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Bottlenose Dolphin (*Tursiops truncatus*) Behaviors in the Presence of Active and Non-Active Shrimp Trawlers in the Mississippi Sound

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by

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Abstract

Bottlenose dolphins, *Tursiops truncatus*, are reported to have close associations with shrimp trawlers worldwide. The goal of this study was to assess differences in the behavior for bottlenose dolphins between activity states of shrimp trawlers in the Mississippi Sound. During active trawling, nets are actively gathering the catch closely behind the trawler, which provide feeding opportunities for bottlenose dolphins. Non-active groups are not able to take advantage of feeding prospects and display fewer feeding behaviors and maintain a farther distance than active trawler groups.

Video of trawlers were collected from the Mississippi Wild Dolphin Project and analyzed for feeding and social behaviors; this study also took note of the state of the dolphins, group size, and distance from the dolphins to the trawlers. Group size was not significant between trawler activity states. Behaviors were statistically significant between active and non-active trawlers. Active trawlers dolphin groups engaged in feeding behaviors, while non-active trawler groups engaged in social behaviors. Bottlenose dolphins associated with active trawlers spent the majority of time at close distances while non-active groups spent most of their time at farther distances.

Key Words: Shrimp trawlers, *Tursiops truncatus*, depredation, active trawling, social behavior, Mississippi Sound

Acknowledgments

As I look back on my college years, so many people have encouraged and supported me. I would like to thank my advisor Dr. Kuczaj, for providing me the opportunity to tackle a project like this and for allowing me to work in his lab. In addition, I would like to recognize all past and present members of the Marine Mammal Cognition Lab for recording the video used in my project. In particular, I would like to say thanks to Erin, who supervised my thesis, and Kendall, who coded my videos for reliability.

I would like to dedicate this thesis to my family, who have always encouraged me and made me feel that nothing is impossible. I love you all SO much.

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Literature Review

In the Gulf of Mexico, shrimp trawlers are an integral part of the ecosystem. Bottlenose dolphins, *Tursiops truncatus*, are hypothesized to be relying on these trawlers as a dependable food source. This project focused on bottlenose dolphin associations with shrimp trawlers by looking at the differences in behavioral frequency and type that occur between active and non-active trawling dolphin groups. This provides novel insight into dolphin behavioral ecology and allows for a better understanding of how bottlenose dolphins and the shrimping industry affect each other. Much of the research on bottlenose dolphin behavior addresses different behaviors associated with anthropogenic foraging and the composition of the catch taken by the dolphins in question. Few studies cross-examined the behaviors of dolphins between activity states of trawlers. This study provides new perspective on bottlenose dolphin and shrimp trawler interactions by examining behavioral differences between trawling dolphin groups, which is seldom reported in the current literature.

In the past years, violent encounters have been reported between dolphins and fishermen. It is unknown whether these encounters have increased in number or if these encounters are being reported more often. By studying the behaviors and occurrences of dolphins in association with fishing boats it can be determined if the fishing industry is having a positive or negative impact for this population and if dolphins could transmit these behaviors from generation to generation.

The Gulf of Mexico shrimping industry is vast, covering 1,631 miles along the coastline from Florida to Texas and 186,200 square miles of Economic Exclusive Zone that surrounds the United States (Diamond, 2004). This fleet encompasses well over

5,000 ships from the states of Florida, Alabama, Louisiana, Texas, and Mississippi (National Marine Fisheries Service, 2013). In 2011, 5,357 ships participated in the shrimping season (NMFS, 2013).

This fleet has national as well as regional economic importance. The 2011 total net worth for the catch of this industry reached over $440 million. The average revenue for an active trawler in 2011 was $316,425 (NMFS, 2013). After estimated depreciation and owner labor costs, this profit drops to $13,000 annually (NMFS, 2013). Since the profit of an average trawler is not is very high, depredation or damaged catch from dolphin interference easily influences the salary and economic lifestyles of fishermen.

Dolphins have been associated with fishermen and their activities since humans first began harvesting oceanic resources. From the ancient Greeks and Romans to the native tribes of Africa, fishing practices with the aid of dolphins have long been documented (Kemf, 1993; Lytle, 2006). Plutarch, a Greek historian, commented in 977 A.D. that dolphins would chase fish towards the nets of boats and then feed at leisure on the concentrated mass of fish (Lytle, 2006). There are even records of dolphins intentionally entering the nets of boats in order to feed (Lytle, 2006).

There has been resurgence in recent years concerning the importance of bottlenose dolphin behavior with fishing industries. Much of the current research focuses on the effects of anthropogenic foraging and the behaviors that often accompany these events. Among these are begging, depredation, scavenging, and provisioning behaviors. Noke and Odell (2002) defined begging as an event in which the dolphin will swim near a boat with an open mouth and the head above the surface. Zollett and Read (2006) modified this description to a category of behaviors in which a dolphin moves closer to a

boat to receive food. Depredation is any set of behaviors that a dolphin uses to take bait or fish directly out of traps or nets (Read, 2008; Zollett & Read, 2006). Broadhurst (1998) provided an example of depredation in which bottlenose dolphins depredated codends by using their rostrums to manipulate the net openings. Two other common feeding events are scavenging and provisioning. These events are very similar; in both events, the dolphins are feeding on bait or discarded bycatch from the fishermen. However, provisioning is the intentional feeding of dolphins, while scavenging is the non-intentional feeding of dolphins (Powell & Wells, 2011).

Kovacs and Cox (2014) report that bottlenose dolphins associating with trawlers in Georgia display differences in behavior with trawler activity. Kovacs and Cox did not differentiate between feeding or social/play behaviors, but between fishing operations and the distance of the dolphins to the trawler (Kovacs & Cox, 2014). Kovacs and Cox (2014) reported four behaviors concerning net positions: begging, foraging, association with trawlers, and approaches with trawlers. Bottlenose dolphins were associated with trawlers at distances of 150m; approaches occurred within 10m of the trawler (Kovacs & Cox, 2014). Associations with trawlers occurred most frequently when nets were in the haulback or trawling positions (Kovacs & Cox, 2014). Approaches were mainly observed when fishermen were sorting bycatch and cleaning the nets (Kovacs & Cox, 2014).

Trawlers also affect the behavioral distribution of bottlenose dolphins. Chilvers and Corkeron discovered in 2001 that bottlenose dolphins in Australia separate into trawling and non-trawling populations. This further supports the theory that trawler activity affect dolphin behavior. These groups of bottlenose dolphins utilized different food sources and even occupied different spatial areas (Chilvers & Corkeron, 2001;

Chilvers, Corkeron, & Puotinen, 2003). One group would feed from trawler bycatch and the other group utilized trawlers less often. Consequently, these groups had different space ranges to accommodate these feeding habits (Chilvers & Corkeron, 2001). Trawling dolphins were most often found in areas of trawling activity while non-trawling dolphins ranged farther from trawling sites (Chilvers, Corkeron, & Puotinen, 2003).

Bottlenose dolphins frequent shrimp trawlers and fishing boats often, but it is unknown how dolphins know which boats to forage from. Since trawlers making feeding more beneficial, there is a reduction in foraging time which dolphins are able to devote to calf rearing or social activities (Bearzi, 2002). Bottlenose dolphins have high plasticity when it comes to feeding and foraging styles, which is advantageous for survival (Corkeron, Bryden, & Hedstrom, 1990; Emlen, 1966). The aim of feeding is to take in as much food as possible in as short a period as possible with little energy expenditure (Emlen, 1966). Selectivity is how an animal chooses what prey to eat. High selectivity in animals results in a specific diet, whereas low selectivity results in a wide range of potential prey. Selectivity can vary depending on the environment (Emlen, 1966). As food becomes more available, selectivity will increase for a species (Emlen, 1966). As such, selectivity can be used to approximate how much food is available for a habitat (Emlen, 1966). Bottlenose dolphins in Australia have been known to illustrate selectivity in prey choices when involved with trawling (Corkeron et al., 1990). Moreover, dolphins in the Mediterranean have been observed attacking nets with high catch abundance, (Rocklin et al., 2009). If dolphins can afford to be selective and only attack nets with high variety of catch, this suggests a high abundance of food in those areas and could reflect areas of little concern for conservation.

In order to use trawlers for feeding and foraging purposes, the ability to tell non-active and active trawlers apart is critical. Dolphins need to be able to tell which trawlers are gathering catch to maximize feeding opportunities. Some studies have hypothesized that bottlenose dolphins can acoustically distinguish between cruising and trawling boats (Fertl & Leatherwood, 1997; Leatherwood, 1975; Noke & Odell, 2002). Fertl and Leatherwood (1997) in particular, proposed that boat engines have a specific sound for different activities and dolphins are familiar with these sounds, particularly during the initial deployment of nets and sorting of the catch . These two times are the easiest times to obtain fish from nets or from provisioning (Leatherwood, 1975; Noke & Odell, 2002). Furthermore, both Noke and Odell (2002) and Leatherwood (1975) report that the majority of times dolphins are seen is just after the first trap or net is pulled in. This supports the notion that bottlenose dolphins may possibly associate a particular sound of the boat with easy prey.

Noke and Odell (2002) also proposed that rather than learning specific boat sounds, dolphins are potentially learning the routes of the trawlers. Many trawlers have a set route and they will only check traps or trawl along that route. Noke and Odell (2002) reported that dolphins are unintentionally reinforced by being able to obtain food at locations of traps along this set route. To support this theory, Noke and Odell (2002) also reported that bottlenose dolphins have a preference to approach the side of the trawlers that bycatch is most often discarded from . Additionally, Kovacs and Cox (2014) hypothesized that the sight of the nets and the positions of the nets may be sufficient stimuli for the dolphins to determine whether there are opportunities to feed.

Due to these interactions, there are often consequences for both fishermen and bottlenose dolphins. Economic losses from depredation behaviors can lead to aggressive retaliatory actions (Powell & Wells, 2011). Dolphins frequently damaged the nets of the boats when engaged in feeding behaviors (Zollett & Read, 2006). When bottlenose dolphins engage in depredation, they can damage up to 8% of the catch (Powell & Wells, 2011; Rocklin et al., 2009). Any damage to the catch decreases its selling power, which influences shrimpers' income. Bottlenose dolphins in the Mediterranean are estimated to liberate 600g of fish from each trawling net (Rocklin et al., 2009). At first, this seems to be a small amount. With an estimated consumption rate of 7-10kg, 600g represents only a small portion of an adult's daily diet (Corkeron et al., 1990; Rocklin et al., 2009). In other areas, the effects of depredation are more substantial. Zollett and Read (2006) reported that with mackerel trawlers, up to one-fifth of the catch was taken. In addition to taking significant portions of the catch for each trawl, dolphins can influence the catch composition, which may lead to more bycatch and financial loss for fishermen (Rocklin et al., 2009). Even when not engaged in feeding, bottlenose dolphins have been known to entangle themselves and rip nets in order to get free (Fertl & Leatherwood, 1997). Damaged nets put an even larger economic drain on shrimpers by costing time and money to repair. The results of these interactions drastically influence many fishermen financially (Fertl & Leatherwood, 1997; Powell & Wells, 2011; Rocklin et al., 2009; Zollett & Read, 2006). Violent retaliatory measures are sometimes reported that include bullets, firecrackers, and seal bombs (Fertl & Leatherwood, 1997; Read, 2008; Zollett & Read, 2006). Increases in fishing activities only increase the interactions between boats and dolphins (Powell & Wells, 2010).

Bottlenose dolphins are also reported to swim inside the nets during depredation events (Broadhurst, 1998; Jaiteh, Allen, Meeuwig, & Loneragan, 2013). Bottlenose dolphins in Australia entered the nets of trawlers in over 80% of reported encounters (Jaiteh et al., 2013). Most dolphins that enter nets are involved in feeding behaviors like fish chases (Jaiteh et al., 2013). Broadhurst (1998) observed that even turning spotlights on and off during night trawling had no effect on depredation behavior of bottlenose dolphins (Broadhurst, 1998). This suggests that bottlenose dolphins engage in depredation as an established pattern of behavior (Broadhurst, 1998). The benefits of entering these nets are contrasted with the dangers of becoming potentially entangled.

By being inside the nets, dolphins expose themselves to entanglement and drowning (Bearzi, 2002; Read, 2008). Dolphins are also impacted by discarded fishing lines and nets (Bearzi, 2002; Fertl & Leatherwood, 1997; Wells, Hofmann, & Moore, 1998). In one instance, researchers physically removed fishing line from a female bottlenose dolphin after it became clear that the line could result in fluke detachment (Wells et al., 1998). Later examination of the tail and peduncle region revealed deep scars from the fishing line (Wells et al., 1998).

Juveniles and calves are also involved in these depredation events. Dolphins with calves are often observed following trawlers (Bearzi, 2002; Jefferson, 1992). Depredation is a behavior that may potentially be learned through social learning (Jefferson, 1992). It is hypothesized that a lack of experience and the desire to participate may lead juveniles and calves to have higher injury rates than adults Bearzi, 2002; Jefferson, 1992). Kovacs and Cox (2014) reported an instance of a stranded emaciated calf that was seen earlier feeding on trawler bycatch. The authors suggested that the calf may have been unable to

get enough to eat without trawlers present (Kovacs & Cox, 2014). This suggestion is strengthened by a study on provisioned females and their calves, which concluded that calves with heavily provisioned mothers have higher rates of mortality and lower rates of care than unprovisioned mothers (Foroughhirad & Mann, 2013). Understandably, these interactions may pose a serious threat to the safety of bottlenose dolphin populations.

Previous research draws comparisons between trawling and non- trawling dolphin groups; no study cross-examined behaviors between activity states of shrimp trawlers. Most studies compared trawling and non-trawling populations rather than differences in trawling dolphin groups. In 1975, Leatherwood broadly categorized seven states based on dolphin and trawler interactions differentiated by the absence or presence of trawlers (Leatherwood, 1975). Successive studies emulated this example. In order to gain a more thorough understanding of behavior, studies should also identify differences in dolphin interactions due to differences in trawler activities.

By modeling the studies presented and expanding on them, this study aimed to discover if bottlenose dolphin behaviors are different depending on the activity state of the trawler. It is also possible to discover if interactions in the Mississippi Sound reflect interactions in other areas. Since this study only observed encounters in which boats are present, dolphin behavior can be compared between active and non-active trawlers.

Methods

The data for this study was obtained from videos of encounters from the Mississippi Wild Dolphin Project conducted by the Marine Cognition and Behavior Laboratory at The University of Southern Mississippi. Members of the laboratory

collected this data using all occurrence sampling for a 15-minute interval, or until dolphins were recorded as "not found" for five consecutive minutes (Altman, 1974). Only encounters with trawlers were used in analysis for a total of 50 encounters dated from November 2003 to July 2012. The total video time for these encounters was 14 hours and 20 minutes. Out of these 50 encounters, 29 contained active trawlers and 17 had non-active, with respective video totals of 6 hours 50 minutes and 6 hours 12 minutes for each category. Both active and non-active trawlers were present in four encounters.

All occurrence sampling was utilized to record bottlenose dolphin behavioral events in videos of trawler activity. States of dolphin behavior were recorded by one-zero sampling (Altman, 1974). The states were then compared to find the most predominant state for that encounter. Videos were coded for the entire duration of the encounter, and all behaviors were tallied at the end of the encounter. Overall frequency of each behavioral event will be calculated and compared across both active non-active trawler groups. No distinction was made in regards to the time/duration of the behaviors, only that they occurred in the presence of a trawler.

The four states coded include the following: milling, traveling, foraging, and social. Milling is defined as swimming around or following the trawler or staying in the same area for an extended amount of time. For the purposes of this study, traveling will mean that the dolphin group does not stay in the area and does not display any changes of behavior because of the trawlers' activities. Foraging will encompass any behaviors that result in the dolphin obtaining food. This differs from milling in that the dolphins are observed engaging in feeding behaviors. A social state will include behaviors that are

directed toward other members of the group or the trawler boats. Any of the below behaviors will be loosely categorized under these four states.

Types of behaviors that were coded for analysis include aerial and visual displays, chases, group social balls, and feeding behaviors. Aerial behaviors include leaps and breaches. A leap is an instance where the dolphin comes completely out of the water, whereas in a breach the dolphin comes partly out of water with considerable force. Visual displays include chuffs and fluke and pectoral slaps. Chuffs are forceful exhales seen at some height above dolphin. Fluke and pectoral slaps are contact with the appendages against the surface of the water resulting in a loud clapping sound. There are two types of chases in this study; chase fish is a feeding behavior, while chase dolphin is a social behavior. Chase dolphin behaviors are identifiable by a change in speed or direction across or into boat wake or going backwards in wake, with a dolphin either in front or behind. In fish chases, no dolphin is behind or in front of the chasing dolphin. A group social ball is rapid social interaction between two or more dolphins where individual behaviors cannot be distinguished from one animal to another. Due to the indistinguishable nature of this situation, it is impossible to differentiate behaviors for this interaction. There are three feeding behaviors that are of particular interest in this study: scavenging, provisioning, and depredation. Scavenging behavior is the non-intentional feeding of dolphins by shrimpers. Conversely, provisioning is the intentional l feeding of dolphins by shrimpers. When the shrimper orients towards the dolphin, it is assumed that he/she has seen the dolphin. Intentional feeding can then be identified when the shrimper places or throws the food within easy reach of the dolphin. Depredation is the act of feeding directly over or beside net and is evident by the proximity of the

dolphin to the towlines of the trawler. Bow and wake rides are behaviors in which the dolphins are able to ride on the waves that the trawler creates. Bow rides occur near the front of the trawler and wake rides are observed near the back. Any bow or wake rides were counted only in the case of the trawler; any laboratory boat behaviors were not coded.

All observation periods for this study include shrimp trawlers in the vicinity. This vicinity is defined as 500ft or less from the dolphins and subdivided into categories of close, middle, far, and extremely far from the trawler boat. Close distances are 50 ft or less, middle distances include lengths from 100ft to 50ft, and far distances are anything beyond 100ft. extremely far distances are only noted when the trawler activities on the horizon are clearly distinct. The behaviors observed were tallied and grouped according to the most frequent state when they were observed. Inter-observer reliability was assessed for behavioral events, states, distance, and group size for both active and non-active trawlers for approximately twenty percent of the total data set. Reliability was achieved at above 94% for all variables using Pearson correlational coefficient.

To find differences between active and non-active trawling groups, four variables were tested: behaviors, group size, states, and distance. The most common behaviors for each group were found by tallying the number of behaviors for active and non-active trawlers. The most frequent behavior was then found by comparison. To test for differences in behaviors between active and non-active groups, a chi squared independent test was conducted ($\alpha = 0.05$; $df = 11$). With group size, both adults and calf numbers were recorded for each encounter. The Mann Whitney nonparametric test was used to

find if group numbers between active and non-active trawlers are statistically different for both adults and calves.

Percentages of time spent in each state for active and non-active trawlers were calculated and compared to the total video time in each group. The most common states were found by taking the highest percentage. Percentages of time were also calculated for each distance category for both groups. The most common distance was found by tallying the distances for each group.

Results

Analysis of the data revealed group size did not significantly differ between active and non-active trawlers ($U= 188.0$, $p< .179$) or calves ($U= 193.0$, $p< .185$). However, there was statistical significance between the frequency of behaviors between active and non-active trawlers, ($X^2= 179.12$, $p <.05$). A number of behaviors coincided between groups. Bow and wake rides, chuffs, and provisioning behaviors were slightly dissimilar. No bow or wake rides occurred with active trawlers. Pectoral slaps and dolphin chases did not differ at all between groups. Depredation and fish chase events were elevated in active trawler groups as compared to non-active groups. In non-active trawler groups, group social balls were distinctly higher than active trawler groups. Non-active trawlers had no chase fish, scavenging, or depredation behaviors.

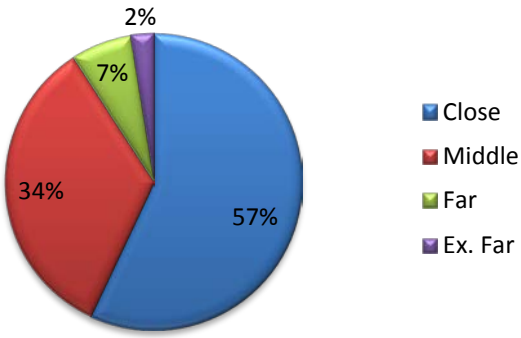

Chart 1: Bottlenose dolphin (*Tursiops truncatus*) distances from active trawlers as percentages of the total time with active trawlers.

Chart 1 shows that the most common distance of active trawler dolphin groups was close (less than 50ft from the trawler). At 57%, this category of distance comprised the majority of time spent associating with the active trawler. Bottlenose dolphins associating with shrimp trawlers spent the most time with active trawlers at close distances. As referenced in Chart 1, active trawler dolphins spent 37% of their time at distances of 50ft to 100ft (middle) and spent the least amount of time at far and extremely far distances.

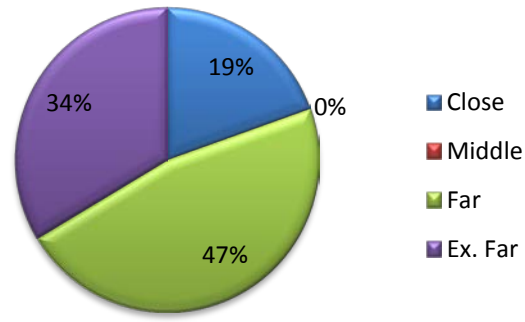

Chart 2: Bottlenose dolphin (*Tursiops truncatus)* distances from non-active trawlers as percentages of the total time with non-active trawlers.

In Chart 2, it is clear that bottlenose dolphins associating with non-active trawler groups spent the majority of time at far distances (100ft or greater). The dolphins following non-active trawlers spent only 19% of their time at close distances and no time at middle distances. Dolphins following non-active trawlers spent 34% of their time at extremely far distances.

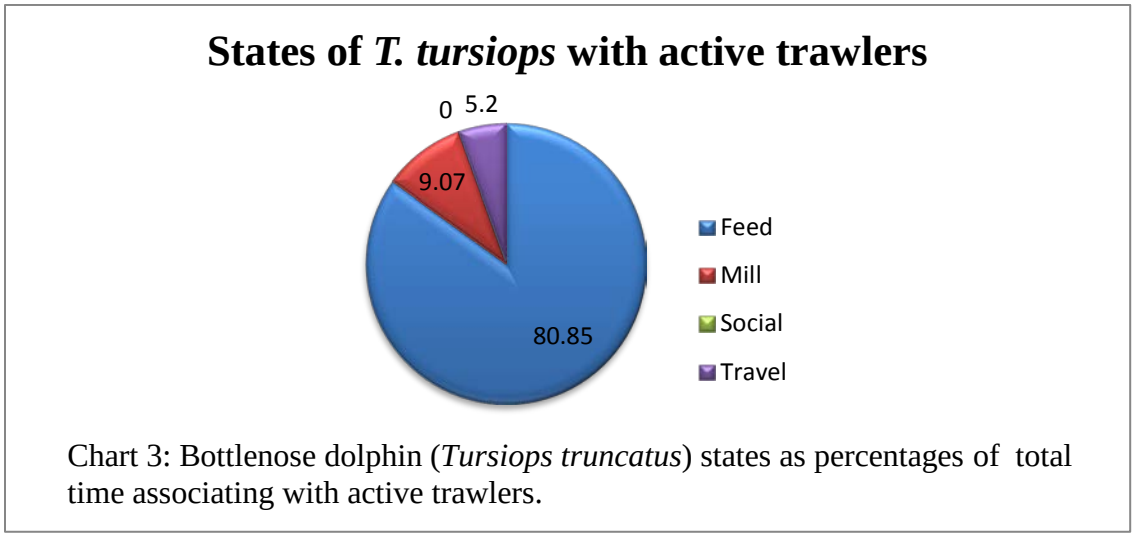

Chart 3: Bottlenose dolphin (*Tursiops truncatus*) states as percentages of total time associating with active trawlers.

A majority (80%) of active trawler encounters occurred as feeding states. Few milling or traveling states occurred while associating with active trawlers. No social states were observed for active trawler dolphins.

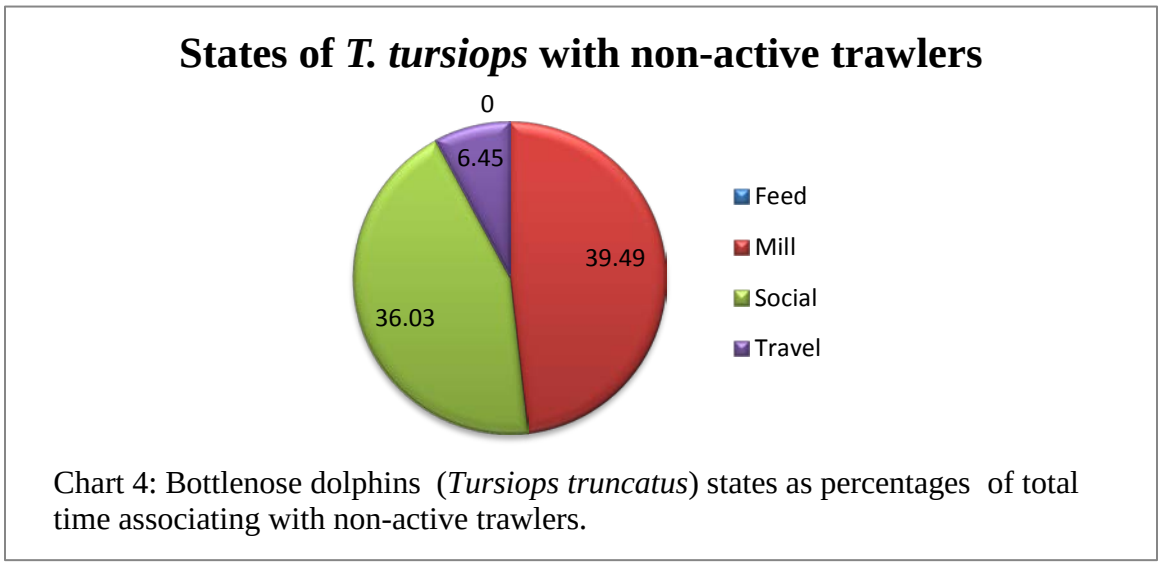

Chart 4: Bottlenose dolphins (*Tursiops truncatus*) states as percentages of total time associating with non-active trawlers.

Conversely, mill was the most common state for inactive trawlers and no feeding states occurred in this group. By comparing the values in Chart 4, social states accounted for a slightly smaller percentage of non-active trawler total time. Non-active trawler groups spent the least time traveling and feeding.

Discussion

In past studies, shrimp trawling operations have been shown to have effects on bottlenose dolphin behavior. This study supports the theory that bottlenose dolphins exhibit significantly different behaviors during different trawler activities. Active trawlers provide an easy means for dolphins to feed with little energy output in a shorter period than natural foraging would require. Bottlenose dolphins associating with active trawlers spent the majority of time feeding at close and middle distances. The distances of the dolphins to the trawler reflect the proximity of nets to the trawler as well. When actively trawling, the openings to the nets are usually within 100ft of the boat. Since active trawlers typically tow nets at close ranges behind the boat, dolphins maximize their foraging time by following closely behind trawlers. This distance occupies the same spaces that active trawler dolphins are found 91% of the time. Feeding is prioritized, with little time spent on milling and traveling. This supports Chilvers and Corkeron's study (2003) while observing a population of dolphins that forage from trawlers. While following active trawlers, dolphins spent no time engaging in social behaviors.

Conversely, bottlenose dolphins with non-active trawlers spent the most time socializing and milling at far and extremely far distances. Non-active groups spent no time in feeding states. Non-active trawlers are not gathering catch, so bottlenose dolphins

spent little time trying to obtain food and devote their time to socialization behaviors. As with the active trawler dolphins, their distance to the trawler is reflected in their activities. Since they are not actively feeding on the contents of the nets, the dolphins have no immediate need to remain close to the trawler and can conserve energy by following at a leisurely pace. As a result, 81% of the time they are located at greater distances from the trawlers than their active counterparts.

There was no statistical difference in group size for adults or calves. Chilvers and Corkeron (2001) had similar group sizes to this study; the average group size for trawler associated dolphins was 5-8 dolphins. In this study, the average group size was 6 dolphins. Several studies have reported calves learning from older dolphins and participating in depredation behaviors. Since the numbers of adults and calves were similar for both groups, this implies that there is just as much emphasis on non-trawling boats as there is on actively trawling boats. Learning most likely occurs under both situations, but what they learn may be different. With non-trawling shrimpers, calves could be learning to familiarize themselves with the boat. With trawling shrimpers, calves could be learning how to manipulate the nets and maximize feeding. Similar group sizes do not mean that bottlenose dolphins are not teaching skills to calves; neither does it imply that learning is occurring. Further research needs to be done before this question can be definitively answered.

Dolphin behaviors differed depending on if they were in the presence of active or non-active trawlers. During actively trawling, the most common behaviors were chuffs, depredation, and chase fish. Non-active trawling behaviors focused on more social behaviors like group social balls, chuffs, and breaches. Jaiteh et al. (2013) report that fish

chases and foraging behaviors were most common for dolphins foraging from trawling nets. The activity of the trawler signals the bottlenose dolphins to respond differently (Kovacs & Cox, 2014). Bottlenose dolphins will adjust their distances and shift from foraging to social behaviors as the trawler progresses through stages of operation.

One behavior that was not noticed in this study was begging behavior. This behavior is widely described in the literature and occurs both with trawlers and with other boats. Begging behavior requires that dolphin to swim closely beside the boat and orient towards the boat with the head out of the water (Kovacs & Cox, 2014; Noke & Odell, 2002; Zollett & Read, 2006). Some definitions of begging may include an open mouth (Noke & Odell, 2002). One reason this behavior may not have been sighted is lack of stationary trawlers in this study. It would be difficult for a dolphin to keep up with a moving trawler while exhibiting begging behavior. Additionally, Kovacs and Cox (2014) concluded that provisioning and bycatch discard may lead to this prevalence of this behavior. For this study, only one provision instance was directly observed. If provisioning does lead to begging, then the absence of provisioning for this study may be the reason that begging was not observed.

Bow and wake rides were rarely observed for trawlers. Kovacs and Cox (2014) note that the haulback and sorting catch periods are the slowest times for a trawler. The only bow/wake rides observed during this study were observed in association with active trawlers. It may be possible that non-active trawlers are moving too slow for the dolphins to bow or wake ride. Active trawlers may also be difficult to ride with as the nets are often towed directly behind the boat and may disrupt the wake stream. Kovacs and Cox

(2014) theorized that the risks of riding between the boat and the nets are too costly for bottlenose dolphins.

One limitation of this study was the video constraints. Video was taken of dolphin interactions with a single trawler for a brief period of time. This brief period does not reflect the entire repertoire of dolphin behaviors with trawlers. Future research might include focal groups of bottlenose dolphins that prey on trawlers or monitor the actions of a trawler with respect to specific behaviors. Focal groups of bottlenose dolphins may tell how many trawlers dolphins interact with throughout the day.

Dolphins and shrimp trawlers have a long history of associations. Ecologically, this study demonstrates the high frequency of depredation events for dolphin groups interacting with active trawlers. Shrimpers often lose profit when depredations occur. To protect their catch, shrimpers may resort to violent measures. This study is crucial towards better understanding the ecological relationship between bottlenose dolphin populations and various types of fishing boats, as well as assisting conservation efforts for dolphins in this context.

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Appendix A

States- category in which the dolphins spent the most time

Feed- behaviors associated with feeding

Mill- dolphins are present with trawlers but there is no direct interaction

Social- characterized by play and social behaviors

Travel- dolphins pass by trawlers with no direct interaction

Distance

Close <50ft

Middle 50-100ft

Far >100ft

Extremely Far – distinct on edge of horizon

Behaviors

Bow/Wake Ride- only on trawler, not on Lab boat

Leap- completely out of water

Breach- dolphin comes partly out of water with considerable force

Chuff- forceful exhale seen at some height above dolphin

Fluke slap- contact with flukes on surface of the water

Pectoral Slap- contact with pectorals on surface

Chase dolphin- change in speed or direction with a dolphin either in front or behind

Chase fish- any change in direction across or into boat wake, speeding up with no dolphin behind or in front, or going backwards in wake

GSB- some type of social interaction that is not clear or partially underwater

Scavenge- non-intentional feeding of dolphins by shrimpers

Provision- intentional feeding of dolphins by shrimpers

Depredation- feeding directly over or beside net