers, as they were actually included in the historical development process of TEDs, and their local ecological knowledge was respected and used to improve the design of the TED [97]. On the other hand, Duarte et al. 2019 found that the Brazilian penaeid-trawl fisheries are resistant to the adoption of TEDs due to mandated designs, limited third-party expertise, and insufficient advocacy from authorities on the importance of accepting minimal financial losses to enhance ecological sustainability [104]. Overall, the effective implementation of TEDs depends not only on the design and functionality of the gear but also on how resource managers integrate them and the engagement of those who are required to use them, reflecting a balance between community involvement and innovation.

In our study, sea turtle handling procedures varied among commercial shrimpers, indicating a need for knowledge of the standardized protocols for addressing bycatch scenarios. In the interview responses, the shrimpers described methods for reviving sea turtles by turning them over to remove water from their lungs, performing CPR, checking for injuries, and releasing them back into the water. According to NOAA Fisheries, in trawl fisheries, caution must be taken to prevent major injury from occurring by dropping the sea turtle from the net onto the deck. Due to the extended amount of time an accidentally captured sea turtle can be submerged underwater, fishermen may need to provide resuscitation or time to recover before

releasing it [94]. In 2019, Zollett et al. reviewed the safe handling practices within the tuna fisheries. Their findings show the strategies that increase the post-capture survival of marine species include minimizing immediate mortality, limiting injury to delay mortality, and reducing stress that can result in mortality [105]. To address the misinterpretation of correct and safe sea turtle handling in the commercial shrimp fisheries in Alabama and in other regions, educational programs may be of benefit, as seen in the Zollett et al. study, where routine training of fishermen on safe handling practices significantly improved the effectiveness of such protocols. Education programs promoting wildlife-friendly practices foster a culture of responsible natural resource stewardship while encouraging coexistence between important human activities, such as commercial fishing and marine wildlife conservation efforts.

Conclusion

Our findings shed light on the current demographics, fishing practices and gear, and interactions within the commercial shrimp industry on the Alabama coast. The demographics of our commercial shrimpers sample were primarily white (100%) males (100%), which are consistent with previous literature on commercial fisheries in the Gulf of Mexico [58]. Our findings reveal the varied nature of interactions that occur between commercial shrimpers and marine wildlife, ranging from dolphin depredation to sea turtle bycatch.

Our research strengthens the understanding of how commercial fisheries are impacted by human-wildlife conflict amongst two groups targeted by increased conservation funding following the BP oil spill. To promote sustainable fishing practices and reduce negative effects on marine wildlife, such as bycatch, effective mitigation measures should consider the unique interactions between wildlife and commercial fishing gear in regional and local fisheries, as well as standardized training practices to ensure commercial fishermen are aware of the best available

science to protect wildlife. Future studies can concentrate on longitudinal studies to track changes in the knowledge held by commercial fishermen about avoiding human-wildlife conflict as well as interactions between commercial fisheries and wildlife. Despite conservation efforts like the use of TEDs in shrimp nets, challenges remain, which highlights the need for ongoing research, education, outreach, and adaptive management strategies.

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Appendices

AUBURN UNIVERSITY
College of Forestry, Wildlife and Environment

Commercial Fishermen Survey

We are looking to understand how commercial anglers as well as charter boat and head boat captains interact with sea turtles and dolphins along the coast of Alabama. Understanding how YOU, as a fisherman in Alabama, interact with wildlife will help us understand how to better inform management. This survey is funded with Deepwater Horizon natural resource damage settlement funds provided by the Alabama Trustee Implementation Group. This project is associated with the Alabama Department of Conservation and Natural Resources and Auburn University College of Forestry, Wildlife, and Environment. Respondents who fully complete the survey will be entered to win a $50 Bass Pro Gift Card. If you have any questions, comments, or concerns please reach out to TiAnna Olivas (MS student) at tmo0017@auburn.edu. Your responses will all be anonymous and no identifying factors will be collected. We really appreciate your time, and respect your point of view, and want to understand it.

If you would like more information on the policies regarding this survey please click the file below. To begin please click the next button below.

Policies and Procedures

Demographics.

What year were you born?

Please indicate your race.

○American Indian or Alaskan Native Asian

○Asian

○Black or African American

○White

○Other (fill in)

○I prefer not to answer

Do you identify with Latino, Hispanic, or Spanish origin?

○Yes

○No

○I prefer not to answer

Please indicate your gender.

○Male

○Female

○Other

○I prefer not to answer

In which state do you currently reside?

What is your US Zip Code (5 digit zip code)?

What is your highest level of education?

○Did not graduate high school/no GED

○High school graduate/GED

○Technical/Vocational School

○Some College/AA or AS (2 year degree)

○College Graduate/BA or BS (4 year degree)

○Graduate or Professional School

Fisheries information.

Are you a commercial or recreational angler?

○Charter Boat Captain/ guide

○Headboats

○Commercial Fisherman

○Other (fill in)

What fish are you trying to catch (select all that apply)?.

☐Reef fish

☐Mackerels

☐Mullet

☐Shrimp

☐Blue crab

☐Other finfish (fill in)

What gear do you use (select all that apply)?

☐Gillnet

☐Trawls

☐Skimmers

☐Trap pots

☐Hook and line

☐Other (fill in)

Who to contact if you encounter an injured animal and what to do.

In the event that I encounter an injured **dolphin**, I call:

○The police

○The Coast Guard

○ADCNR

○The Marine Mammal Stranding Hotline

If I find a dead or injured **sea turtle** I should call:

○The police

○The Coast Guard

○ADCNR

○The Alabama Sea Turtle Stranding and Salvage Network Hotline

Would you be willing to report an injured **dolphin**?

○Yes

○Probably yes

○Unsure

○No

○Probably no

○Definitely no

Explain your answer here (optional).

Would you be willing to report an injured **sea turtle**?

○Yes

○Probably yes

○Unsure

○No

○Probably no

○Definitely no

Explain your answer here (optional).

Please select all of the gear that, to your knowledge, is required by law to be on board a commercial vessel (According to Appendix F to Part 622 - Specifications for Sea Turtle Release Gear and Handling Requirements).

- ☐ Long-handled line clipper or cutter
- ☐ Long-handled dehooker for internal hooks
- ☐ Long-handled dehooker for external hooks
- ☐ Long-handled device to pull an "inverted V"
- ☐ Net or hoist
- ☐ Cushion or support device
- ☐ Short-handled dehooker for internal hooks
- ☐ Short-handled dehooker for external hooks
- ☐ Long-nose or needle-nose pliers
- ☐ Bolt cutters
- ☐ Monofilament line cutters

☐Mouth openers or mouth gags

☐Other:

True or false (to the best of your knowledge): Any **sea turtle** incidentally captured during fishing operations must be handled, and release gear must be used, in accordance with the National Marine Fisheries Service careful handling, resuscitation, and release protocols.

○True

○False

○I don't know

Sea turtle information.

How frequently do you encounter **sea turtles**?

○Daily

○Once a week

○Once a month

○Other (fill in)

What species of **sea turtles** are you most likely to encounter?

○ Green sea turtle

○ Kemp's ridley sea turtle

○ Olive's ridley sea turtle

○ Other (fill in)

Interactions with wildlife.

Please check the frequency that the following events occur:

	Never	Rarely (1-3 times per year)	Sometimes (around 4-12 times per year)	Frequently (more than 12 times per year)
Accidental gear interaction with dolphins	○	○	○	○
Accidental gear interaction with sea turtles	○	○	○	○

Feeding dolphins bycatch	○	○	○	○
Dolphins eating bait or fish off my gear	○	○	○	○
Dolphins eating thrown back, undersized or out of season fish	○	○	○	○

Respondents knowledge of threats faced by wildlife.

One of the most important threats faced by **dolphins** are interactions with fishing gear.

○Agree

○Disagree

○I don't know

Feeding **dolphins** bycatch is a threat to **dolphins**.

○Agree

○Disagree

○I don't know

Accidental capture of **sea turtles** by anglers is one of the main threats **sea turtles** face.

○Agree

○Disagree

○I don't know

Willingness to change behavior.

Please select your willingness to adjust certain behaviors if it means that **dolphin** and **sea turtle** populations increase:

	Very unwilling to change this behavior	Unwilling to change this behavior	Neutral or I do not know	Willing to change this behavior	Very willing to change this behavior
Feeding dolphins bycatch	○	○	○	○	○
Changing my bait to be safer for turtles	○	○	○	○	○
Use non stainless	○	○	○	○	○

steel hooks

Pull gear out of the water when dolphins come nearby	○	○	○	○	○
Relocating to a different location where there are no dolphins	○	○	○	○	○

General attitude towards sea turtles and dolphins.

I enjoy seeing **dolphins** when out on the water:

○Agree

○Disagree

○Neither

○I don't know (Explain answer if you can)

I enjoy seeing **sea turtles** when out on the water:

○Agree

○Disagree

○Neither

○I don't know (Explain answer if you can)

I feel that having **dolphins** in the ecosystem is:

○Very important

○Somewhat important

○Neither important nor unimportant: I'm neutral

○Somewhat not important

○Not at all important (Explain answer if you can)

I feel that **marine mammal** conservation laws and policies are:

○Very important

○Somewhat important

○Neither important nor unimportant: I'm neutral

○Somewhat not important

○Not at all important (Explain answer if you can)

I feel that the future survival of **sea turtle** species is:

○Very important

○Somewhat important

○Neither important nor unimportant: I'm neutral

○Somewhat not important

○Not at all important (Explain answer if you can)

I feel that **sea turtle** protection laws and policies are:

○Very important

○Somewhat important

○Neither important nor unimportant: I'm neutral

○Somewhat not important

○Not at all important (Explain answer if you can)

Educational Materials & Outreach

We are asking for help planning new educational material on wildlife. Please indicate your willingness to read certain types of education materials ranking them from 1 (unlikely to read) to 5 (very likely to read).

	Very unlikely to read	Unlikely to read	Neutral or I do not know	Likely to read	Very likely to read
Pamphlet	○	○	○	○	○
Sign posted outside	○	○	○	○	○
Magnet for my fridge	○	○	○	○	○
Sticker	○	○	○	○	○

Other (write in):

In your opinion, where would placement of educational signage on wildlife reach the biggest audience?

☐Orange Beach

☐Gulf Shores

☐Dauphin Island

☐Bayou La Batre

☐Fairhope

☐Write in any specific opinions or alternative locations:

Preferred media for getting information.

How do you stay informed with the latest fish and wildlife news?

☐Print News

☐Social media (write in main sources)

☐Friends and family

☐Television news (non-cable)

☐Television news (cable)

☐Radio

☐Online forums (e.g. reddit or fishing forums)

☐Other (fill in)

Where have you learned information about **wildlife** conservation (including the laws protecting **dolphins** and **turtles**)?

☐Print News

☐Social media (write in main sources)

☐Friends and family

☐Television news (non-cable)

☐Television news (cable)

☐Radio

☐Online forums (e.g. reddit or fishing forums)

☐School

☐Other (fill in)

Email.

Enter your email for a chance to win a $50 Bass Pro gift card.