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Quantification of Interactions Between Common Bottlenose Dolphins (*Tursiops truncatus*) and a Commercial Shrimp Trawler near Savannah, Georgia

Carolyn Kovacs and Tara Cox

Savannah State University, Marine Sciences Program, Box 20467, Savannah, GA 31410, USA
E-mail: coxt@savannahstate.edu

Abstract

The common bottlenose dolphin (*Tursiops truncatus*) has been known to forage in association with shrimp trawlers by feeding on fish caught in or disturbed by nets and on discarded bycatch. In addition, common bottlenose dolphins in the estuarine waterways near Savannah, Georgia display a high rate of begging behavior, and it is hypothesized that interactions between bottlenose dolphins and the shrimp trawl fishery may be a contributing factor. The purpose of this study was to determine which activities of the shrimp trawl fishery resulted in associations between trawlers and bottlenose dolphins, and which activities resulted in bottlenose dolphins begging from the trawler. The presence of common bottlenose dolphins around a commercial shrimp trawler and the activity of the trawler were recorded for 129 h over 20 d from August to November 2010 and June to October 2011. Bottlenose dolphins associated with the shrimp trawler (i.e., within 150 m of the trawler) for 68 ± 33% of the day; and they associated with the vessel for the majority of the time spent in the net positions of haulback (90 ± 20%) and trawling (89 ± 17%). However, bottlenose dolphins approached the vessel (i.e., within 10 m) most often while the fishermen were manipulating and cleaning the nets (60 ± 23%) and least often during trawling (2 ± 5%). Begging was observed on 90% of days and occurred most often when the fishermen were cleaning the nets and bringing the trawl doors onboard the vessel (79% of days). Whether or not a bottlenose dolphin interacted with a trawler was dependent on several factors, including trawler activity, net position, and fisherman behavior. Furthermore, bottlenose dolphins that forage behind active trawlers may later engage in begging behavior as a result of direct interactions with fishermen, perpetuating the begging problem near Savannah.

Key Words: shrimp trawler, fisheries interactions, begging, bottlenose dolphins, *Tursiops truncatus*

Introduction

Trawling is a widely used fishing technique for catching fish and shrimp (Graham, 2006); it also results in the incidental catch of organisms known as bycatch. At least 15 cetacean species have been observed feeding in association with trawlers worldwide (Fertl & Leatherwood, 1997). One of the most common cetacean–trawler interactions is between bottlenose dolphins (*Tursiops* sp.) and shrimp trawls (Leatherwood, 1975; Gruber, 1981; Delgado-Estrella, 1997; Fertl & Leatherwood, 1997; Broadhurst, 1998; Chilvers & Corkeron, 2001; Gonzalvo et al., 2008; Perrtree, 2011). Bottlenose dolphins forage in association with trawlers during multiple stages of trawler operation, including foraging behind actively trawling vessels, consuming discarded bycatch, and foraging around non-active vessels to feed on fish attracted by food particles in the nets or discharged from the bilges (Leatherwood, 1975).

Bottlenose dolphins that forage behind a trawl likely feed on the organisms stirred up or disoriented by the net as it passes along the seafloor, pick out fish that are caught in the net, feed on fish that pass through the net, or feed on fish within the net itself (Gruber, 1981; Fertl & Leatherwood, 1997; Jaiteh et al., 2012). Underwater video has been used to observe bottlenose dolphins manipulating trawl nets to increase the size of the mesh opening in the codend, allowing small fish to be released (Broadhurst, 1998) as well as swimming into the nets and feeding on organisms within the nets (Jaiteh et al., 2012). Gruber (1981) observed common bottlenose dolphins (*Tursiops truncatus*) (hereafter bottlenose dolphins) in Matagorda Bay, Texas, associating with a vessel while it was anchored, docked, traveling, trawling, and discarding bycatch. Multiple groups, totaling 3 to 10 bottlenose dolphins, were commonly observed behind the actively trawling vessel. Bottlenose and Atlantic spotted (*Stenella frontalis*) dolphins were present while vessels in Campeche Sound, Mexico,

trawled, hauled in nets, discarded bycatch, and were anchored, with a mean of 4.70 (± 2.00 SD) bottlenose and 5.43 (± 2.30 SD) spotted dolphins present during trawling (Delgado-Estrella, 1997). Both Gruber (1981) and Delgado-Estrella (1997) described similar numbers of dolphins present during haulback and trawling. In contrast, Svane (2005) reported that short-beaked common dolphins (*Delphinus delphis*) and bottlenose dolphins appeared only during haulback.

Bottlenose dolphins foraging in association with shrimp trawlers are likely able to decrease foraging costs as they find a high concentration of prey in one location (Fertl & Leatherwood, 1997). In addition, the time required to capture the prey may be reduced since the fish are often stunned, injured, or dead (Fertl & Leatherwood, 1997). It is possible for a bottlenose dolphin to obtain a large portion of its daily caloric needs within a short period of time spent with a trawler (Corkeron et al., 1990). For example, a female bottlenose dolphin consumed an estimated 6.6 kg of trawl bycatch on one occasion (Corkeron et al., 1990). This falls within the estimates for bottlenose dolphin daily prey consumption, which ranges from 5.2 to 12 kg (Broadhurst, 1998; Kastelein et al., 2003). In addition, the composition of shrimp trawls often matches the diet of bottlenose dolphins. Greenman (2012) found that white shrimp (*Litopenaeus setiferus*), brief squid (*Lolliguncula brevis*), and five species of fish from the Family Sciaenidae were among the most common in trawls in South Carolina, which matched the diet of stranded bottlenose dolphins in South Carolina (Pate & McFee, 2012).

Fishermen that discard their bycatch while drifting, idling, anchored near shore, or at dock create a temporary but stationary food source. This provides an opportunity for bottlenose dolphins to associate food with anthropogenic sources (e.g., fishermen, vessels). In Indian River Lagoon, Florida, bottlenose dolphins became conditioned to approach commercial blue crab boats, possibly reinforced by the discards of old bait (Noke & Odell, 2002; Durden, 2005). A solitary bottlenose dolphin in Belize, known to interact with humans in the water, became conditioned to humans after fishermen threw fish and conch to it (Dudzinski et al., 1995). Similarly, in Novo Airão, Brazil, Amazonian boto (*Inia geoffrensis*) became conditioned to human interaction and accepted food from humans after first being attracted to the fish discards from a restaurant (de Sá Alves et al., 2009). Bottlenose dolphins in the Indian River Lagoon and the boto in Brazil were also both observed begging, suggesting that associations with fishing vessels or humans for discards may lead to begging behavior (see definition of *begging* in Table 1).

Bottlenose dolphins in the estuaries near Savannah, Georgia exhibit the highest rate of begging behavior (see Table 1) reported worldwide (Perrtree et al., 2014). Bottlenose dolphins near Savannah begged on 63.8% of survey days, and during 22.2% of the sightings in 2009 and 2010 (Perrtree et al., 2014). Between 2009 and 2011, 68 beggars were identified out of 353 (19.3%) individuals in the local photo-identification catalog, and 40% (n = 55) of the 137 non-calf dolphins sighted on 6 d or more were confirmed beggars (Kovacs, 2012; Perrtree et al., 2014). Provisioning of bottlenose dolphins by recreational boaters has been reported anecdotally in the area, but rarely observed. Commercial feed-the-dolphin tours that operated out of Hilton Head Island, South Carolina, just north of Savannah, from 1988 until 1993 (Bryant, 1994) also may have contributed to begging behaviors in both the Hilton Head and Savannah areas. While the cause of the high rate of begging near Savannah is unknown, one

Table 1. Descriptions of common bottlenose dolphin (*Tursiops truncatus*) behaviors

Net position	Description
Begging	Surfacing parallel to the vessel within 2 m with the ventral side toward the vessel or surfacing with its head out of the water oriented toward the vessel within 10 m of the vessel (Perrtree et al., 2014)
Associating with the trawler	Engaging in one of the following behaviors within 150 m of the vessel: trawler foraging, traveling behind the trawler in the same direction as the moving vessel, begging, or moving non-directionally around the trawler
Approaching the trawler	Engaging in one of the following behaviors within 10 m of the vessel: trawler foraging, traveling behind the trawler in the same direction as the moving vessel, begging, or moving non-directionally around the trawler
Trawler foraging	Peduncle-up diving near the nets during trawling (Chilvers & Corkeron, 2001) or direct positioning next to the nets when the nets are at the surface

possible contributor to the behavior is interactions with shrimp trawlers.

Interactions between the Savannah shrimp trawl fishery and bottlenose dolphins can be dated back to the 1970s (Hogan, 1975) or earlier. Hogan (1975) reported groups of 5 to 10 bottlenose dolphins associating with as many as 3 to 10 shrimp trawlers in the area between the Savannah River mouth and Calibogue Sound in 1972. In addition, half of the respondents of a 2011 survey of shrimp and blue crab fishermen in Georgia had seen bottlenose dolphins associate with their gear or vessel for over 20 y, and 30.8% had seen bottlenose dolphins exhibit begging behaviors for over 20 y (M. A. Cochran, unpub. data, 2 February 2012). Hand-feeding of bottlenose dolphins by fishermen on docked shrimp trawlers has been observed near Savannah as recently as 2009, and large groups (group size: 8 to 22) of bottlenose dolphins have also been seen begging from and swimming next to docked shrimp trawlers (Perrtree, 2011).

The behavior of dolphins begging from trawlers may be unique to the Savannah area as begging has not been reported in most studies of interactions between bottlenose dolphins and trawlers (Fertl & Leatherwood, 1997; Broadhurst, 1998; Chilvers & Corkeron, 2001; Gonzalvo et al., 2008). However, it is possible that bottlenose dolphins may have begged from shrimp trawlers in other locations, although it was not always described in such terms. Gruber (1981) noted groups of 10 to 15 bottlenose dolphins bringing their bodies halfway out of the water to be fed by shrimpers and "bobbing up and down." Researchers attempting to create a feeding station in Tangalooma, Australia, used a trawler to attract bottlenose dolphins; the researchers then fed the bottlenose dolphins and were able to rest a hand or foot in the mouth of the bottlenose dolphin (Green & Corkeron, 1991).

Interacting with humans to obtain food, either through direct provisioning or by associating with trawlers, can have negative effects on bottlenose dolphins. Gubbins (2002) hypothesized that provisioning was the most serious threat to the bottlenose dolphin population in Hilton Head Island, South Carolina, as it leads to behaviors and situations that make them vulnerable to injury or death. As bottlenose dolphins lose their wariness toward humans and are conditioned to approach boats, they become more likely to be struck by a boat or entangled in fishing gear (Donaldson et al., 2010). Several studies have noted injuries and deaths while observing bottlenose dolphins interacting with fisheries (Corkeron et al., 1990; Noke & Odell, 2002; Durden, 2005; Cunningham-Smith et al., 2006; Powell, 2009). Additionally, some fishermen blame bottlenose dolphins for damage to gear or competition for catch, resulting in the reported use of guns and seal bombs to deter the animals or retaliate for lost catch or gear (Zollett & Read, 2006). Bottlenose dolphins that feed in association with trawlers also put themselves at risk of getting caught in the trawl (Greenman, 2012) or attacked by sharks (Corkeron et al., 1990; Fertl & Leatherwood, 1997). Finally, when bottlenose dolphins engage in human-related foraging, it may also put humans at risk. Provisioned dolphins and those that engage in close human interactions can become more aggressive (Bloom, 1991; Orams et al., 1996; Cunningham-Smith et al., 2006). One bottlenose dolphin in Nokomis, Florida that begged and was provisioned on a regular basis was observed biting a human on 18 separate occasions (Cunningham-Smith et al., 2006).

Bottlenose dolphins associating with trawlers or foraging on discarded bycatch is a common occurrence among trawl fisheries worldwide (Leatherwood, 1975; Gruber, 1981; Delgado-Estrella, 1997; Fertl & Leatherwood, 1997; Broadhurst, 1998; Chilvers & Corkeron, 2001; Gonzalvo et al., 2008; Perrtree, 2011). However, many published studies that have noted trawler associations obtain their information from opportunistic observations made of bottlenose dolphins during routine photo-identification surveys (Leatherwood, 1975; Chilvers & Corkeron, 2001). Sighting data from surveys can provide a snapshot of bottlenose dolphin behavior or associations, but due to their short duration, typically 30 min or less, they may leave out valuable information that would be obtained over longer observation times. Because photo-identification surveys are dependent on dolphin presence, important data regarding the absence of bottlenose dolphins around trawlers may not be documented. The primary objective of this study was to conduct an investigation of all bottlenose dolphin–trawler interactions to determine which net positions and trawler activities resulted in associations between trawlers and bottlenose dolphins. Furthermore, the study sought to investigate speculation that trawler interactions have led to the unprecedented rate of begging exhibited by the bottlenose dolphins near Savannah by comparing the prevalence of begging behavior during different trawler activities.

Methods

Study Site

The study site covered approximately 20 km^2 and spanned a creek, river mouth, and sound that opened into the Atlantic Ocean. The trawler that was the focus of this study docked at Lazaretto Creek Marina on Tybee Island, Georgia, and it operated in the southern portion of Calibogue Sound near the mouth of the Savannah River, located between Tybee Island, Georgia and Hilton Head Island, South Carolina (Figure 1). Trawlers can be found

all along the coast; however, this is an area of relatively high fishing activity, and from 1 to 10 trawlers may be active within sight on a given day. The shrimp season opens in May or June and continues through January, although the number of active trawlers decreases after November.

Focal Follows of Trawler

Focal follows, or focusing on an individual or group for an extended period of time, are used to obtain information about the behavior of an individual or group. Focal follows were conducted in this study, with the shrimp trawler acting as the "focal animal." A single observer worked from an 18-m wooden shrimp trawler with a pair of 360 hp engines and two otter trawl nets that were 18 m in length with a 4.7-cm mesh size.

A variety of sampling methods for focal follows exist, two of which are predominant activity and one-zero sampling (Mann & Smutts,

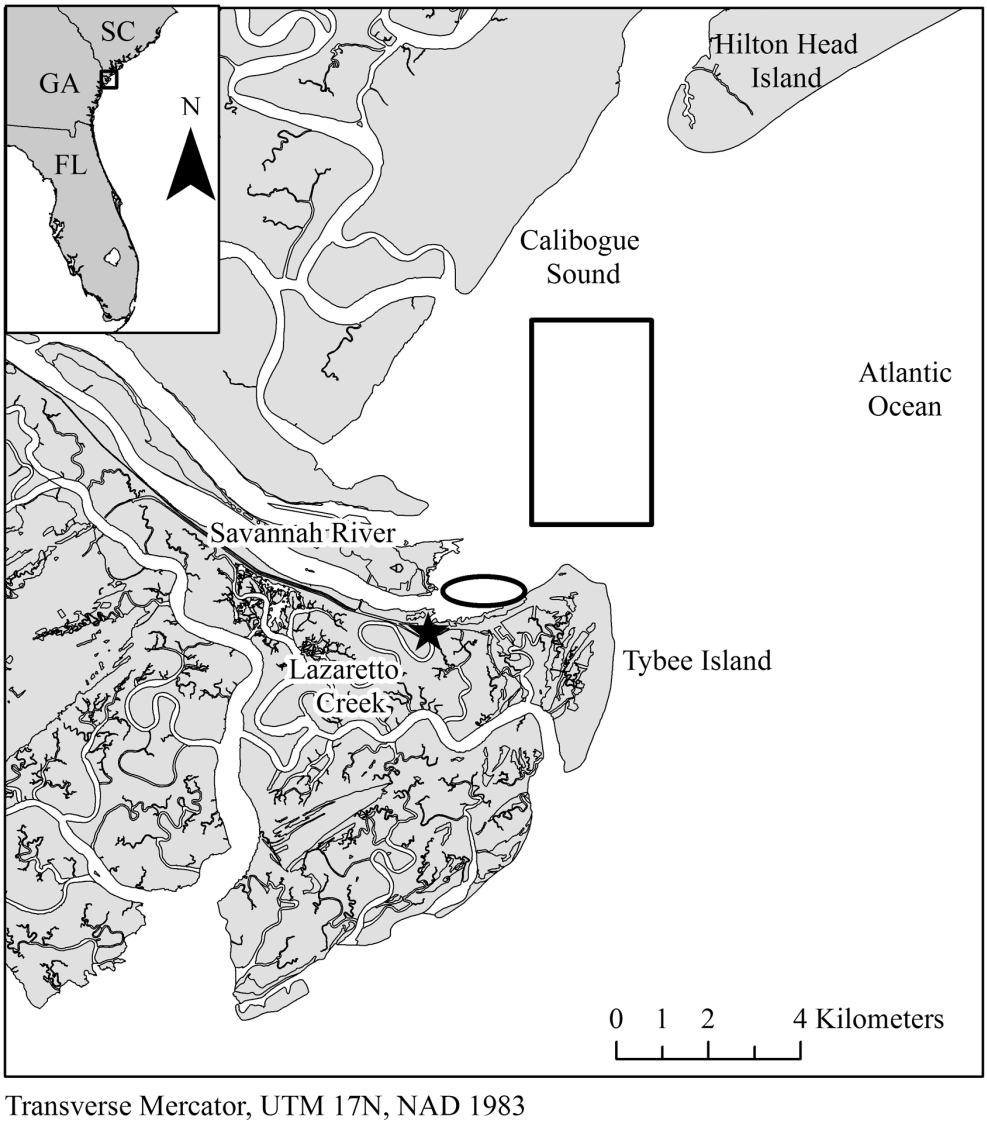

Figure 1. The study area included the northern portion of Lazaretto Creek, the mouth of the Savannah River, and Calibogue Sound, located between Tybee Island, Georgia and Hilton Head Island, South Carolina. The star represents Lazaretto Creek Marina, where the shrimp trawler was docked. The rectangle denotes the area where the vessel operated. The oval denotes the area where the trawler activity "clean nets/doors up" occurred.

1999). Predominant activity sampling (Hutt & Hutt, 1970) is a method in which the behavior that occurred for over half of the selected time interval is scored. During one-zero sampling, the researcher records whether or not a behavior occurred during the time interval, and therefore produces presence/absence data (Altmann, 1974). One-zero sampling was used to record whether or not bycatch was discarded and whether any bottlenose dolphins "associated with" the shrimp trawler (i.e., within 150 m; Table 1), "approached" the vessel (i.e., within 10 m; Table 1), or begged from the vessel. Predominant activity sampling was used to record net position (Table 2) and trawler activity (Table 3). Sampling intervals were 5 min. The predominant position of the nets was

Table 2. Descriptions of the five net positions designated for trawler focal follows

Net position	Description
Nets secure	The nets were secured to the vessel and not in the water. The outriggers of the vessel were either straight up or out to the side.
Nets in water	The nets were sitting in the water; however, they were not open and not being towed.
Trawl	The nets were open and being actively towed by the vessel, starting when the nets were set.
Haulback	The time from when the winch started, indicating that the nets were being hauled back toward the vessel, until the nets were brought on board.
Manipulating nets	Crew were cleaning out the nets, hanging the nets up, or putting the doors of the trawl on or off the outriggers.

Table 3. Descriptions of the nine trawler activities designated for trawler focal follows

Trawler activity	Description
Pre-travel	From the time the vessel left the dock until the vessel set the nets; comprised mostly of the net position "nets secure" with a short time of "manipulating nets." The majority of this time was spent traveling to the location where trawling would occur; this activity lasted approximately 45 min.
Set nets	From the time the winch started to extend the line of the trawl until the winch stopped, indicating that the trawl reached its maximum distance from the vessel; the process usually took less than 5 min prior to each trawl.
Trawl	From the end of setting nets to the start of haulback; the nets were open and actively towed by the vessel. Trawl time varied from 30 min to 2.5 h and between 1 to 7 trawls occurred daily.
Haulback	The time from when the winch started, indicating the nets were being hauled back toward the vessel, until the nets were brought on board; this lasted 5 to 10 min after each trawl.
Sort	In between trawls, when the crew sorted through the catch and trawling was not occurring; during this time, the net position was usually "nets in water." It usually lasted 5 to 10 min, although occasionally it lasted up to 30 min when heavy bycatch loads were present. This activity did not occur on every day of trawling; if "sort" did not occur, then sorting took place simultaneously with trawling.
1st clean nets	This occurred at the end of the last trawl, when the crew spent approximately 10 min removing any organisms stuck in the nets, which were tossed overboard, and hanging the nets up on the sides of the vessel.
Post-travel	Traveling from the site of trawling to the dock; included time traveling between "1st clean nets" and "clean nets/doors up" as well as between "clean nets/doors up" and "at dock," totaling approximately 45 to 50 min.
Clean nets/doors up	The crew spent approximately 10 min cleaning any remaining organisms out of the nets and tossing them overboard, hanging the nets in the center of the vessel, and putting the doors back on the outriggers. This took place in approximately the same location each day.
At dock	Once the vessel reached the dock at the end of the day—because this period could continue indefinitely, only two 5-min intervals were recorded each day.

categorized in one of five ways: (1) nets secure, (2) nets in water, (3) trawl, (4) haulback, and (5) manipulating nets (Table 2). Additionally, the activity of the trawler was recorded. Some of the activities were identical to the predominant net position, but others were more specific, shorter activities. Nine trawler activities were identified: (1) pre-travel, (2) set nets, (3) trawl, (4) haulback, (5) sort, (6) 1st clean nets, (7) post-travel, (8) clean nets/doors up, and (9) at dock (Table 3).

At the same 5-min sampling intervals, the number of bottlenose dolphins "associating with" the shrimp trawler (i.e., within 150 m), the number of bottlenose dolphins that "approached" the vessel (i.e., within 10 m), and whether any bottlenose dolphins begged were recorded. A distance of 150 m was used based on the distance to the mud plume visible at the end of the trawl nets. If a bottlenose dolphin was present within 150 m of the vessel and was not engaged in trawler-associated activities (e.g., traveling past the vessel), it was not included in the analysis. Bottlenose dolphins sighted within 10 m of the shrimp trawler were included in both the 10 and 150 m counts. The number of bottlenose dolphins present was based on the best estimate of the largest group size observed during that 5-min period. Data were collected continuously from the time that the trawler left the dock until 10 min after the trawler returned to the dock on each sampling day, here out referred to as a fishing "day."

Behavior of Trawler and Percentage of Time Bottlenose Dolphins Associated with Trawler

The percentage of time that the trawler spent in each of the five net positions was calculated. The percentage of time that one or more bottlenose dolphins was present during each of the net positions was calculated by dividing the number of 5-min intervals in which bottlenose dolphins were present by the total number of 5-min intervals for that net position for that day. The five net positions were used as opposed to the nine trawler activities because several of the trawler activities were of short duration and occurred for < 5 intervals per day, which could have led to biased results. Percentages were determined separately for bottlenose dolphins that associated with the vessel (i.e., within 150 m) and those that approached the vessel (i.e., within 10 m). The percentages for each activity were then averaged across all days. It is likely that many of the same bottlenose dolphins associated with the trawler across multiple net positions, so the data were not independent. A Wilcoxon signed rank test was used to compare the percentages between each of the net positions. A Bonferroni correction resulted in an alpha level of 0.005 for the results of the Wilcoxon signed rank test. The 2 d in which the net position "nets in water" did not occur were removed from analyses that compared this position.

Maximum Number of Bottlenose Dolphins Associated with Trawler

The maximum number of bottlenose dolphins present was determined for each of the nine trawler activities on each day. The maximums from all days were averaged for each of the nine activities. The mean maximum was calculated for both the number of bottlenose dolphins that associated with the shrimp trawler (i.e., within 150 m) and the number of bottlenose dolphins that approached the vessel (i.e., within 10 m). A Wilcoxon signed rank test was used to compare the values between each trawler activity, and a Bonferroni correction resulted in an alpha level of 0.0014. The 4 d when the activity "sort" did not occur were excluded from statistical analyses that involved this activity.

Bycatch Discards

The presence or absence of bycatch discards was recorded during each 5-min time interval. The percentage of time that at least one bottlenose dolphin was present was determined for the intervals when bycatch was and was not discarded. Percentages were calculated for bottlenose dolphins within 150 and 10 m, and each was averaged across days. A Wilcoxon signed rank test was used to determine the statistical difference between the percentages of time that bottlenose dolphins were present when there was and was not bycatch. In addition, the net position in which the majority of time spent discarding and not discarding was calculated.

Begging

If begging occurred during each of the nine trawler activities, it was recorded in a one-zero sample. The percentage of days with begging in each activity was also calculated by dividing the number of days with begging in each given state by the total number of days.

Results

Focal Follows of Trawler

Twenty follows representing 129 h of observations were recorded over 20 d from August to November 2010 and June to October 2011, with 9 d of effort in 2010 and 11 in 2011. On 7 October 2010, only one bottlenose dolphin was observed during one time point the entire day; therefore, data from this date were not used in any analyses. The focal trawler left dock between 0500 and 0600 h on all but 2 d and returned to dock between 1200 and 1500 h. The length of fishing days ranged from 3.7 to 10.7 h with an average of 6.6 h. There were between 1 to 7 trawls in a

day, and the length of a trawl varied depending on the weight of the catch. Trawls were as short as 30 min on days when cannonball jellyfish (*Stomolophus meleagris*) loads were high, and as long as 2.5 h on days with a low catch. Typical trawl duration was 1 to 1.5 h.

Behavior of Trawler and Percentage of Time that Bottlenose Dolphins Associated with Trawler

Of the five net positions sampled for this study, trawling was the position most frequently observed (57.3%). Nets secure was second with 25.9%, and manipulating nets, haulback, and nets in water each accounted for less than a tenth of the time, with 8.1%, 4.5%, and 4.2%, respectively.

Bottlenose dolphins associated with the shrimp trawler (i.e., within 150 m) for a mean of 68.2 ± 33.9% of the day. They associated most often during haulback, with associations during 90.5 ± 20.1% of the time spent in haulback, followed by trawling at 88.5 ± 17.2% (Figure 2). Haulback and trawling were not significantly different from one another ($p = 0.2106$); however, haulback and trawling were both significantly different from nets secure ($p < 0.0001$) and manipulating nets (haulback: $p = 0.0030$; trawling: $p = 0.0023$). Bottlenose dolphins associated with the trawler the least when the nets were secure (21.5 ± 17.3% of the time; nets in water: $p = 0.0004$; trawl, haulback, and manipulating nets: $p < 0.0001$).

In contrast, bottlenose dolphins approached the vessel closely (i.e., within 10 m) least during trawling (2.4 ± 5.9%; Figure 2). This was significantly less than the net positions of nets in water ($p = 0.0010$), haulback ($p < 0.0001$), and manipulating nets ($p < 0.0001$), but not nets secure. Bottlenose dolphins approached most often during the stage of manipulating nets (59.8 ± 23.0%), although it was not significantly different from either nets in water or haulback. Overall, bottlenose dolphins approached the vessel closely for a mean of 31.6 ± 33.3% of the day.

Maximum Number of Bottlenose Dolphins Associated with Trawler

The maximum number of bottlenose dolphins associating with the shrimp trawler occurred during trawling (10.3 ± 4.1 dolphins; Table 4 & Figure 3), which was significantly higher than the maximum during all other activities except haulback (Table 5). The activities of haulback and sort had the next highest maximums, with 8.4

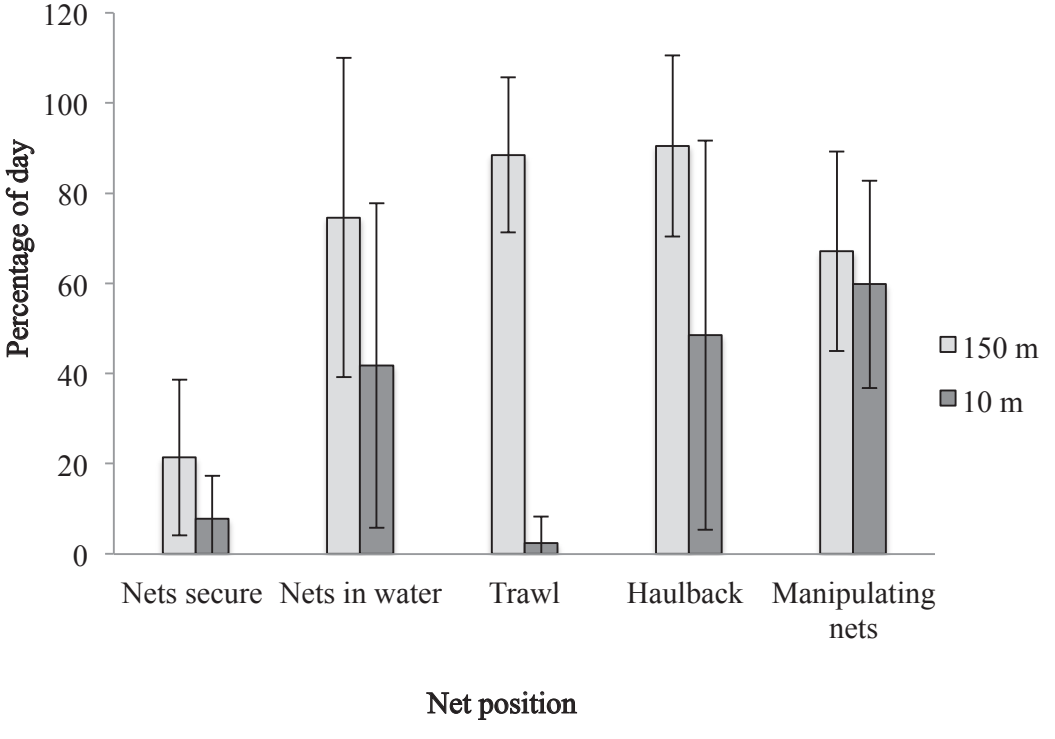

Figure 2. Mean percentage ± 1 SD of the day that one or more common bottlenose dolphins (*Tursiops truncatus*) associated with (150 m) and approached (10 m) a commercial shrimp trawler near Savannah, Georgia during each net position

Table 4. The mean number of bottlenose dolphins that associated with (150 m) and approached (10 m) a commercial shrimp trawler during each trawler activity, and the percentage of days that a bottlenose dolphin begged during each of the trawler activities near Savannah, Georgia

Trawler activity	150 m	10 m	Percentage of days with begging
Pre-travel	1.1 ± 1.6	0.1 ± 0.2	0.0
Set nets	4.8 ± 5.1	0.5 ± 1.3	0.0
Trawl	10.3 ± 4.1	0.6 ± 1.3	15.8
Haulback	8.4 ± 4.3	3.3 ± 3.0	0.0
Sort	6.4 ± 5.3	2.8 ± 2.9	0.0
1st clean nets	4.4 ± 5.1	3.1 ± 3.2	15.8
Post-travel	3.3 ± 2.7	0.9 ± 1.7	5.2
Clean nets/doors up	4.4 ± 2.7	3.1 ± 2.2	78.9
At dock	2.3 ± 2.6	1.9 ± 2.6	31.6

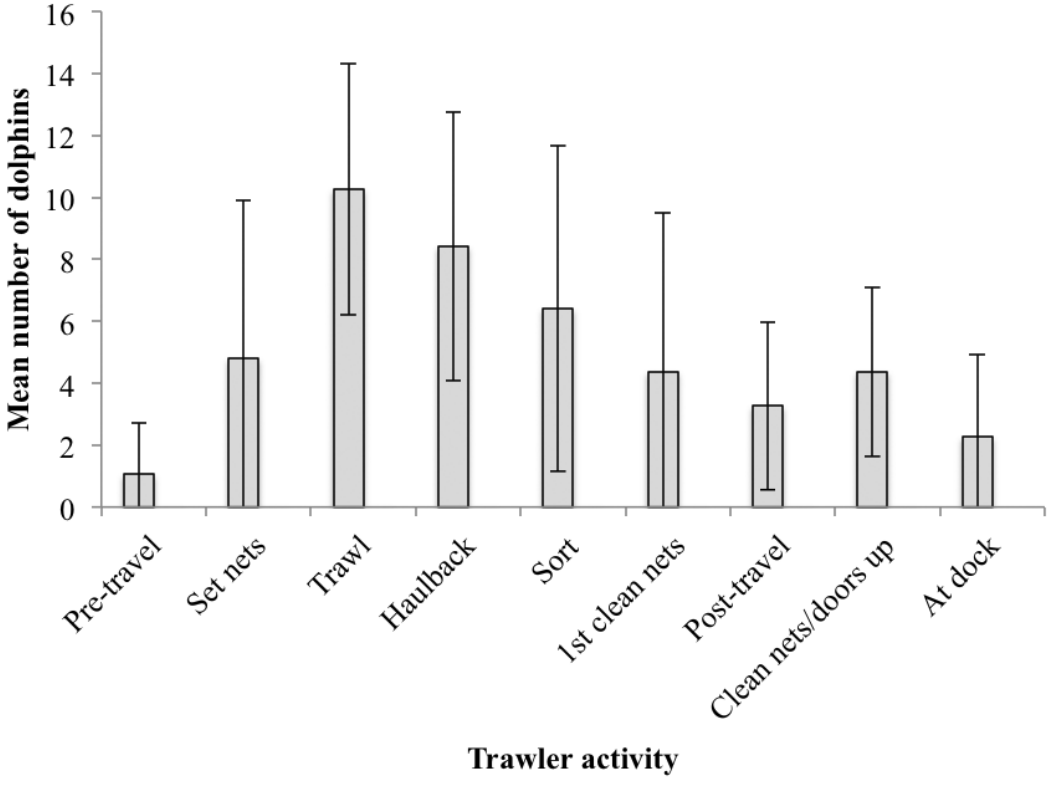

Figure 3. The mean maximum number of bottlenose dolphins ± 1 SD that associated (i.e., within 150 m) with a commercial shrimp trawler near Savannah, Georgia within 150 m during each trawler activity; *p* values are shown in Table 5.

± 4.3 and 6.4 ± 5.3 bottlenose dolphins, respectively (Table 4). These three activities occurred in sequential order, so it is likely that many of the bottlenose dolphins that associated with the vessel during trawling were also present for the haulback and sort. The least number of bottlenose dolphins associated during pre-travel, with a maximum of 1.1 ± 1.6 dolphins (Table 4), which was significantly different from trawl, haulback, sort, and clean/doors (Table 5).

The activity during which the greatest number of bottlenose dolphins approached the vessel was haulback (3.3 ± 3.0 dolphins; Table 4 & Figure 4), followed closely by the 1st clean nets (3.1 ± 3.2 dolphins) and clean nets/doors up (3.1 ± 2.2 dolphins). None of these activities were

Table 5. *P* values from the Wilcoxon signed-rank test comparing the maximum number of bottlenose dolphins that associated with (150 m) a commercial shrimp trawler near Savannah, Georgia during each of the trawler activities; significant results are bolded. A Bonferroni correction resulted in an alpha level of 0.0014.

	Pre-travel	Set nets	Trawl	Haulback	Sort	1st clean	Post-travel	Clean net/ doors up	At dock
Pre-travel	--	0.0016	**< 0.0001**	**< 0.0001**	**0.0006**	0.0032	0.0042	**0.0002**	0.0892
Set nets	--	--	**< 0.0001**	**< 0.0001**	0.0996	0.6651	0.3000	0.7755	0.0538
Trawl	--	--	--	0.0039	**0.0005**	**< 0.0001**	**< 0.0001**	**< 0.0001**	**< 0.0001**
Haulback	--	--	--	--	0.0034	**0.0001**	**< 0.0001**	0.0019	**< 0.0001**
Sort	--	--	--	--	--	0.0332	0.0193	0.3536	0.0061
1st clean	--	--	--	--	--	--	0.3214	0.5557	0.1176
Post-travel	--	--	--	--	--	--	--	0.1341	0.1192
Clean/ doors	--	--	--	--	--	--	--	--	**0.0002**
At dock	--	--	--	--	--	--	--	--	--

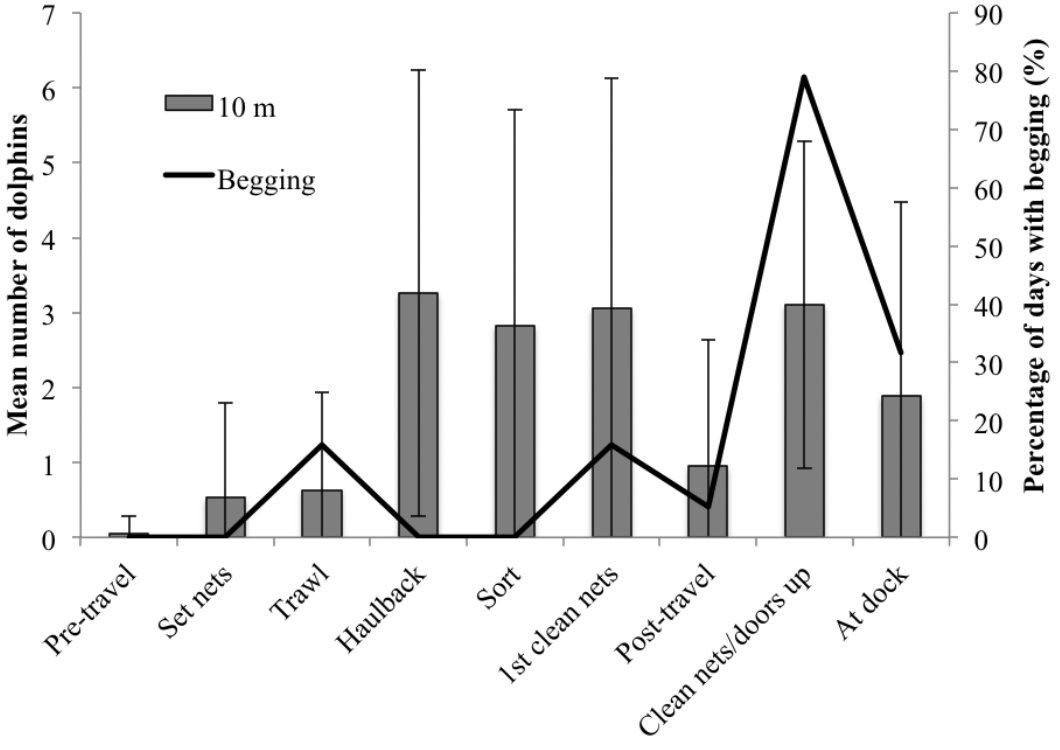

Figure 4. The mean maximum number of bottlenose dolphins ± 1 SD that approached (i.e., within 10 m) a commercial shrimp trawler near Savannah, Georgia and the percentage of days that a bottlenose dolphin begged from the trawler during each trawler activity; *p* values are shown in Table 6.

Table 6. *P* values from the Wilcoxon signed rank test comparing the maximum number of bottlenose dolphins that approached (10 m) a commercial shrimp trawler near Savannah, Georgia during each of the trawler activities; significant results are bolded. A Bonferroni correction resulted in an alpha level of 0.0014.

	Pre-travel	Set nets	Trawl	Haulback	Sort	1st clean	Post-travel	Clean net/ doors up	At dock
Pre-travel	--	0.2500	0.1250	**< 0.0001**	**0.0005**	**0.0005**	0.0391	**< 0.0001**	0.0020
Set nets	--	--	0.7500	**< 0.0001**	**0.0005**	0.0024	0.5313	0.0070	0.0745
Trawl	--	--	--	0.0031	0.0015	0.0020	0.6924	**0.0014**	0.0962
Haulback	--	--	--	--	0.2832	0.5842	0.0088	0.9379	0.1404
Sort	--	--	--	--	--	0.8479	0.0735	0.5685	0.4349
1st clean	--	--	--	--	--	--	0.0141	0.9355	0.1862
Post-travel	--	--	--	--	--	--	--	**< 0.0001**	0.0752
Clean/ doors	--	--	--	--	--	--	--	--	0.0342
At dock	--	--	--	--	--	--	--	--	--

significantly different from one another (Table 6). Pre-travel, set nets, trawl, and post-travel each had less than a mean maximum of one bottlenose dolphin approach the vessel within 10 m (Table 4).

Bycatch Discards

Bycatch was discarded during 12.6% of the 5-min time periods. Bycatch was discarded during all five net positions, but the majority of discards (43.8%) occurred during nets secure. In comparison, the majority of time in which bycatch was not discarded (59.0%) occurred during trawling. Bottlenose dolphins associated with the shrimp trawler for significantly less time (53.8 ± 31.8%, $p = 0.0141$) when the vessel was discarding bycatch than when there were no discards (70.8 ± 14.4%). They closely approached the vessel more often when the vessel was discarding bycatch (17.2 ± 14.8%) as opposed to when it was not discarding (12.2 ± 7.3%), although differences were not significant. The quantity and composition of bycatch was not quantified as part of this study; however, the majority of the discarded organisms were dead and had been sitting on deck for at least 30 min. A wide variety of fish species, including spot (*Leiostomus xanthurus*), star drum (*Stellifer lanceolatus*), and weakfish (*Cynosicon regali*) were present; however, on some days, at least half of the catch was comprised of cannonball jellyfish or sea wasps (*Tamoya haplonema*).

Begging

Begging was observed on 89.5% of days. Begging occurred most frequently during the activity of clean nets/doors up, with one or more begging events taking place on 78.9% of days (Figure 4). On approximately half of the observed days during clean nets/doors up, the crew tossed individual fish in the direction of the bottlenose dolphins or tapped the side of the vessel to get their attention, to which many of the dolphins responded by begging. Begging was observed at dock on 31.6% of days (Figure 4). Bottlenose dolphins also exhibited begging during the 1st clean nets on 15.8% of days, while trawling on 15.8% of days, and while post-traveling on 5.2% of days. Bycatch was discarded prior to two of the three begging events that occurred during trawling. Begging was never observed during the activities of pre-travel, set nets, haulback, and sort.

Discussion

This study was the first to collect quantitative data about bottlenose dolphin–trawler interactions by conducting a focal follow of a trawler, and our results provide support to statements made by previous studies that relied on survey sighting information (Leatherwood, 1975; Fertl, 1994; Chilvers & Corkeron, 2001). The results of this study also provided insight into vessel activities that may have led to begging behavior in bottlenose dolphins. Bottlenose dolphins near Savannah, Georgia primarily associated with (i.e., within 150 m) the trawler during trawling and haulback; however, they approached the vessel closely (i.e., within 10 m) most often when the nets were being manipulated by fishermen. Bottlenose dolphins exhibited begging behavior most often while fishermen were cleaning the nets and bringing the trawler doors up.

Overall, whether bottlenose dolphins associated with or approached a trawler appeared to be based on a combination of factors, including net position, discards, and human behavior. Additional factors, such as vessel speed and location, also may have influenced dolphin behavior. While foraging in association with active trawlers was likely not the direct cause of begging near Savannah, this foraging technique brings bottlenose dolphins in close proximity to trawlers and fishermen, which may have led to further interactions. Interactions including provisioning by fishermen coupled with the discard of bycatch may have conditioned begging behavior.

The greatest numbers of bottlenose dolphins associated with the trawler during trawling and haulback, and they associated with the shrimp trawler for the majority of the time spent in both of these net positions. This fits with the assumption that bottlenose dolphins associate with trawlers to feed on organisms that are stirred up by the trawl or get stuck in or pass through the nets (Fertl & Leatherwood, 1997). In addition, the bottlenose dolphins approached the vessel least often during trawling. This is further evidence that when the vessel is trawling, the bottlenose dolphins utilize the food resources available in and around the nets rather than approach the vessel itself. It is also possible that the risk of being between the vessel and the nets was too great for the reward of discarded bycatch, although bottlenose dolphins were seen swimming next to the vessel within 2 m on several occasions.

The percentage of time and the mean number of bottlenose dolphins that approached the vessel both indicated that they were likely to approach the trawler during haulback and net manipulation. Individual organisms were often picked out of the nets by the fishermen and tossed into the water during net manipulation, providing a small but easily obtained food source. This was also the time that the vessel had the slowest speed, making it easier for bottlenose dolphins to maintain a close proximity. There was a mean of around three dolphins that approached the vessel during the trawler activities of 1st clean nets and clean nets/doors up, both of which were included in the net position of net manipulation. The bottlenose dolphins that followed the nets toward the vessel during haulback often approached the vessel within 10 m as a result of maintaining proximity to the nets. However, by following the nets to the vessel, they were brought within the vicinity of the vessel and the humans on that vessel, providing an opportunity for more direct human interactions.

Bottlenose dolphins associated with the shrimp trawler (i.e., within 150 m) more often when bycatch was not discarded. However, the highest percentage of dolphin associations occurred during trawling, when bycatch was not typically discarded. Bottlenose dolphins in the Gulf of Mexico remained near the nets when bycatch was discarded while the nets were being towed (Gruber, 1981; Fertl, 1994). Therefore, the factor determining the presence of bottlenose dolphins may have been the net position rather than whether or not bycatch was discarded. Bottlenose dolphins approached the vessel (i.e., within 10 m) more often when bycatch was discarded, although this was not significant. It is possible that the bottlenose dolphins near Savannah respond to the discard of bycatch; however, it appears that whether a bottlenose dolphin associates with or approaches a trawler may be based on a combination of other factors, including net position and potentially vessel speed. In a study near the Balearic Archipelago in the Mediterranean Sea, bottlenose dolphins associated with trawlers during trawling, haulback, and discards on a regular basis (Gonzalvo et al., 2008). However, only some of these dolphins approached the vessel closely during haulback or discards. Gonzalvo et al. (2008) suggested that bottlenose dolphins within the same group might utilize the food resources available from the shrimp trawler in different ways. This may also be true near Savannah: some bottlenose dolphins may forage primarily behind the nets during trawling, whereas others forage preferentially on discards.

Bottlenose dolphins exhibited begging behavior on 89.5% of fishing days for this study. In addition, begging occurred significantly more during clean nets/doors up (78.9% of days) than during any other vessel activity, despite the fact that similar numbers of bottlenose dolphins approached the vessel during 1st clean nets and haulback as they did during clean nets/doors up. All three activities occurred at a speed of < 3 km/h, so vessel speed was not likely a factor. Bottlenose dolphins may have reacted to cues by fishermen as the crew sometimes tapped on the side of the vessel, stood at the side of the vessel and talked to the dolphins, or tossed fish over the side of the vessel. Bottlenose dolphins frequently responded to these human behaviors by begging. The crew most often initiated interactions during the clean nets/doors up vessel activity.

Clean nets/doors up always took place in the same location along the northern edge of Tybee Island, which is the southernmost portion of the sound. The captain of the focal vessel stated that prior to the enforcement of laws prohibiting the feeding of bottlenose dolphins, the vessel would stop in this area and entertain the people on the nearby dolphin tour boats by feeding and interacting with the bottlenose dolphins (J. B. Riffle, pers. comm., 6 February 2012). It is likely that the bottlenose dolphins learned to associate this location

and a slow moving trawler with fish handouts, and bottlenose dolphins that foraged by begging may have sought out the trawler during this activity as they have been known to learn set routines associated with humans and vessels (Leatherwood, 1975; Hill & Wassenberg, 1990; Lockyer, 1990).

A chain of human-related foraging behaviors may have led to some of the begging observed presently. Bottlenose dolphins likely began associating with shrimp trawlers, feeding on fish stirred up or passing through the nets. Some of these dolphins may have become conditioned to approach the vessel during the discard of bycatch. These dolphins possibly spent more time close to the vessel and the humans aboard, providing increased opportunities for direct interactions with fishermen, including provisioning. Bottlenose dolphins that were rewarded for begging at shrimp trawlers may have then transferred the behavior to other targets, like recreational boats. While this is only a hypothetical situation, it is supported by a similar chain of events involving bottlenose dolphins (Orams, 1995; Noke & Odell, 2002; Durden, 2005) as well as boto (de Sá Alves et al., 2009). Although trawler associations may be responsible for some of the begging observed near Savannah, Kovacs (2012) found that almost half of beggars near Savannah (45.5%) were never sighted with a shrimp trawler. Social learning can facilitate the acquisition of human-related foraging behaviors (Donaldson et al., 2012); however, analyses indicated that social learning from trawler dolphins could not be the sole vehicle of the begging behavior exhibited by bottlenose dolphins near Savannah (Kovacs, 2012). Therefore, a second source of human-related food and positive reinforcement was likely present near Savannah to lead to the high rate of begging. Interviews of residents and visitors in the Savannah area reported witnessing illegal feeding of bottlenose dolphins (Wu, 2013); thus, recreational boaters likely have contributed to the high rate of begging. In addition, in the late 1980s and early 1990s, commercial boat operators fed wild bottlenose dolphins in the Hilton Head, South Carolina area, which is adjacent to the Savannah study area (Bryant, 1994). It is possible some of the Hilton Head Island area animals also inhabit the waters around Savannah (Waring et al., 2009), further contributing to the begging behavior witnessed in the Savannah area.

Associating with trawlers could have a negative effect on the health of bottlenose dolphins near Savannah. Bottlenose dolphins that associate with humans for food are more likely to be struck by a boat or entangled by fishing gear (Donaldson et al., 2010). During this study, a calf with scars on its dorsal fin indicative of fishing gear entanglement was seen with its mother associating with a shrimp trawler. Previously, Perrtree (2011) described a calf that stranded near Savannah in 2009 2 mo after the end of the shrimp season; it showed signs of emaciation as well as healed shark bites and a healed fluke injury. Both this calf and its mother had been observed feeding from docked shrimp trawlers. If the mother did not teach natural foraging behavior to its calf, it is possible that the calf was not able to forage for itself once the trawlers stopped providing food.

Bottlenose dolphins near Savannah did not approach the vessel when bycatch was discarded while trawling and traveling. It would be ideal for vessels to discard their bycatch during these activities so that the bottlenose dolphins cannot associate a specific location or human contact with their food should they feed on the discards. Discarded bycatch may have been an important link between trawler-associated foraging and begging, and it may also be an obstacle in extinguishing begging behavior. Discards may condition animals to approach the boats and humans more closely (Orams, 1995; Noke & Odell, 2002; Durden, 2005; de Sá Alves et al., 2009). Even if fishermen no longer deliberately feed dolphins, discards can still act as a positive reinforcement for begging. Therefore, a complete extinction of the begging behavior near Savannah cannot be expected as long as bycatch is discarded in the vicinity of begging dolphins. Unfortunately, discarding during travel and trawling may not be ideal for shrimpers who may prefer to finish sorting catch at the dock where the vessel is protected from waves and no fuel is used. Fishermen appear to have decreased their direct interactions with the bottlenose dolphins, including hand feeding, following a series of publicized enforcements of illegal feeding in 2009. This suggests that the most important factor in decreasing begging behavior is changing human behavior through education or law enforcement.

Bottlenose dolphins that associate with a trawler are within close proximity to the vessel, creating an increased opportunity for interactions with fishermen. Altering the behavior of fishermen through education and enforcement of federal law appears to be an important method for decreasing begging near Savannah. However, even if illegal feeding no longer occurs, these bottlenose dolphins may still be positively rewarded with the discard of bycatch. Associations with trawlers provide many anthropogenic foraging opportunities, including fish stirred up by or taken from the nets, discarded bycatch, and direct handouts from fishermen. Trawler interactions, more specifically routine bycatch discards and provisioning by fishermen, have likely contributed to the high rate of begging behavior near Savannah.

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