# REPORT TO CONGRESS

## INTERACTIONS BETWEEN BOTTLENOSE DOLPHINS AND SHARKS AND COMMERCIAL, FOR-HIRE, AND PRIVATE RECREATIONAL FISHERIES IN THE GULF OF MEXICO AND SOUTH ATLANTIC

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*Developed pursuant to: Joint Explanatory Statement accompanying the Consolidated Appropriations Act, 2021 (Public Law 116-260)*

Janet Coit
Assistant Administrator for Fisheries
National Oceanic and Atmospheric Administration

Dr. Richard W. Spinrad
Under Secretary of Commerce for Oceans and Atmosphere
and NOAA Administrator

THE JOINT EXPLANATORY STATEMENT ACCOMPANYING THE CONSOLIDATED APPROPRIATIONS ACT, 2021 (PUBLIC LAW 116-260) INCLUDED THE FOLLOWING LANGUAGE

*Assessment of Fishing Interference. —The agreement directs NMFS to undertake a review, no later than 90 days after enactment of this Act, to assess and better understand the occurrence of conflicts between dolphins and sharks and commercial, for-hire, and recreational fishing vessels in the Gulf of Mexico and South Atlantic. The review should provide: (1) a quantification, to the extent practicable within existing resources, of the degree to which dolphins and sharks interfere with commercial, charter, and recreational fishing; and (2) recommendations for non-lethal methods to deter dolphins and sharks from interfering with commercial, for-hire, and recreational fishing, in accordance with existing laws. NMFS shall report to the Committees on the results of the review no later than one year after the review is commenced. In conducting the review, NMFS shall consult with the Marine Mammal Commission, the Gulf of Mexico Fishery Management Council, the South Atlantic Fishery Management Council, the Atlantic Highly Migratory Species Advisory Panel, and conduct outreach to commercial, for-hire, and recreational fishermen.*

THIS REPORT RESPONDS TO THE COMMITTEES' REQUEST.

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# I. EXECUTIVE SUMMARY

This report responds to the directive in the Joint Explanatory Statement accompanying the Consolidated Appropriations Act, 2021 (Public Law 116-260) to undertake a review to assess and better understand dolphin and shark interactions with private recreational, for-hire (charter and headboat), and commercial fisheries in the Gulf of Mexico and South Atlantic. The report was informed by consultations with the Marine Mammal Commission, Gulf of Mexico Fishery Management Council, South Atlantic Fishery Management Council, and Atlantic Highly Migratory Species Advisory Panel, as well as public comment to the Councils and Advisory Panel. The input received through those consultations is attached in Appendices I–IV. Dolphin and shark interactions with fisheries are complex and challenging, and increasing in some areas of the Gulf of Mexico in recent years. Existing information indicates dolphin interactions occur primarily in private recreational, for-hire, and commercial hook and line fisheries throughout the Gulf of Mexico and off Florida's east coast. Shark interactions have been reported in private recreational, for-hire, and commercial hook and line fisheries in both the Gulf of Mexico and South Atlantic.

Types of interactions include: dolphins and sharks taking bait or catch directly off a fish hook or lure (depredation); eating discarded, often undersized, fish (scavenging); and, in the case of dolphins, illegal feeding by boaters and fishers. Many known environmental and human-caused factors contribute to these interactions; but perhaps the largest driver of dolphin-fishery interactions is illegal feeding of dolphins. Within the Gulf of Mexico, the areas with the greatest rates of dolphin depredation are also the areas with the greatest reports of illegal dolphin feeding by fishers, ecotours, tourists, and residents.

Interactions are problematic for both fishers and dolphins and sharks. Dolphin and shark interactions with fisheries result in loss of catch, damaged gear, and degraded fishing experiences, and may also impact the post-release survival of target fish. These interactions also negatively impact dolphin and shark populations. Dolphins are seriously injured or killed by ingesting, being hooked by, or becoming entangled in fishing gear, being struck by a vessel or its propeller, or being intentionally harmed. According to anecdotal reports, sharks have also been entangled in fishing gear during depredation events, and some fishers use fireworks or firearms to deter shark depredation when returning undersized fish to the water.

The nature, extent, frequency, and geographic locations of dolphin- and shark-fishery interactions are not fully understood. More data would be needed to improve our ability to quantify dolphin and shark interactions with fisheries. These data could be collected if additional resources were available to augment and analyze existing datasets. Specifically, augmenting the Marine Recreational Information Program (MRIP), the Southeast For-hire Integrated Electronic Reporting (SEFHIER) logbook program, and state fishery surveys would provide additional information on the scope, scale, and frequency of dolphin and shark interactions with private recreational and for-hire fisheries. And Federal fishery observer data could be analyzed to better quantify dolphin and shark interactions with commercial hook and line fisheries. Without more information from these data sources, dolphin- and shark-fishery interactions will remain poorly understood, thus limiting productive management and prevention strategies.

Fishers have limited tools and options to reduce dolphin and shark interactions and are frustrated by the inability to prevent interactions. Deterrents are often a solution explored by fishers to address depredation. However, deterrents are not the only solution, particularly for dolphin depredation given questions about their long-term effectiveness due to bottlenose dolphins' highly food-motivated and adaptable behaviors. Instead, avoiding interactions, whenever possible, is the safest method for preventing death or serious injury to dolphins and sharks and the best way to minimize risk to human safety.

Additional studies would be needed to determine the long-term effectiveness of promising non-lethal deterrents, such as gear modifications, descender devices and, in the case of sharks, chemical deterrents, to ensure fisher's investments in prevention devices or methods remain viable and effective over time, and deterrent methods are safe for dolphins, sharks, and other non-target species. Most importantly, given the known link between illegal feeding of dolphins and increased fishery interactions, continued and active engagement with fishers, ecotour operators, and others on the importance of not feeding dolphins is the most effective and long-term prevention technique, along with enforcement of feeding prohibitions. Additional resources would be required to improve the reach of and effectiveness of current engagement activities, which should be informed by social science studies, and include ways to prevent the association of dolphins and sharks with fishing boats and feeding opportunities when returning undersized or other prohibited catch to the water.

The National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) recognizes an enhanced, thoughtful, and collaborative approach is needed to manage the complex nature of fishery interactions with dolphins and sharks, in coordination with numerous stakeholders, including state natural resource agencies, commercial and recreational fishers, researchers and academics, and others. We are committed to pursuing this approach to the fullest extent our resources allow.

## II. INTRODUCTION

Conflicts between marine mammals and fisheries are complex, increasing in occurrence, and global in extent.[1, 2, 3] Throughout the southeastern United States, bottlenose dolphins are known to occasionally interact with commercial blue crab pots in two locations of the South Atlantic, and interactions between commercial and private recreational hook and line fisheries and bottlenose dolphins (dolphins) are prevalent.[4, 5, 6, 7, 8] Because the blue crab pot interactions are managed under the Bottlenose Dolphin Take Reduction Plan, this assessment focuses on interactions between dolphins and hook and line fisheries. These interactions are problematic for both fishers and dolphins. Fishers experience frustration and economic impacts[3, 9] and there may be impacts to post-release survival of target fish. Dolphins suffer injuries and deaths from being entangled in and ingesting fishing gear, vessel strikes, and retaliation from humans based on these interaction behaviors – all of which can have a negative impact on dolphin populations.[8, 12, 13, 14, 15]

Similarly, reports of shark interactions are increasing in recent years due to potentially learned behavior, rebuilding of some shark populations, increasing fishing effort, and more fish being released and discarded due to more restrictive regulations. However, shark depredation is not a

recent phenomenon. In fact, some of the first photos from Ernest Hemmingway's fishing days in the 1930s document shark depredation when he lived in Cuba and the Florida Keys (www.anglersjournal.com/saltwater/fighting-big-fish-with-ernest-hemingway). A recent article by Jane Fogt in *Anglers Journal* states, "Ernest Hemingway returned from the Spanish Civil War in the 1930s, a time when fishermen were landing giant bluefin tuna on rod and reel in the shallow waters off Nova Scotia. But they found it nearly impossible to land giants or marlin in the deep waters off Bimini before sharks 'apple-cored' them." Impacts from shark depredation have become more salient in fisheries worldwide in the last two decades.[62] Accordingly, anecdotal reports of shark depredation have increased in both state-managed and federally managed fisheries.

## A. Types of Interactions

*Depredation:* Depredation most often consists of a dolphin or shark taking bait or catch directly off of a fishing hook or lure[3, 8] (Figures 1b and 1d). Depredation may also include damage to a fish before the fish can be brought on board the vessel by the fishers or angler; but can also include the damage inflicted on gear and bait in attempts by the dolphin or shark to remove the fish. The dolphin or shark may be incidentally caught by the fishers during these events.

*Scavenging:* Scavenging is the act of a dolphin or shark eating discarded, often undersized, fish immediately after it is thrown back (e.g., the fish that is released because it is under a legal size limit or out of season).[5] Fish are often disoriented or immobilized after being caught and are more vulnerable to predators after they are returned to the water[10, 11] (Figure 1a).

*Illegal Feeding:* Specific to dolphins, illegal feeding of wild dolphins by boaters and fishers contributes to further dolphin-fishery interactions and occurs commonly throughout the Southeast United States.[5, 8, 9, 10, 11, 14, 58, 60, 61] The Marine Mammal Protection Act's (MMPA) implementing regulations prohibit feeding or attempting to feed any marine mammal in the wild (50 CFR 216.3 (Defining *Feeding* and *Take*), 216.11 (Prohibiting Take). Illegal feeding often serves as the catalyst for depredation and scavenging because it teaches dolphins to associate humans, boats, and fishing gear with food (Figure 1c).


**Figure 1. (a) A dolphin preying on a discarded fish (i.e., scavenging) from a recreational fishing boat in Sarasota, Florida (photo courtesy of Sarasota Dolphin Research Program); (b) a dolphin taking fish directly from recreational hook and line fishing gear (i.e., depredation) in Tampa Bay, Florida (photo courtesy of NMFS Southeast Regional Office); (c) Recreational fishers feeding a dolphin in Naples, Florida (photo courtesy of Sarasota Dolphin Research Program); and (d) shark depredation on a sailfish (photo courtesy of Chase Green).**

## B. Causes of Interactions

Fishery interactions with dolphins and sharks are caused by a combination of factors. For dolphins, these include the decline of dolphin prey populations from environmental events or overfishing and dolphins teaching one another depredation or scavenging behaviors, especially mothers teaching calves.[5, 9, 16, 17, 18, 19, 20, 22, 23] In the Gulf of Mexico, declines in fish populations following harmful algal blooms, impacts of the Deepwater Horizon Oil Spill, and climate change likely exacerbate fishery-dolphin interactions.[5, 26, 27, 28] Perhaps the greatest driver, however, is the continued illegal feeding of wild dolphins.[21, 24] When fishers and other boaters illegally feed dolphins, it causes dolphins to associate fishers with a food source. Illegally fed dolphins depredate and scavenge more often than dolphins that are not fed.[14, 24, 25] In addition, although

releasing fish that are undersized or otherwise prohibited by regulations near dolphins is not illegal, it can reinforce dolphins' association with fishing boats and feeding opportunities in the same way as when they are illegally fed, leading to continued depredation and scavenging behaviors. Fishers have suggested that increased dolphin populations are a major contributing factor to the increase in dolphin-fishery interactions in the Gulf of Mexico. However, scientific data and published literature indicate increased mortality in bottlenose dolphin populations in the Northern Gulf as a result of impacts from the Deepwater Horizon Oil Spill and multiple Unusual Mortality Events over the past 11 years.[29, 30, 31] There is no evidence to suggest that growing dolphin populations are the cause of increased depredation and scavenging interactions.

Increased reports of shark depredation may be due to a learned behavior by the sharks, decreased prey abundance, increased shark abundance, increased fishing effort, increased social media posts, or a combination of these factors. Regardless of the cause, shark depredation has substantial economic and sociocultural impacts on commercial and recreational fisheries[62] and so must be considered as a source of conflict affecting fishery management and conservation efforts, especially when it leads to fishers or anglers killing sharks without landing or reporting them or opposing management measures that are needed to sustain or rebuild overfished populations.

## III. QUANTIFICATION OF DOLPHIN AND SHARK INTERACTIONS WITH HOOK AND LINE FISHERIES

### A. Bottlenose Dolphins

Bottlenose dolphins depredate fishing gear and scavenge discarded fish across the following hook and line fisheries: private recreational, for-hire (i.e., charter and headboats), and commercial (e.g., bottom longline and hook and line). Existing information indicates bottlenose dolphin interactions with hook and line fisheries occur throughout the Gulf of Mexico and off Florida's east coast. Data and information on private recreational and for-hire interactions are scarce but have been quantified to some extent. Additional resources would be needed to quantify limited data on commercial interactions gathered through observer coverage, and to address considerable information needs and data gaps across all hook and line fisheries.

1) *Private Recreational* – Private angler hook and line fishing for pleasure or as part of a competition. Catch is not sold for profit.

    a) A study conducted in Sarasota Bay, Florida, found increased interactions between bottlenose dolphins and recreational fisheries between 2000 and 2007, peaking in 2006 and 2007. Fourteen percent of the local dolphin population was observed interacting with recreational fishing gear. Individual dolphins observed engaging in scavenging and depredating were more likely to continue those behaviors and less likely to revert to natural feeding behavior. Interactions with dolphins increased seasonally coinciding with greater recreational use of the bay as well as following harmful algal blooms (i.e., red tide events) when there was sustained recreational activity yet lower prey availability.[5]

b) The Florida Fish and Wildlife Conservation Commission administered an online survey of fishers in March 2021. About 60 percent of charter fishers and about 40 percent of private recreational fishers who responded reported interactions with dolphins over the last year on at least one trip, and the majority of interactions occurred while the catch was still on the gear (i.e., depredation).[47]

2) *For-hire industry* – Entities who own and operate their vessel for the use of recreational fishing by other parties. This includes charter and headboat vessels.

a) A study investigating dolphin scavenging on discarded fish from for-hire vessels off Florida's Gulf coast found scavenging increased by 12 percent on average between 2009 and 2019.[4] Increased scavenging mainly occurred in areas around Panama City and Destin, Florida (Figure 2), which are known hot-spots for dolphins being illegally fed by fishers, ecotours, residents, and tourists.[24, 57, 58] The number of fishing lines in the water had a positive effect on the occurrence of scavenging, with more fishing indicating a higher likelihood of observed dolphin scavenging. Most observed scavenging events (75 percent) occurred with species such as red snapper and red drum, perhaps indicating a prey preference by dolphins when interacting with hook and line fisheries.[4]
b) A study conducted off Alabama and the northwest Florida panhandle from 2014 to 2017 did not observe depredation and scavenging interactions by dolphins despite encountering them on 6 percent of fishing stations over 19 trips with for-hire and private anglers.[7] However, a previous study from 2008 to 2010 in similar locations encountered dolphins on more than half of the fishing trips (61 percent) and observed depredation and scavenging on 38 percent of those trips.[6] The discrepancy between these studies in dolphin interaction frequency over time highlights the challenges with understanding contributing factors to fisheries interactions without long-term systematic data collection and sufficiently large sample sizes.
c) A 2003 study of the Florida King mackerel troll fishery operating along the southern Florida East Coast and Florida Keys reported dolphins depredating 6 percent of charter vessels' catch. Almost all charter and commercial fishers (47 out of 49) interviewed during this study reported prior observations of dolphins depredating bait or catch.[8]
d) A study conducted during 2007 and 2008 in the northwestern Gulf of Mexico estimated the post-release mortality of recreationally caught red snapper from barracuda and bottlenose dolphin scavenging occurred between 17 and 27 percent of the time, depending on the depth and season.[10]

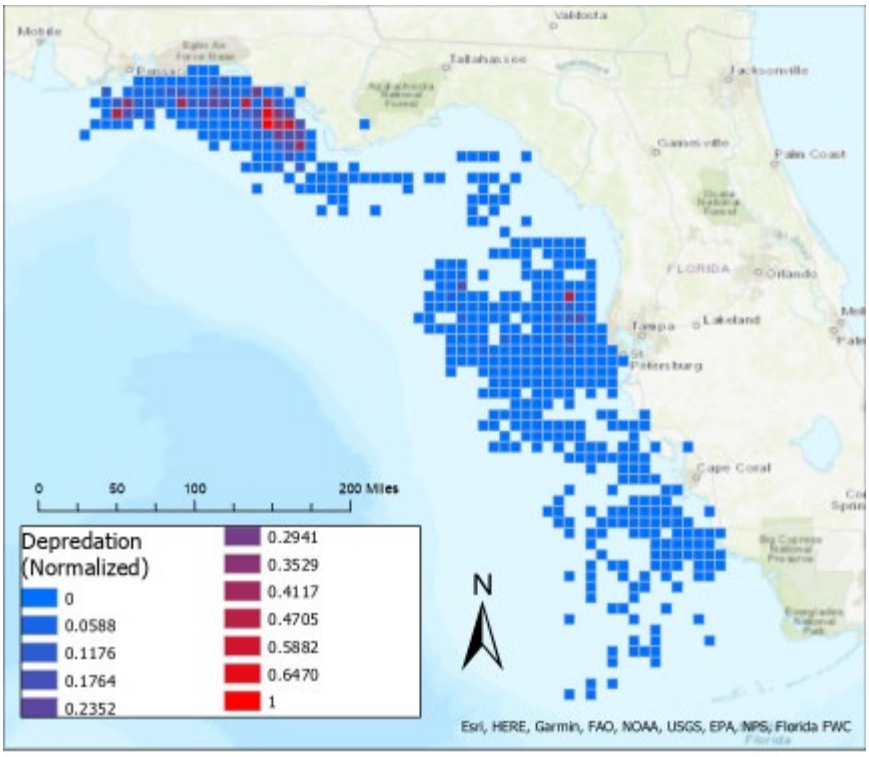


**Figure 2. Percent of observations with scavenging in each geographic fishing zone designated by Florida Fish and Wildlife Conservation Commission in the eastern Gulf of Mexico.[4]**

3) *Commercial fisheries* – Fisheries selling fish and catch for profit. Two commercial hook and line fisheries that may experience dolphin depredation and scavenging interactions are the Gulf of Mexico reef fish fishery (vertical hook and line portion) and the shark bottom longline fishery.

   a) Only one study in the Southeast United States directly quantified dolphin depredation or scavenging interactions in commercial fisheries. A study of a portion of the Florida king mackerel troll fishery in 2003 observed dolphins depredating 20 percent (or 13 depredation events) of the commercial catch. Almost all charter and commercial fishers (47 out of 49) interviewed during this study reported prior observations of dolphins depredating bait or catch.[8]
   b) An independent research survey conducted offshore of Alabama from 2016 to 2018 using vertical longlines recorded 69 depredation events, of which 15 (22 percent) were by dolphins.[48] The 15 depredation events by dolphins were highly concentrated over only two sampling days.[48]

   Dolphins are illegally fed by fishers, ecotour operators, and others in the southeastern United States, which directly contributes to these interactions. Illegal feeding is prevalent in areas such as the Florida Panhandle and the southwest coast of Florida; Corpus Christi, Texas; and Hilton Head, South Carolina[24, 57, 58] (Figure 3). There is no available information that

quantifies the extent of illegal feeding by private recreational, for-hire, and commercial fisheries.

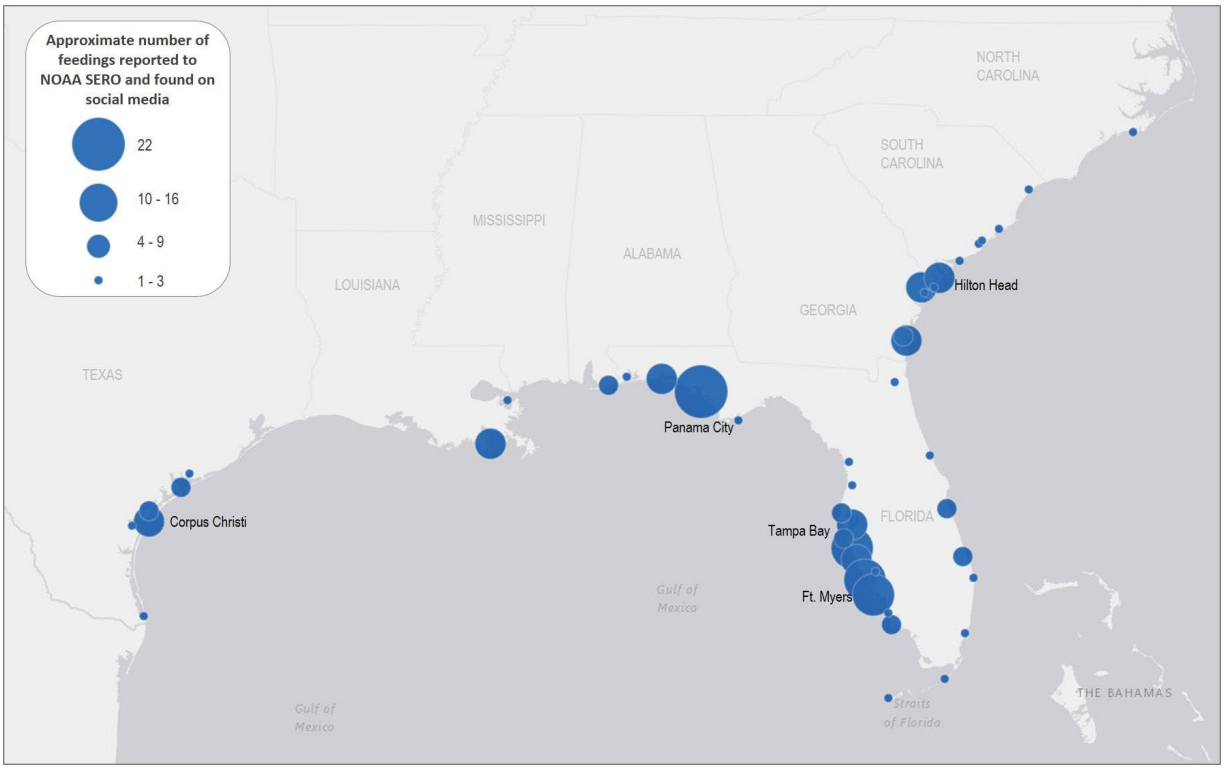


**Figure 3. Approximate number of illegal bottlenose dolphin feedings that were reported to NMFS Southeast Regional Office and found on social media across the southeastern United States from 2007-2019. This figure illustrates general geographic locations for these feeding incidents as described in reports.**

## B. Sharks

The number of reports received by NMFS, or posted on social media by charter and private anglers, of shark depredation on released undersized fish or fish that are primarily caught and released (e.g., tarpon) have been increasing in recent years. For example, there are numerous social media videos of great hammerhead sharks and bull sharks depredating Atlantic tarpon during the fight with the fish or immediately after release in areas around Boca Grande Pass and in the Florida Keys. Charter and headboat captains have also documented sharks feeding on undersized red snapper and other reef fish after these fish are released by the anglers.

1) *Private Recreational* – Private angler hook and line fishing for pleasure or as part of a competition. Catch is not sold for profit.

   a) The Florida Fish and Wildlife Conservation Commission administered an online survey of fishers in March 2021. About 80 percent of charter fishers and about 70 percent of private recreational fishers who responded reported

interactions with sharks over the last year on at least one trip, and the majority of interactions occurred while the catch was still on the gear (i.e., depredation).[47]

2) *Commercial fisheries* – Fisheries selling fish and catch for profit. Two commercial hook and line fisheries have reported shark depredation events: the pelagic longline fishery in the Atlantic and Gulf of Mexico, and the Gulf of Mexico reef fish fishery (bottom longline and vertical hook and line portions).

   a) Preliminary analyses of NMFS' observer data indicate that shark depredation rates (quantified as proportion of sets that had a depredation event relative to the total number of observed sets) have fluctuated but remained relatively stable in the pelagic longline fishery, but show an increasing trend for sets deploying bottom longline and vertical line gear in the Gulf of Mexico reef fish fishery (Figure 4). The relatively flat trend observed in the pelagic longline fishery was also noted by MacNeil, et al. (2009)[64] when they examined data for the same fishery from 1992 through 2006. Their study drew a positive association between blue shark catch per unit effort (CPUE) and depredation rates. There is a hypothesis that blue sharks are responsible for much of the depredation in the fishery, which may have been bolstered by recent CPUE indices from the recent stock assessment.[65] In addition, the blue shark population has remained relatively stable and has roughly mirrored the depredation rates observed in the pelagic longline fishery. However, the observed depredation rates in the pelagic longline fishery were lowest in fishing areas most distant from shore in the North Central Atlantic (NCA), Northeast Distant (NED), and Sargasso Sea (SAR) areas, which might indicate that fishing activities occurring closer to shore are influenced by more than only those sharks considered "pelagic."

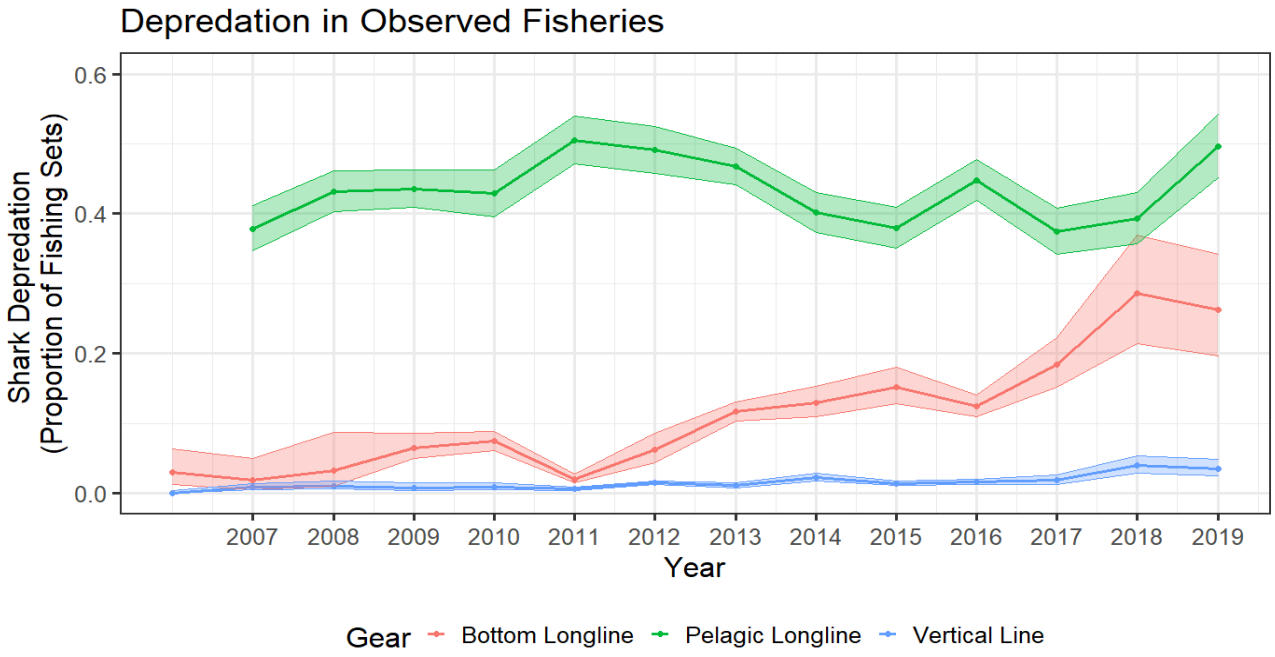


**Figure 4. The proportions of fishing sets with shark depredation from bottom longline, vertical line, and pelagic longline gear types by year, 2006-2019. Note: All the data are**

**shown with 95 percent confidence intervals. Bottom longline and vertical line data are from 2006 through 2019. Pelagic longline data are from 2007 through 2019. Source: Southeast Fisheries Science Center Observer Program.**

b) Observer data were also examined for trends across seasons and fishing areas (fishing areas are shown in Figure 5). The Gulf of Mexico was split into two regions (east and west) by the 85° W longitude line for the reef fish fishery and the regional fishing area designations recorded by the pelagic observer program were collapsed to combine the Caribbean and Florida's East Coast regions; the Mid-Atlantic Bight and Northeast Coastal regions; and North Central Atlantic, Northeast Distant, and Sargasso Sea due to limited number of observed sets in certain years. The Gulf of Mexico and South Atlantic Bight regions were treated individually. In the reef fish fishery, observed rates of shark depredation were higher in the warmer periods of summer and fall (Figure 6). Of particular note, depredation rates were not consistent for gears across the regions of the Gulf of Mexico. Bottom longline generally had higher rates of depredation in the eastern Gulf of Mexico, whereas vertical longline exhibited higher rates in the western Gulf of Mexico. Figure 7 shows the depredation rates for the pelagic longline fishery, which appear to exhibit less seasonal variation in more consistently warm regions. Shark depredation in the South Atlantic Bight was consistently higher than all other areas throughout all seasons, while rates were lowest in the North Central Atlantic, Northeast Distant, and Sargasso Sea area. The Gulf of Mexico along with the Mid-Atlantic Bight and Northeast Coastal areas showed variation among seasons, though they peaked at different times of the year. Relatively high rates of shark depredation were observed in the Caribbean and Florida's East Coast area throughout the year. However, more detailed analysis of these data is required to fully understand the trends in depredation rates (Duffin et al., in preparation).

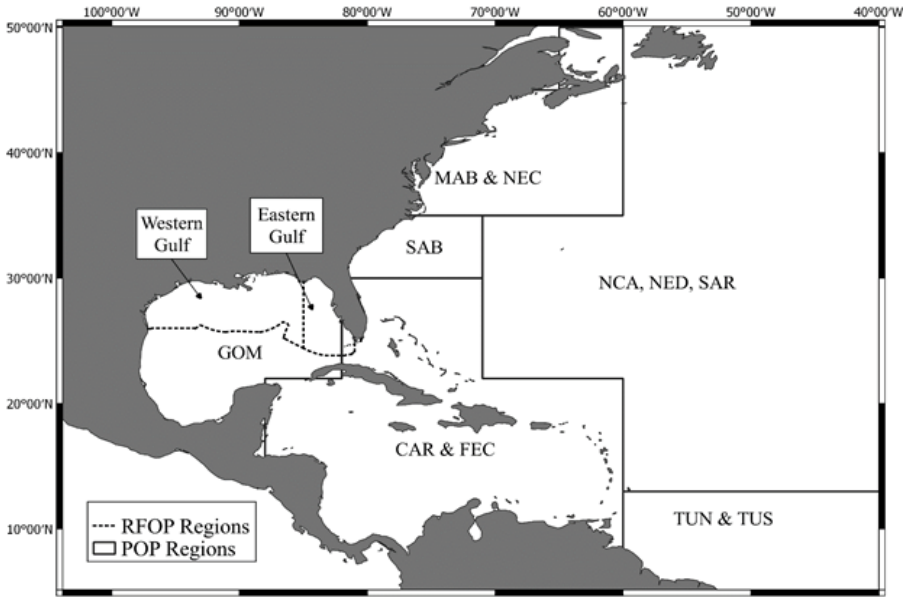


**Figure 5. Spatial depiction of fishing areas for the reef fish and pelagic observer programs used for analyzing spatial trends in shark depredation rates. Note: The reef fish observer**

**program operates within the dashed lines. The pelagic observer program operates within the solid lines. MAB = Mid-Atlantic Bight. NEC = Northeast Coastal. NCA = North Central Atlantic. NED = Northeast Distant. SAR = Sargasso Sea. TUN = Tuna North. TUS = Tuna South. SAB = South Atlantic Bight. GOM = Gulf of Mexico. CAR = Caribbean. FEC = Florida's East Coast.**

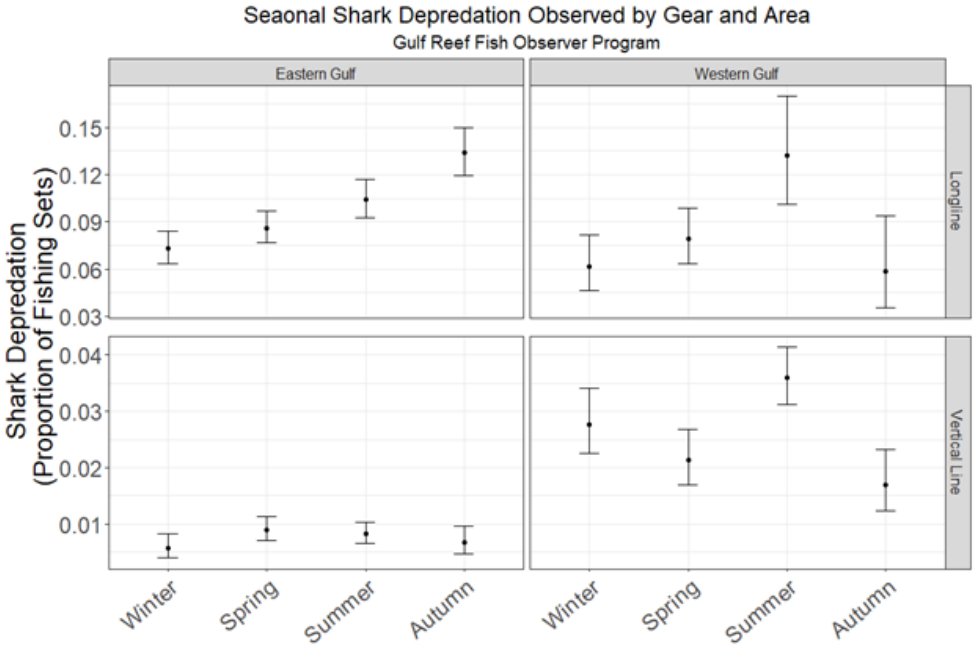


**Figure 6. The proportions of fishing sets with shark depredation for each season, fishing area, and gear from the reef fish observer program, 2006-2019. Note: All the data have 95 percent confidence intervals. Source: Southeast Fisheries Science Center Reef Fish Fishery Observer Program. Eastern Gulf = Gulf of Mexico east of the 85° W longitude line Western Gulf = Gulf of Mexico west of the 85° W longitude line.**

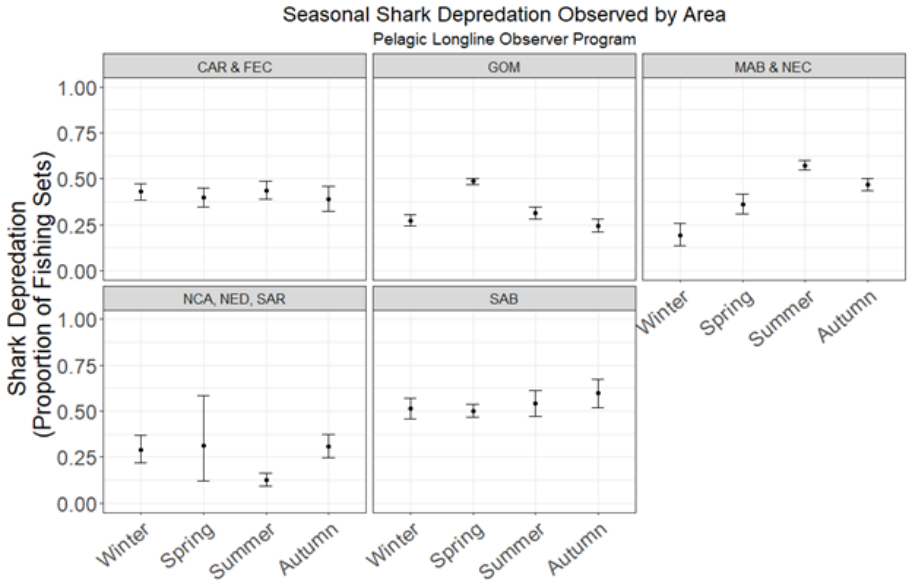

**Figure 7. The proportions of fishing sets with shark depredation for each season and fishing area from the pelagic longline observer program, 2007-2019. Note: All the data have 95 percent confidence intervals. Source: Southeast Fisheries Science Center Pelagic Observer Program. CAR = Caribbean. FEC = Florida's East Coast. GOM = Gulf of Mexico. MAB = Mid-Atlantic Bight. NEC = Northeast Coastal. NCA = North Central Atlantic. NED = Northeast Distant. SAR = Sargasso Sea. SAB = South Atlantic Bight.**

## IV. CONSEQUENCES OF INTERACTIONS

### A. Fisheries

Consequences to fisheries and fishers from depredation and scavenging interactions include economic losses to fishers from lost or damaged bait, catch, and gear; impacts to post-release survival of target fish; and degraded fishing experiences. Fisheries consequences, however, are not well studied and remain mainly anecdotal or inferential. Additional broad-scale quantitative data would be needed to fully understand the nature, scope, and magnitude of interactions before we could calculate or quantify the extent of these consequences.

1) *Economic losses*

a) Loss or damage to bait or catch: Private recreational, for-hire, and commercial fishers experience economic loss when bait is depredated by dolphins and sharks. Commercial fishers may also lose revenue when catch is depredated.[8] These depredated fish have little or no market value.[62] Similarly, if an angler is competing in a tournament, their catch, regardless of its size, may be disqualified if it is bitten by predators before being brought on board the vessel. Given the number of anecdotal and observer reports of depredation by sharks in a wide variety of fisheries, the lost economic value of depredated commercial or recreational fish could be substantial.

b) Gear loss and damage: Depredating dolphins and sharks can break fishing line or remove the hook to take hooked fish. In more extreme cases, dolphins and sharks may damage other parts of the rig. Repairing or replacing gear due to damage or loss can be costly for fishers.[32]
   i) Across 15 observations of dolphin depredation on commercial and charter fishing vessels targeting Florida king mackerel in 2003, related loss of gear included line, lures, hooks, and planers.[8]
   ii) In the Southeast shrimp fishery, sharks have been identified as causing damage to trawl nets, and sharks are feeding on fish discarded from the nets.

c) Additional expenses (e.g., fuel and time): Fishers may need to travel to other fishing locations to avoid areas experiencing depredation. This causes additional expenses from associated fuel costs and lost time fishing.

Because the overall scope of depredation is not known, the economic value of these various losses cannot be calculated.

2) *Impacts to Post-Release Survival of Target Fish*

Discarded catch that is scavenged by predators may decrease the number of fish contributing to the growth of the fishery stock, which may also limit the future economic fishing potential of the targeted stock.[10,11] This may occur if the released fish dies as a direct result of being scavenged but would have otherwise survived release. There are no known studies analyzing potential impacts or lack thereof on fish populations from dolphin and shark scavenging discarded fish from fisheries in the Southeastern United States, and the resulting impacts to overall population abundance. Depredation represents an unknown level of mortality on the target catch and, if significant beyond natural and release mortality events, could impact population assessments for these species.

3) *Degraded fishing experience*

Interactions with predators can lead to a degraded fishing experience for fishers because they become frustrated by the loss of prized catch.[8] For-hire vessel captains depend on a good fishing experience to attract customers, and increasing interactions may limit returning customers, thereby reducing future economic profits. The price for chartering a trip may also increase as captains may need to travel farther or find new fishing areas where reports of depredation have not occurred.

## B. Dolphins and Sharks

Illegal feeding of dolphins by all entities and depredation and scavenging interactions can lead to population-level impacts for dolphins from increased mortalities and serious injuries associated with entanglement or ingestion of gear, vessel strikes, and retaliation, as well as decreased survival from reduced maternal care and increased predation. Population-level impacts create conservation challenges for small populations of dolphins inhabiting bays, sounds, and estuaries in coastal waters of the Gulf of Mexico and South Atlantic. Recreational fishing gear interactions remain the leading identifiable cause of death for bottlenose dolphins in Sarasota Bay, Florida.[62] For example, hook and line related deaths of bottlenose dolphins in Sarasota Bay caused the loss of more than 2 percent (four animals) of the 160 resident dolphins in 2006.[5] This is an unsustainable mortality level for this small dolphin population where it is estimated that more than one human-caused mortality per year would impact its ability to remain at a stable size.

1) *Increased mortality and serious injury from entanglement in, hooking by, and ingestion of gear*

Dolphins interacting with fishing gear or operations have a higher risk of becoming entangled in or hooked by gear externally, or ingesting fishing gear because they spend more time in closer contact with gear.[5, 9] Naive calves swimming with mothers interacting with gear are also at higher risk of being hooked or entangled given the proximity to gear. Impacts can cause lacerations, puncture wounds, amputations, infections, and serious injury or death due to drowning, starvation, or suffocation[12, 13, 33, 34, 35, 36] (Figure 8).

The Southeast Marine Mammal Stranding network documented 294 bottlenose dolphins stranded with hook and line gear attached in the Southeast United States between 2002 and August 2021 (143 in the Gulf of Mexico; 151 along the South Atlantic) (NMFS Marine Mammal Health and Strandings data accessed August 24, 2021). These numbers represent minimum known counts of interactions because only a portion of stranded animals are detected and recovered; actual numbers may be at least three times higher.[37, 38] When a dolphin strands with hook and line gear attached, it often cannot be determined whether the gear originated from a for-hire or private fishers. Commercial gear is not as commonly identified, given this portion of the fishery operates farther offshore and carcasses originating offshore are less likely to make it to shore and be recovered.

In the Gulf of Mexico, the 5-year annual average of dolphins stranded with hook and line gear has ranged between about five and 11 dolphins over the past two decades, with an annual maximum of 16 in 2012 (Figure 9). The number of dolphins stranded with gear in the Gulf of Mexico has increased overall since 2002, particularly during the Northern Gulf of Mexico Unusual Mortality Event following the Deepwater Horizon oil spill. There are various factors that may have contributed to this increase in the Gulf of Mexico, including the decline of prey populations, increased fisheries interactions, and increased reporting and recovery of marine mammal strandings that led to an increased detection of carcasses with entanglements. In the South Atlantic, the numbers remained relatively stable across the time series, with the 5-year annual rolling average ranging between seven and nine entangled dolphins, with a maximum of 15 in 2017 (Figure 9).

**Figure 8. A resident dolphin of Sarasota Bay, Florida, found dead with a large lure hooked in its mouth (photo courtesy of Mote Marine Laboratory Strandings Investigations program).**

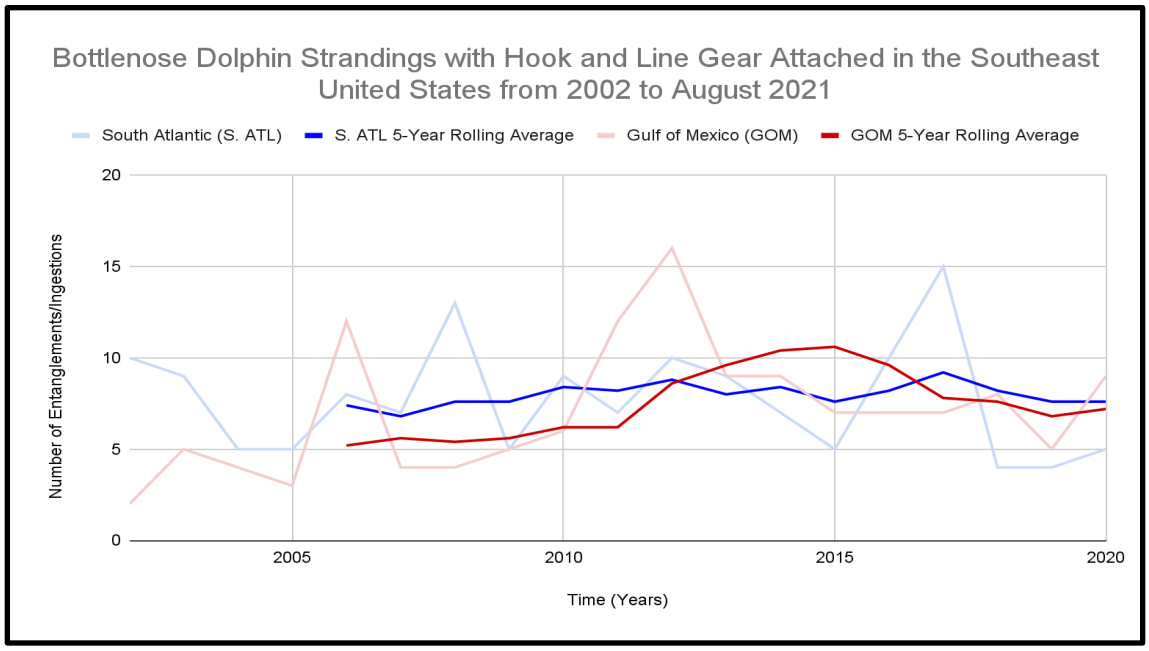


**Figure 9. Number of bottlenose dolphins stranded with hook and line gear in the Southeast United States from 2002 to August 2021 (NOAA National Marine Mammal Health and Stranding Program data; accessed August 24, 2021). The light blue line indicates the number of dolphins stranded with hook and line gear (entangled or ingested) in the South Atlantic (S. ATL), and the dark blue line indicates the associated 5-year average. The light red line indicates the number of dolphins stranded with hook and line gear (entangled or ingested) in the Gulf of Mexico (GOM), and the associated dark red line indicates the 5-year average.**

Anecdotal reports indicate sharks also have been entangled or injured in shrimp nets during depredation events. This is most likely due to sharks feeding on discarded bycatch during the processing of the catch.

2) *Increased predation and decreased survival of dolphins and sharks interacting with fisheries*

Anecdotal reports indicate dolphins are attacked by large sharks when distracted by illegal feeding, scavenging, or depredating.

Female dolphins fed by humans have lower reproductive success. Studies show that the calves of females who are fed are less likely to survive than the calves of females that are not fed.[15] This increased mortality of calves is likely a result of the calves of fed females spending more time separated from their mother.[15, 39] In Western Australia, an IndoPacific bottlenose dolphin calf was killed by a tiger shark while its mother was being fed near the beach.[40]

Bottlenose dolphins in Sarasota Bay, Florida, that are conditioned to interact with humans or fishing gear have a higher probability of subsequent injury from human interactions over time.[14] Those dolphins have been documented to transfer unnatural foraging patterns across

generations, leading to unusually high levels of injury and mortality in subsequent generations.[63]

There are no reports of increased predation and decreased survival of sharks interacting with fisheries.

3) *Increased retaliation*

Dolphin interactions with fishing gear and operations can frustrate fishers because of economic losses related to catch, bait, gear, and degraded fishing experience.[8, 41] This frustration can lead to retaliation where fishers intentionally attempt to harm dolphins by impaling, shooting, or throwing explosives at them. The injuries from intentional harm can lead to death through organ damage, loss of blood, or by causing secondary infection related to the initial wound. Sometimes death is immediate; other times, dolphins may endure chronic pain, stress, or injury for several days before ultimately dying. In some cases, fatal wounds in pregnant mothers from gunshot have also killed their near full-term fetuses.

a) From 2002 through August 2021 in the Southeast United States, at least 37 dolphins were stranded with evidence of being shot by guns or arrows or impaled by sharp objects such as spears and screwdrivers (Figure 10). The majority of these strandings occurred in the Gulf of Mexico and within the last 10 years (NOAA Marine Mammal Health and Stranding Response Data, accessed August 24, 2021).

b) The Department of Justice federally prosecuted four fishers for acts of retaliation against depredating dolphins in the Gulf of Mexico. Three cases involved captains of either for-hire or shrimp trawl vessels shooting at dolphins with guns.[42, 43, 44] One case involved a commercial hook and line fishers who made and threw pipe bombs at depredating dolphin(s).

**Figure 10. Bottlenose dolphin found dead off Florida's west coast in May 2019. The dolphin died from an apparent penetrating wound, extending almost six inches toward the top and back of its head and ending at the skull, which was consistent with a spear-like object. The dolphin was last observed swimming around fishing boats and was seen with other "begging dolphins." The nature of the puncture wound indicates the dolphin might**

**have been in a begging posture when stabbed (photo Courtesy of the Florida Fish and Wildlife Conservation Commission).**

Some fishers also perceive sharks as a threat to their catch.[63] There are many anecdotal reports that fishers will use fireworks and firearms to ward off sharks when releasing undersized fish. Similarly, as reports of shark depredation increase, a number of fishers and other groups have been asking for increased harvest of sharks. For example, in May 2019, the South Atlantic Fishery Management Council requested the Highly Migratory Species Management Division to coordinate the opening and retention limits of the commercial shark fishery to coincide with important commercial fisheries in the region in an attempt to localize the harvest and culling of sharks that are perceived to be responsible for high levels of depredation.

4) *Increased vessel strikes*

Dolphins interacting with fishing vessels spend a high proportion of time near vessels and are therefore at greater risk of boat strikes[45, 46] (Figure 11). Boat strike injuries result in lacerations, propeller cuts, or blunt force trauma, which can lead to disfigurement, serious injury, or death.[13]

**Figure 11. Photo of a bottlenose dolphin that stranded dead in southwest Florida with a watercraft-related wound on the right lateral side of the animal. The dolphin was also recovered with an ingested fish with an attached j-hook and monofilament fishing line.**

## V. Recommendations for Non-lethal Deterrents: Dolphins and Sharks

Fishers, scientists, and managers share a common goal to reduce dolphin and shark interactions. Methods to reduce interactions involve altering the behavior of fishers, ecotour operators, and others, or using non-lethal devices to deter dolphins and sharks.

### A. Non-lethal Deterrents

The Marine Mammal Protection Act (MMPA) section 101(a)(4)(B) allows for specified persons to employ measures to deter marine mammals from damaging fishing gear and catch, damaging personal or public property, or endangering personal safety, as long as those measures do not result in death or serious injury of marine mammals. The MMPA also requires the Secretary of Commerce, through NMFS, to publish in the *Federal Register* a list of guidelines for safely deterring marine mammals.

Under the authority of the MMPA, NMFS published a proposed rule[a] on August 31, 2020, including guidelines for safely deterring marine mammals under NMFS' jurisdiction (Figure 12). NMFS evaluated[b] several different types of deterrents broadly classified as either "acoustic" or "non-acoustic." The evaluation considered the potential impacts to marine mammals but did not evaluate the effectiveness of deterrents. While the deterrence guidelines and specific measures are not mandatory, the MMPA provides protection from liability for take resulting from such deterrence measures by specifying that any actions taken to deter marine mammals that are consistent with the guidelines or recommended specific measures are not a violation of the Act. Although deterrents that are not included in the guidelines may be used, if a marine mammal is killed or seriously injured as a result of the deterrence not included in the guidelines, the protection from liability in section 101(a)(4)(B) would not apply. The proposed regulations also include prohibitions on certain forms of deterrence determined by NMFS based on the best available scientific information to have a significant adverse effect on marine mammals (i.e., causing mortality, serious injury, and/or permanent hearing loss) (Figure 11). The public comment period closed on October 30, 2020. NMFS is considering public comments and preparing a final rule.

[a] www.federalregister.gov/documents/2020/08/31/2020-18718/guidelines-for-safely-deterring-marine-mammals
[b] www.fisheries.noaa.gov/action/guidelines-safely-deterring-marine-mammals

| Non-Acoustic Deterrents: non-ESA Odontocete Taxa (Bottlenose Dolphins) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| GUIDELINES | | | | | | PROHIBITIONS | | | |
| Taxa | Visual | Physical Barriers | Tactile: Projectile | Tactile: Manual | Tactile: Water | Visual | Chemo-sensory | Tactile: Projectile | Tactile: Manual |
|  | • Bubble curtains<br>• Flashing or strobe lights<br>• Predator shapes<br>• Vessel patrolling<br>• Unmanned Aircraft Systems | Containment booms, waterway barriers, & log booms | Foam projectiles with toy guns | *Blunt objects:* blunt tip poles, brooms, mop handles, etc. | Water hoses, sprinklers, & water guns | Vessel chasing | Any chemical irritants, corrosive chemicals, & other taste deterrents | Firearm, bow, or spear gun | Sharp objects |
| | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗ | ✗ |

**Figure 12. PROPOSED non-acoustic guidelines and prohibitions specific to odontocetes (i.e., bottlenose dolphins in the Southeastern United States) included in NMFS' proposed rule for safely deterring marine mammals (85 FR 53763, August 31, 2020).**

In 2021, NMFS formed a national Steering Committee composed primarily of experts from NMFS on marine mammal depredation who participated in drafting the proposed Guidelines for Safely Deterring Marine Mammals. The Steering Committee will work collaboratively with fishers to identify effective marine mammal deterrents to reduce fisheries interactions, marine mammal injury and death, and economic and time loss to fishers. NMFS will hold several virtual workshops in 2022 to better understand which existing deterrents are effective and explore innovative methods to safely deter marine mammals. Potential outcomes include more collaboration and enhanced working relations between fishers, managers, and researchers; priority non-lethal deterrents to evaluate for effectiveness; new information based on gear modifications or deterrents trialed by fishers; a list of data gaps; and potential deterrent evaluation approaches to inform next steps.

The earliest research on shark deterrent methods focused on preventing shark attacks. While research on shark deterrents has included chemical, visual, and auditory repellents, the primary technology applied to fishing methods has focused on electrical repellents. Researchers have investigated the use of electropositive metals,[66, 67, 68] permanent magnets,[69, 70] and rare earth magnets[71] as mechanisms to reduce shark bycatch and depredation. Induction of even relatively weak electrical fields has been shown to elicit a reaction in sharks, and in some cases may deter them from eating bait or catch by saturating their specialized electroreceptors, the ampullae of Lorenzini. In fisheries applications, fields can be passively induced by attaching electropositive metals or magnets to fishing gear, or by actively powering a source to generate the field. Results to date are mixed,[72, 73] and further field-based work is needed to verify these approaches.[62, 74] Costs associated with deploying magnets or electropositive metals at the scale of commercial fisheries may also be high, as they must be replaced due to dissolution in seawater.

Hundreds of chemical compounds have been studied as shark deterrents,[75] yet researchers have not identified one that is effective across a variety of species. Both synthetic surfactants and semiochemicals produced by sharks appear promising.[76, 77] Chemical deterrents are an intriguing option to reduce elasmobranch interactions with fishing gear, although control over the chemical dispersion rates remains a challenge. In 2012, NMFS funded research for a chemical deterrent that reduced shark bycatch during commercial pelagic longline fishing by 75 percent.[78] The

chemical has not been tested on all shark species; however, that research has led to a deterrent that is available for fishers to buy and use. The key for chemical deterrents will be identifying an inexpensive and easy-to-use chemical that masks attractive odors or elicits a repulsion response in elasmobranchs without altering behavior of other non-target (e.g., teleosts, bottlenose dolphins, seabirds) and target species.

### B. Avoidance

One of the simplest and most effective methods currently used to reduce dolphin and shark interactions is avoidance. Avoidance involves the fishers voluntarily relocating to a different fishing location and fishing in areas where dolphins and sharks are not immediately present or generally not found. In some instances, fishers report dolphins or sharks following the vessels when relocating to avoid them. Many experienced fishers agree that avoidance is the most effective method and have learned the needed distance to relocate so dolphins and sharks do not follow.

Although NMFS published proposed guidelines for safely deterring marine mammals while fishing, the agency strongly encourages using avoidance techniques first. Avoiding interactions is the safest method for preventing death or serious injury to marine mammals and the best way to minimize risk to human safety.[49, 50] In 2007, NMFS and partners developed Dolphin Friendly Fishing & Viewing Tips[c] with fisher's input to help reduce and avoid dolphin-fishery interactions. Since then, fishers have anecdotally reported that moving fishing locations when dolphins show up is the most effective approach to avoiding interactions. The distance fishers need to move to avoid interactions is reportedly variable across the Gulf of Mexico.

Research has shown that sharks can learn behaviors and can learn to associate locations and sounds (such as the sound of a boat motor) with food. By changing fishing locations, fishers may be able to find a location where the sharks nearby have not yet associated that location with food. Unfortunately, relocating is not always the best solution. Sharks may be present at the new fishing location, and there are costs associated with curtailing fishing effort, moving locations, and redeploying fishing gear.

## VI. RESEARCH

More data and information would be needed to better understand and reduce dolphin and shark interactions with private recreational, for-hire, and commercial fisheries.

### A. Current Research

NMFS is involved with the following research projects related to depredation and scavenging interactions and illegal feeding activities.

1) The Deepwater Horizon Regionwide Implementation Trustees finalized their first restoration plan[d] in September 2021, which includes an approximate 5-year project to reduce

[c] www.fisheries.noaa.gov/resource/educational-materials/dolphin-friendly-fishing-tips-sign
[d] www.gulfspillrestoration.noaa.gov/restoration-areas/regionwide

interactions between bottlenose dolphins and hook and line fishing gear and fishery practices, including illegal feeding activities. The project will characterize the nature and magnitude of interactions between dolphins and hook and line gear through systematic fishery surveys, social science studies, and evaluation of bottlenose dolphin stranding data. Resulting information will be used to collaboratively identify possible solution(s) to reduce interactions. A future project would collaboratively develop and test the effectiveness of those solution(s), and implement them.

2) The Deepwater Horizon Open Ocean Trustees (via the Gulf States Marine Fisheries Commission[e]) funded four projects[f] in April 2021 documenting depredation or scavenging by species, among other objectives:

   a) *Do Descender Devices Increase Opportunities for Depredation? A Gulf-wide Examination of Descender Device Depredation Rates and Depredating Species*. Researchers are working with 30 charter boat vessels in the Gulf of Mexico to document whether hooked reef fish are eaten by predators and which species are responsible.
   b) *Determination of Predation Mortality, Barotrauma Survival, and Emigration Patterns for Catch-and-Release Red Snapper*. Researchers are working with eight charter vessels in the Gulf of Mexico to better understand the survival rates of red snapper released with descending devices. This indirectly measures predator depredation/scavenging rates.

   c) *Mitigation of Gag Release Mortality in the Eastern Gulf of Mexico.* This study will employ 3D acoustic telemetry to estimate the fate (e.g., survival, mortality, depredation, emigration) of gag captured with standard recreational gear.

   d) *Efficient Methods to Reduce Recreational Fishing Barotrauma Effects on Red Snapper, Gray Triggerfish, and Greater Amberjack.* This project is designed to evaluate the biological effectiveness of fish descender devices by documenting post-release condition and depredation rates.

   Results from these four projects, which have just begun, are expected in 2023 and should help managers evaluate the effectiveness of a larger, related post-release mortality reduction project[g] that should conclude around 2028.

3) The 2020 NOAA's Bycatch Reduction Engineering Program[h] funded a Phase II project[i] to use innovative technologies for electronic monitoring in support of best fishing practices for the Commercial Gulf of Mexico Reef Fish Fishery. Among other goals, the project will improve the understanding of post-release and other indirect mortality associated with the bottom longline fishery, including depredation and scavenging activities by predators.

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[e] www.fisheries.noaa.gov/feature-story/noaa-and-gulf-states-marine-fisheries-commission-partner-restore-recreational-fish

[f] www.gulfspillrestoration.noaa.gov/2019/12/226-million-projects-approved-second-open-ocean-restoration-plan

[g] www.gulfspillrestoration.noaa.gov/project?id=226

[h] www.fisheries.noaa.gov/feature-story/2020-bycatch-reduction-engineering-program-awards

[i] https://mote.org/research/program/center-for-fisheries-electronic-monitoring-at-mote-cfemm

Results from this project are expected in 2023 and should support strategies designed to help fishers avoid depredation and scavenging activities.

4) The Deepwater Horizon Alabama Trustees[j] finalized a restoration plan in September 2018 that includes an approximately 4-year project to reduce injury and mortality to Alabama estuarine dolphins from illegal feeding activities, among other things. The project includes informing the public and vessel operators about the harmful impacts of feeding wild dolphins. This project encountered implementation delays but recent efforts include collaborating with the State of Alabama on updates to Snapper Check to enhance data collection on dolphin depredation events.

5) The RESTORE Act project, Characterizing Cryptic Mortality in Gulf of Mexico Reef Fish: Evaluating the Nature and Extent of Depredation, will gather, analyze, and interpret Gulf of Mexico depredation-related datasets, design and implement a depredation-related electronic survey of commercial and recreational fishers across the Gulf of Mexico, and present results to stakeholders at a collaborative mental modeling workshop. This project began in September 2021 and should produce results by the end of 2022, including identification of potential depredation deterrents favored by stakeholders – information which could then direct future research priorities for testing depredation deterrents.

## B. Immediate Research Priorities and Management Needs

*Dolphins:* The following four categories describe future research that would be needed to better understand and quantify bottlenose dolphin depredation and scavenging interactions in hook and line fisheries operating within the Southeast United States, and the illegal feeding activities that contribute to those interactions.

*1) Quantifying bottlenose dolphin depredation and scavenging interactions through augmentation and analysis of available datasets*

Baseline surveys and data analysis would be needed to characterize the nature of interactions and determine how often (frequency) and where (geographic extent) dolphin interactions occur. Various existing avenues may be able to provide this information, with additional resources; for example existing systematic fishery surveys (e.g., NMFS' MRIP[k]; SEFHIER[l]) could be augmented, and existing state or federal datasets, such as the federal fishery observer data from the Gulf of Mexico Reef Fish Fishery could be assessed. Assessing the existing datasets would require inspection by an analyst to determine whether data collection and quality is sufficient to support an analysis of frequency or scope of dolphin-fishery interactions. The results of such an assessment could inform future management options by helping prioritize research needs and target locations, including ways to prevent interactions

[j] www.gulfspillrestoration.noaa.gov/restoration-areas/alabama
[k] www.fisheries.noaa.gov/recreational-fishing-data/about-marine-recreational-information-program
[l] www.fisheries.noaa.gov/southeast/recreational-fishing-data/southeast-hire-integrated-electronic-reporting-program

or further identify the role of other variables such as social learning, habitat changes, or fluctuations in prey availability.

2) *Developing effective outreach and engagement strategies to reduce dolphin-fishery interactions*

   a) Social science studies would be needed to inform the development of effective messaging, targeted outreach, and engagement tools. The results of such studies could be used to characterize the attitudes, knowledge, perceptions, and motivations of fishery user groups about dolphin-fishery interactions. This is similar to how advertising campaigns study their audiences before developing messaging.

   b) Informed outreach and engagement with the fishing community is crucial to reducing dolphin-fishery interactions. This includes providing information on how to avoid and how to handle interactions (e.g., avoidance techniques, gear modifications, non-lethal deterrents, etc.) – and the importance of not feeding dolphins to reduce and prevent future interactions.[24, 33, 41, 57, 58, 59] Although releasing fish that are undersized or otherwise prohibited by regulations near dolphins is not illegal, it can also reinforce dolphins' association with fishing boats and feeding opportunities in the same way as when they are illegally fed, leading to continued depredation and scavenging behaviors. Outreach should also educate the community on ways to prevent this association when releasing fish. Additional resources would be required to expand NMFS' outreach capabilities for this purpose. As a priority, outreach and engagement efforts should be targeted to first occur in known, persistent hot-spot areas for illegally feeding dolphins as indicated in Figure 3.

3) *Enhancing Enforcement of the Marine Mammal Protection Act*

   All marine mammals are protected under the MMPA, which prohibits, with certain exceptions, the "take"[m] of marine mammals, including illegal feeding (see 50 CFR 216.3, 216.11). Illegal feeding of dolphins in the wild is one of the greatest drivers of depredation and scavenging interactions with hook and line fishing gear. In addition, repeat interactions between dolphins and fishing activity may lead to retaliation where fishers intentionally harm, or attempt to harm, dolphins (e.g., impaling, shooting, throwing explosives, etc.). Intentionally harming or attempting to harm dolphins is also a violation of the MMPA. Continued MMPA directed enforcement efforts – including outreach to ecotour operators, fishing vessels, marinas, and the public – are key to reducing illegal feeding occurrences. When consulted during the development of this report, the Gulf of Mexico Fishery Management Council recommended increased fines or punishments for violators who directly feed or encourage interactions with dolphins; the Marine Mammal Commission recommended enhanced enforcement of illegal feeding given it reinforces fisheries interactions and leads to intentional harm to dolphins (Appendix B and D).

[m] www.fisheries.noaa.gov/insight/understanding-marine-mammal-protections#what-protections-do-marine-mammals-have-in-the-united-states?-

4) *Determining the long-term effectiveness of potential non-lethal deterrents*

Non-lethal deterrents may reduce dolphin depredation and scavenging. The use of deterrents is challenging for species like bottlenose dolphins that are highly food motivated with adaptable behaviors. For example, using sound emitters (e.g., pingers) to prevent depredation by bottlenose dolphins on fishing gear was found to be statistically ineffective as a deterrent device despite effectiveness for other marine mammal species.[51, 52] Instead, pingers may alert dolphins to the opportunity of nearby prey, serving as a "dinner bell" and enticing dolphins near fishing gear and increasing depredation.[51, 52, 53, 54] Therefore, even when initial results suggest a deterrent method is effective, additional and ongoing research would be important to determining the feasibility and efficacy of non-lethal deterrents, such as gear modifications and fish descender devices, in reducing dolphin depredation and scavenging to ensure dolphins do not adapt their behavior to bypass the deterrent, reducing the deterrent's effectiveness over time.[7, 8, 48, 55, 56]

*Sharks:* Despite reports of increased shark depredation, additional information would be needed to quantify the level of depredation and scope of the issue, especially in recreational fisheries where there is no structured data collection on depredation. With additional resources, this could be accomplished through online surveys, observers on charter and headboats, increased data collection through dockside interviews, or adding fields in logbooks with questions relative to depredation.

Much of the public perception is that shark depredation is increasing because shark numbers are increasing. While some stocks of sharks are considered "healthy" and are no longer overfished (e.g., blacktip sharks in both the Atlantic and Gulf of Mexico), many shark populations are still historically low despite reports of increased depredation by these species. For example, the oceanic whitetip shark population has declined by an estimated 88 percent in the northwest Atlantic Ocean[79] and the species is listed as "threatened" under the U.S. Endangered Species Act. Despite these declines in population sizes, private recreational anglers commonly report oceanic whitetip sharks feeding on hooked tunas, billfish, wahoo, and dolphinfish in the Bahamas.[80] These increases in depredation rates, despite potential declines in many shark pelagic populations,[81] suggest that sharks have the ability to learn where available food is frequently found. Additional research would be required to determine at what level learned behavior is acquired and how prevalent it is within the population. For example, at French Frigate Shoals in the Northwestern Hawaiian Islands it was determined that only a small number of Galapagos sharks (*Carcharhinus galapagensis*) exhibited an unusual predatory behavior of being present when Hawaiian monk seal pups (an endangered species) were first entering the water.[82]

Depredation can best be mitigated if the predatory species is conclusively known.[62] In terrestrial settings, livestock predators, such as wolves and coyotes, have been identified through analysis of salivary DNA recovered from bite wounds. There is evidence that a similar approach can be used for sharks. Specifically, a two-part technique has been recently

developed to identify depredating species from trace amounts of DNA left on prey remains.[83, 84] Interactions between sharks and fisheries (e.g., sharks depredating vertical line catch) can be directly observed using video footage from cameras. Additional resources could be used to fund these research techniques to identify which species are primarily responsible for depredation and potentially determine if it is a small segment of the population that has learned this behavior.

In 2021, a proposal to use a citizen-science approach to characterize shark depredation in the recreational fisheries of the southeast United States was recommended for funding through the Cooperative Research Program. That project is designed to characterize depredation in non-highly migratory species recreational fisheries and evaluate fisher's perceptions of depredation, including identification of covariates that significantly influence depredation rates. Moreover, the 2022 Federal Funding Opportunity for the Cooperative Research Program identified the topic of depredation as a program priority.

## VII. CONCLUSION

Fully understanding and reducing dolphin and shark interactions with fisheries is a complex and challenging management issue. These interactions negatively impact bottlenose dolphin populations, sharks, and private recreational, for-hire, and commercial fisheries. Dolphins are seriously injured or killed by ingesting, being hooked by, or becoming entangled in fishing gear, being struck by a vessel or its propeller, or intentionally harmed. Fishers can experience loss of catch, damaged gear, and degraded fishing experiences. Although there are many known environmental and human-caused factors contributing to these interactions, perhaps the largest driver is illegal feeding of dolphins. Within the Gulf of Mexico, the areas with the greatest rates of dolphin depredation are also the areas with the greatest reports of illegal dolphin feeding by fishers, ecotours, tourists, and residents.

Data limitations preclude our ability to fully understand the nature, extent, frequency, and geographic locations of dolphin and shark interactions with hook and line fishing gear and fishery operations. These data could be obtained if additional resources were available to augment and analyze existing datasets. Specifically, augmenting MRIP, SEFHIER, and state fishery surveys could provide additional information on the scope, scale, and frequency of dolphin and shark interactions with private recreational and for-hire fisheries. Assessing existing data, such as federal fishery observer data, could help to better quantify dolphin and shark interactions with commercial hook and line fisheries if of sufficient quality. Continued support of the marine mammal stranding network also would help us to document and quantify fishery interactions with dolphins. Without more information from these data sources, dolphin- and shark-fishery interactions will remain poorly understood, limiting our ability to effectively prevent and manage interactions.

Fishers have limited tools and options to reduce dolphin and shark interactions and are frustrated by the inability to prevent interactions. Deterrents are often a solution explored by fishers to address depredation. However, deterrents are not the only solution, particularly for dolphin depredation, given questions about their long-term effectiveness due to bottlenose dolphins' highly food-motivated and adaptable behaviors. Avoiding interactions is the safest method for

preventing death or serious injury to dolphins and sharks and the best way to minimize risk to human safety.

Additional studies would be needed to determine the long-term effectiveness of promising non-lethal deterrents, such as gear modifications and descender devices, to ensure fisher's investments in any prevention device or method remains viable and effective over time. Most importantly, given the known link between illegal feeding of dolphins and increased fishery interactions, continued and active engagement with fishers, ecotour operators, and others on the importance of not feeding dolphins is the most effective and long-term prevention technique. Engagement should also include ways to prevent the association of dolphins and sharks with fishing boats and feeding opportunities when releasing undersized or regulatory discarded fish near dolphins. Additional resources would be required to improve the reach of and effectiveness of current engagement activities, which should be informed by social science studies to ensure use of the best engagement techniques and most effective messaging tools. Since illegal feeding is a key driver of increased depredation and scavenging interactions, leading to increased intentional harm by fishers, continued enforcement efforts targeting MMPA violations are a vital tool when tackling this issue. A combination of outreach, education, increased penalties, and prosecutions related to illegal feeding are necessary.

As with any recovering apex predator population, interactions between humans and sharks are expected to increase as their stocks and their prey rebuild, although, as noted above, other factors are likely at play in the increased incidences of shark depredation. Including considerations to manage these interactions in a positive way will become increasingly important as shark populations continue to increase. As noted by Carlson et al. (2019),[85] "implications for current and future conservation management need to be considered as part of conservation strategies in the context of how humans will interact and potentially compete with recovering species." Inclusion of all ocean user groups and points of view will need to be considered as well to ensure management needs meet the multiple goals of conservation, sustainability, and economic prosperity. Ultimately, new data collection methods focused on shark depredation in tandem with cooperation and communication between stakeholders could provide more economic and fishing opportunities while maintaining conservation tenets under the Magnuson-Stevens Fishery Conservation and Management Act. In the face of the great amount of uncertainty surrounding shark depredation, one fact remains true: depredation will persist so long as humans and sharks both use the oceans.

NMFS recognizes an enhanced, thoughtful and collaborative approach is needed to manage the complex nature of fishery interactions with dolphins and sharks, in coordination with numerous stakeholders, including commercial and recreational fishers, researchers and academics, and others. We are committed to pursuing such an approach to the fullest extent our resources allow.

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# IX. APPENDICES

## Appendix A. Consultation Comments from South Atlantic Fishery Management Council

**SOUTH ATLANTIC FISHERY MANAGEMENT COUNCIL**
4055 Faber Place Drive, Suite 201, North Charleston SC 29405
Call: (843) 571-4366 | Toll-Free: (866) SAFMC-10 | Fax: (843) 769-4520 | Connect: www.safmc.net

Melvin Bell, Chair | Carolyn N. Belcher, Ph.D., Vice Chair
John Carmichael, Executive Director

September 28, 2021

Andy Strelcheck, Regional Administrator
NOAA Fisheries Southeast Regional Office
263 13th Avenue South
St. Petersburg, FL 33701

**RE: Response to request for comment on the impact of large coastal sharks on fisheries managed by the South Atlantic Fishery Management Council**

Dear Mr. Strelcheck,

At the September 2021 meeting, the South Atlantic Fishery Management Council (Council) discussed a request from the NOAA Fisheries Southeast Regional Office (SERO) to provide input on shark and bottlenose dolphin interactions with commercial and recreational fisheries. As you are aware, the Council has expressed concern and frustration over the increasingly common interactions with sharks in a wide range of fisheries in the South Atlantic region and we welcome the opportunity to provide such input.

When the Council discussed this request, it was noted that there were not known, notable or widespread problematic interactions with bottlenose dolphin in federal waters in the region. Rather, the concern is centered primarily around sharks, in particular large coastal shark (LCS) species. In recent years, the Council has received an enormous amount of public comment expressed by both recreational and commercial fishermen from throughout the region regarding increasing negative interactions with several LCS species. Written comments and discussions from our advisory panels as well as meeting minutes from public comment sessions and Council discussions on the topic were recently compiled by Council staff and shared with SERO staff on August 31, 2021. We hope that this information will be useful in helping develop the Agency's review that is requested in the Consolidated Appropriations Act, 2021.

The LCS species that have been of particular focus are bull, blacktip, silky, lemon, spinner, tiger, sandbar, and dusky sharks. The Council's Snapper Grouper Advisory Panel has also discussed negative interactions with scalloped hammerhead, smooth hammerhead, great hammerhead, and great white sharks. Cumulatively, these shark species are causing devastating consequences for many fishermen using hook and line, spear, bottom longline, and trawl gear in the region and are seemingly producing notable negative impacts to the conservation of Council-managed species and fisheries.

As many LCS species show clear indications of recovery[i], fishermen are increasingly relaying

concerns to the Council over expanded mortality of Council-managed species, particularly snapper grouper and coastal migratory pelagic species, that is occurring due to LCS species consuming hooked fish before they can be boated or upon being released. It has been noted that there are observed changes in shark behavior involving increased instances of targeted circling or lurking around fishing and dive vessels that result in predation on hooked or speared fish and damage to or loss of fishing gear. Gear damage has also been particularly noted in the shrimp fishery when sharks destroy the tail-bag of trawl nets while attempting to feed on the contents of the net. Not only is part of the catch lost, but the gear is damaged in the process. It has also been noted that the prevalence of shark predation has led to a change in fishing behavior in some circumstances. Some recreational fishermen have indicated forgoing fishing trips all together, which has negative implications on revenue for fishing-related businesses. Both commercial and recreational fishermen have indicated the need to travel further or change locations more often to avoid shark predation on their catch, which increases trip costs and can have adverse economic outcomes on the profitability of commercial and for-hire fishing businesses.

In addition to the notable negative economic consequences and frustration from losing marketable or desired target species as well as damage to fishing tackle and gear, there is apprehension over the additional mortality and potential population-level impacts being caused by LCS species. These concerns largely center around negative impacts to the long-term sustainably and conservation of Council-managed species due to shark predation that increases both fishing-related and natural mortality on these highly important species that are vital to coastal economies.

While we recognize and appreciate that NOAA Fisheries and NOAA Highly Migratory Species (HMS) must abide by provisions within the Magnuson-Stevens Fishery Conservation and Management Act and agreements under the International Commission for the Conservation of Atlantic Tunas in regard to the conservation of federally managed LCS species, the Council strongly shares the above-stated concerns from fishermen. In addition, it appears that HMS has noted an increase in shark predation as well, based on the recent regulatory changes to the size limits for yellowfin and bigeye tuna to accommodate the possession of shark-damaged tunas[ii].

There is a clear need to develop a better balance between the conservation of sharks and other federally managed species. Overall, improved communications and coordination between the Councils, HMS, the science centers, and the public is necessary to help better understand the magnitude of this emerging issue and achieve solutions. One potential avenue to pursue might be to consider more of an ecosystem approach to fisheries management in the region that accounts for both HMS and Council-managed species, particularly in regard to predator-prey interactions and how increasing shark predation may be affecting other federally managed fish stocks.

Additionally, based on anecdotal information that the Council has received from fishermen, predation on other federally managed species from sharks appears to noticeably decrease after sharks are commercially targeted in an area. While many LCS species are seeing improvements in abundance through successful management by HMS, the Aggregated Large Coastal Sharks (ALCS) commercial quota is not being met in the Atlantic Region[iii]. We ask that HMS

continue to pursue actions to allow commercial fishermen to better fulfill the ALCS quota so as to potentially minimize incidences of LCS consuming Council-managed species or damaging fishing gear. Also, the Council and HMS could work together to time step-ups in retention limits for LCS to coincide with regional peak fishing effort of Council-managed fisheries that are being negatively affected by LCS interactions, such as those for snapper grouper and coastal migratory pelagic species, to help address mortality caused by LCS consuming these species while hooked or after being released.

Finally, the Council encourages research and development of deterrents that reduce interactions with sharks and efforts that help quantify such interactions. On the latter, we believe that existing data collection programs such as the Southeast Coastal Logbook Program and Marine Recreational Information Program could be modified to allow fishermen to better report shark interactions. It is our understanding that the Southeast Regional Headboat Survey has added the ability to record shark damaged fish to this reporting system. Also, there are programs, such as MyFishCount and the SAFMC Release Project, that currently provide anglers the capability to electronically report shark damaged fish.

The Council appreciates the opportunity to provide our comments and express our concern over the ever-growing number of negative interactions with LCS species in Council-managed fisheries. We look forward to continuing to work with NOAA Fisheries in the future to help implement actions with mutually beneficial outcomes for our managed fisheries. If further information or follow-up to this letter is desired, please do not hesitate to contact John Carmichael, Executive Director, South Atlantic Fishery Management Council.

Sincerely,

Melvin Bell

Melvin Bell
Council Chair

cc: SAFMC Members & Staff
Monica Smit-Brunello, NOAA GC
John McGovern and Rick DeVictor, NMFS SERO
Clay Porch and John Walter, SEFSC Miami
Erik Williams, SEFSC Beaufort

LN#: 202112

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## Appendix B. Consultation Comments from Gulf of Mexico Fishery Management Council

Gulf of Mexico Fishery Management Council
*Managing Fishery Resources in the U.S. Federal Waters of the Gulf of Mexico*

4107 W Spruce Street, Suite 200, Tampa, Florida 33607 USA
Phone: 813.348.1630 • Toll free: 888.833.1844 • Fax: 813.348.1711
www.gulfcouncil.org

006981NOV2021

November 10, 2021

Mr. Andy Strelcheck
Regional Administrator
National Marine Fisheries Service
263 13th Avenue South
St. Petersburg, Florida 33701

Dear Mr. Strelcheck:

This response is in regard to your September 10, 2021 letter requesting Gulf of Mexico Fishery Management Council (Council) input on the 2021 Consolidated Appropriation Act Joint Explanatory Statement on assessing conflicts between sharks and dolphins experienced by all fishing sectors in the Gulf of Mexico (Gulf). The Council is supportive of National Marine Fisheries Service's (NMFS) effort to investigate the proposed focus areas outlined in your letter. During the past two years, the Council has received numerous comments during public testimony reporting a rise in depredation by sharks and dolphins. From these comments, it is apparent that approaches to mitigating depredation should be specifically tailored for sharks and dolphins. For example, anglers have reported dolphins following vessels to other fishing locations, but have not observed this learned behavior for sharks. However, sharks will follow shrimp trawlers as they tow gear and "net feeding" can cause substantial property damage. So, while the conflict issues are similar between sharks and dolphins, they are different animals that interact in a variety of ways between fishing sectors and addressing these issues will likely require examining each animal group separately. These depredation events impose financial burdens on fishermen due to gear and targeted fish damage, and potential safety risks or reduced customer satisfaction of charter customers. NMFS is also requesting input on further areas of focus not outlined in the letter and the Council submits the following for your consideration:

- NMFS should develop best practices for releasing captured fish, such as allowing vessels to release the undersized fish at a different location to reduce interactions with marine mammals in the area.
    - This could reduce the association and learned behavior of anglers and food. Additionally, testing of release devices, such as the Seaquilizer may work for marine mammals but not for sharks. Further, a release device would not work in other fisheries such as net gear; these differences in interactions and depredation events provide more rationale for separating these conflict issues and detailing best practices and procedures for various interactions.

- Depredation events from sharks can sometimes happen quickly and are largely cryptic. The Council suggests more education and outreach for identification of shark species if they are hooked and can be observed by the fishermen. This could be accomplished

through fishing clubs, various events and meetings of the Councils, and through printed education materials sent to federal permit holders.

  - Further, funding for research that uses DNA, or some other technique, to properly identify which group (or even species) is primarily responsible for depredation so that management to reduce these interactions can be more effectively implemented. A similar study has already been published[1] and the Council encourages further research and exploration on depredation events that can quantified throughout the Gulf.

- Modify data collection protocols in the various fishery-dependent and observer program logbook programs and surveys so that fishers and observers have the ability to report shark and dolphin interactions. This will help identify any spatiotemporal patterns that would be useful in informing potential management.

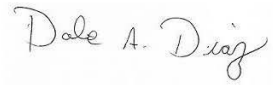
- Increase fines or punishments for violators who directly feed or encourage interactions with dolphins. This will discourage these practices and would minimize food-association with boats for dolphins, which is also healthier for the animals.

- The Council has received comments from the public that dolphins will follow vessels to fishing locations which is a nuisance and increases the likelihood of retaliation by fishers. Dolphins have also been observed teaching their young calves to remove fish from anglers' lines. NMFS should consider researching non-lethal acoustic methods for discouraging these behaviors. The Council would like to see more directed research on practices and studies aimed at reducing interactions with sharks and dolphins across the various gear types and sectors throughout the Gulf of Mexico.

- In the future, if determined that sustainable harvest is attainable, allow increased harvest of certain shark species that frequently contribute to depredation events.

The Council encourages the continued collaboration with NFMS on this issue and welcomes updates as can be provided. The Council is in a position to collect public comment via various outreach tools and is willing to help NMFS with any requests regrading the Joint Explanatory Statement. We thank you for the opportunity to provide comment.

Sincerely,



Mr. Dale A. Diaz
Council Chair

cc: Gulf Council / All Staff / Jack McGovern, Ph.D. / Peter Hood / Karyl Brewster-Geiz

[1] http://coastal.msstate.edu/sites/coastal.msstate.edu/files/files/drymon/29.pdf

## Appendix C. Consultation Comments from Highly Migratory Species Advisory Panel

This Appendix includes verbal comments on the draft assessment outline from the Highly Migratory Species Advisory Panel from September 8, 2021. There were no comments regarding bottlenose dolphin fishery interactions. The following comments were provided on shark interference and depredation:

- Numerous shark species are eating target species and resulting in devastating consequences for many fishers.
- The recovery of shark populations is why depredation is increasing.
- Gear damage is happening in many fisheries.
- The uncertainty of the status of various shark fin ban bills in front of Congress and the increasing number of state fin bans has significantly reduced the number of commercial shark fishers who fish for sharks. This reduced number of fishers has resulted in the commercial shark quotas being under-harvested, and is resulting in increased depredation events.
- Shark interference and depredation is an issue in more than just the South Atlantic and Gulf of Mexico. The Agency needs to focus on the entire fishery, not just these two regions.
- Research should focus on the magnitude of the problem, predator-prey interactions, and impacts on all federally-managed fish stocks.
- Reporting programs should be modified to allow for reporting of shark interactions.
- Genetic information could show both the species involved and whether the same individual sharks are involved in multiple depredation events. Having this information could help with solutions.
- Additional research on the use of pingers, magnets, chemicals, and other types of deterrents could be helpful.

## Appendix D. Consultation Comments from Marine Mammal Commission

Marine Mammal Commission staff comments on
Draft Report to Congress on Interactions between Bottlenose Dolphins and Sharks and Commercial, For-Hire, and Recreational Fisheries in the Gulf of Mexico and South Atlantic

17 November 2021

General Comments

- Although sharks are included in the Congressional directive and in the title of the report, interactions between sharks and fisheries are not discussed anywhere in the report. Is that information contained in a separate document? If so, it would be helpful to review the information contained in that document, particularly to ensure that any recommendations for addressing interactions do not conflict with or undermine actions that might be taken to address interactions with dolphins.

- The emphasis of this report is on interactions between bottlenose dolphins and hook-and-line fisheries, with no mention of dolphin interactions with crab traps. Depredation of bottlenose dolphins on crab traps in the Indian River Lagoon were summarized in Noke et al. (2002), and included recommendations for addressing such interactions. Further research is needed regarding the frequency and location of interactions between bottlenose dolphins and crab traps in the Indian River Lagoon and other locations throughout the Gulf of Mexico and South Atlantic.

- Throughout the report, references to injuries and deaths from fishing gear entanglements and ingestions should also reference hookings as a mode of injury (as indicated in Figure 2).

Specific Comments

- Page 1: Bottlenose dolphins – The sentence stating that dolphins teach each other depredation and scavenging behaviors should include the phrase "especially mothers teaching calves."

  In the same sentence, it is not clear what is meant by "and the decline of prey populations from environmental events or overfishing" in that context.

  The purpose and meaning of the sentence "Therefore, increasing dolphin populations are not a potential cause for depredation and scavenging interactions" should be clarified.

- Page 3: Impacts to Post-Release Survival of Target Fish - This is one of the few places where the report takes an "ecosystem approach" to the analysis. That approach should be emphasized and expanded upon in other parts of the document as appropriate.

  This section implies that there is a high survivorship among released fish and their contribution to the fish stock. To the contrary, Campbell et al. (2010) indicate that catch and release of deep-water fish species leads to stress and impairment, "often resulting in immediate release mortality." This section also seemingly assumes that the dolphins would not be eating a similar amount of fish, perhaps from these same stocks, were it not for the availability of scavenged fish.

- Page 4: Consequences of Interactions – The reference to "increased predation by predators" is redundant (delete "by predators").

  At the end of that paragraph, it might be useful to say something like "Recreational fishing gear interactions remain the leading identifiable cause of death for bottlenose dolphins in Sarasota Bay (Lovewell and Fauquier 2021)."

- Page 4: Increased mortality and serious injury from entanglement in, hooking by, and ingestion of gear ~~bycatch~~ – The sentence referencing impacts should include puncture wounds as a type of injury. That paragraph should end with a sentence something like "Naive calves swimming with mothers interacting with gear are at risk from the gear as well simply from being in close contact with their mothers."

- Page 6: Increased predation and decreased survival of dolphins interacting with fisheries – The reference to a bottlenose dolphin calf in (b)(i) should clarify that it was an IndoPacific bottlenose dolphin.

  Two additional examples that should be included under this section:

  c) Bottlenose dolphins in Sarasota Bay, Florida, conditioned to interact with humans, have a higher probability of subsequent injury from human interactions over time (Christiansen et al. 2016).
  d) Bottlenose dolphins in Sarasota Bay, Florida, have been documented to transfer unnatural foraging patterns across generations, leading to unusually high levels of injury and mortality in subsequent generations (Wells 2019, Fig. 15.3).

- Page 6: Increased retaliation – This section should note that enforcement of violations of the MMPA is lacking, with only a small portion of violations prosecuted. Ineffective enforcement of the MMPA is contributing to increasing incidences of intentional harm-related injuries and mortalities of dolphins. More effective enforcement of intentional harm cases should be highlighted as a need in both the Southeast U.S. and Gulf of Mexico.

- Figure 4: Suggest changing the second sentence to "The dolphin died from an apparent puncture wound, …"

- Page 7: Increased vessel strikes – Suggest including propeller cuts to the sentence "Boat strike injuries result in lacerations, propeller cuts, or blunt force trauma, …". Propeller cuts are easy for people to understand.

- Page 7: Quantification of Dolphin Interactions with Hook and Line Fisheries – This should also include a quantification of interactions with trap fisheries.

  Illegal feeding is noted (on page 8) as a factor contributing to depredation, yet no information is provided regarding how many of the reported incidents of illegal feeding have resulted in enforcement actions.

- Page 9: For-hire industry – It should be noted that increased scavenging by dolphins on discarded fish occurred during the same timeframe that dolphin prey species had likely been reduced due to the Deepwater Horizon oil spill, as noted previously in the report (page 7).

  This section also notes that most scavenging events occurred with target species such as red snapper and red drum, indicating a possible prey preference, based on a study of dolphin depredation in rod and reel fisheries (Grewal et al. in prep.). However, it is not clear whether the inclusion of other fisheries (or other gear types, such as traps) may indicate other prey preferences.

- Page 13: Future Research Needs – This section heading should be more general, to include management, outreach/engagement, and enforcement needs as well as research.

  The report should place a stronger emphasis on "Developing effective outreach and engagement strategies to reduce dolphin-fishery interactions," based on what we understand to be factors contributing to depredation, including illegal feeding and discarding catch in the presence of dolphins. The stronger emphasis on effective outreach and engagement could be made by ranking this need as first or second in the list, above research on the effectiveness of deterrents. Might also want to note that outreach and engagement strategies should be targeted to known, persistent hot-spot areas, as indicated in Figure 5.

  More effective enforcement of intentional harm and illegal feeding cases should be included as a need in both the Southeast U.S. and Gulf of Mexico.

  This section might also suggest the need to review the efficacy of fishery management regulations that require fishermen to release out-of-season or undersized catch. Regulatory discards can reinforce the association between fishing boats and feeding opportunities, leading to a perpetuation of depredation behaviors.

- Page 14: Conclusions – Suggest the following additions to the sentence "Dolphins are seriously injured or killed by ingesting, <u>being hooked by</u>, or becoming entangled in fishing gear, being struck by a vessel <u>or its propeller</u>, or intentionally harmed."

<u>References</u>

Campbell, M.D., J. Tolan, R. Strauss, and S.L. Diamond. 2010. Relating angling-dependent fish impairment to immediate release mortality of red snapper (*Lutjanus campechanus*). Fisheries Research 106, 64–70.

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Noke, W.D., and D.K. Odell. 2002. Interactions between the Indian River Lagoon blue crab fishery and the bottlenose dolphin, *Tursiops truncatus*. Marine Mammal Science 18(4):819–832.

Wells, R.S. 2019. Common bottlenose dolphin foraging: Behavioral solutions that incorporate habitat features and social associates. Pages 331-344 *in* B. Würsig, ed., Ethology and Behavioral Ecology of Odontocetes, Ethology and Behavioral Ecology of Marine Mammals. Springer Nature Switzerland. https://doi.org/10.1007/978-3-030-16663-2_15