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Behaviour of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft

Bernd Würsig[1], Spencer K. Lynn[1], Thomas A. Jefferson[1,2] and Keith D. Mullin[3]

[1]*Texas A&M University, Marine Mammal Research Program, 4700 Avenue U, Building 303, Galveston, TX 77551, USA*
[2]*Current address: Ocean Park Conservation Foundation, Ocean Park Corporation, Aberdeen, Hong Kong*
[3]*National Marine Fisheries Service, Southeast Fisheries Science Center, P.O. Drawer 1207, Pascagoula, MS 39568, USA*

Abstract

Data on behavior may help address relative differences in sightability and identifiability among species. As part of the 1992–1994 GulfCet program of shipboard and aerial cetacean surveys in the north-central and western Gulf of Mexico, we assessed cetacean responses to survey ships and aircraft. *Kogia* spp. and ziphiids showed the most avoidance reactions towards the ships (73%, 11 of 15 sightings), with large delphinids (e.g., blackfish) at 15% (7/48), small delphinids (e.g., *Stenella* spp.) at 6% (15/247), and *Stenella frontalis* and *Tursiops truncatus* at 0% each (26 and 88 sightings, respectively). *S. coeruleoalba* moved to avoid the ships in 33% (9/27) of sightings. Species which responded to the ships (either approaching or avoiding) also changed behavior in response to the survey airplane. *Kogia* spp. changed their behavior in response to the airplane during 40% (12/30) of sightings, and ziphiids during 89% (8/9). Several of the smaller delphinids also showed sensitivity to disturbance by the airplane. 'Diving' and 'other' were the most common responses to the airplane. For all cetacean species, the behavioral states 'milling' and 'resting' appeared to be sensitive to disturbance; over 39% of initial observations of these behaviors were followed by a new behavior. Cryptic species, such as *Kogia* spp. and ziphiids, which were seen resting on most occasions, responded to the airplane a high proportion of the time. Less cryptic species, such as the small delphinids, may have responded as often, but their response did not necessarily make them harder to identify. These data indicate that the sightability and identification of cetaceans may change with variable behavior of species, and should be taken into account when extrapolating from sightings to population status as determined from density estimates. Density estimates for long-diving cetaceans, such as *Physeter macrocephalus*, and species which often react negatively to the survey vessel, such as *S. coeruleoalba*, may tend to be biased downwards, while the reverse may be true for species which tend to approach the ship, unless data can be collected to estimate the value of the detection function.

Contact Author: Dr. Bernd Würsig, Texas A&M University, Marine Mammal Research Program, 4700 Avenue U, Bldg. 303, Galveston, TX 77551. Tel: (409) 740-4413. Fax: (409) 740-4717. email: WursigB@tamug.tamu.edu

Introduction

There is great variability in morphology, school size, and behavior of the approximately 20 species of cetaceans that commonly occur in the Gulf of Mexico (Jefferson *et al.*, 1992; Mullin *et al.*, 1994; Hansen *et al.*, 1995). The variability ranges from small delphinids of about 2 m to sperm whales (*Physeter macrocephalus*) of over 15 m, from single individuals to schools of hundreds, and from animals that habitually approach boats and even bowride to those that ignore or avoid vessels (Leatherwood & Reeves, 1983, provide an excellent summary). It is intuitively obvious that differences in these variables can result in different abilities to detect, identify, and accurately count animals; but descriptive characteristics of such detection variables, especially those stemming from behavior, have been given only rarely (see Barlow, 1995).

During surveys, there are often differences in the distances at which cetaceans are first sighted, identified, and most accurately counted. Differences are determined not only by morphology, school size, and behavior, but also by the variability of weather conditions and inter- and intra-observer reliability (Holt & Cologne, 1987). Sightings have been analyzed only when they occurred during good sighting conditions, such as Beaufort 2 or less (e.g., Barlow, 1988), or Beaufort 5 or less (Gerrodette, 1993; Wade & Gerrodette, 1993; Barlow, 1995; Jefferson, 1996). Observer reliability has also been addressed

Table 1. Species categories, based on similar sighting characteristics, used in analysis of reactions

Category 1	pygmy and dwarf sperm whales (*Kogia* spp.) beaked whales (ziphiids)
Category 2	(small delphinids, mainly of the oceanic waters): pantropical spotted dolphin (*Stenella attenuata*) clymene dolphin (*S. clymene*) striped dolphin (*S. coeruleoalba*) spinner dolphin (*S. longirostris*) melon-headed whale (*Peponocephala electra*) rough-toothed dolphin (*Steno bredanensis*) Fraser's dolphin (*Lagenodelphis hosei*)
Category 3	bottlenose dolphin (*Tursiops truncatus*)
Category 4	Atlantic spotted dolphin (*Stenella frontalis*)
Category 5	(larger delphinids): short-finned pilot whale (*Globicephala macrorhynchus*) Risso's dolphin (*Grampus griseus*) false killer whale (*Pseudorca crassidens*) killer whale (*Orcinus orca*) pygmy killer whale (*Feresa attenuata*)
Category 6	sperm whale (*Physeter macrocephalus*)

(e.g., Holt & Cologne, 1987); in the present case, reliability was addressed by observer training, after-sighting discussions and inter-observer calibration, and an independent observer scan sample periodically conducted behind the two primary observers (Davis *et al.*, 1996; Jefferson, 1996).

In this paper we address differences in sightability and identifiability of species or species categories according to their morphology and behavior, and discuss how these relate to assumptions of line transect-based abundance estimates. We pooled species into six categories, based on similar sighting characteristics (e.g., body size, typical school size, and general activity at surface) (Table 1). We also examined individual species or species groupings within categories as they related to differences in morphology, behavior, and hence potential sightability.

Materials and methods

Study area

The study area was between the 100- and 2000-m isobaths, extending as far east as the Florida-Alabama border, and as far southwest as the Texas-Mexico border. West of 90°00.0′W, the aerial survey study area included only waters from 100-1000 m deep; the entire continental slope was aerially surveyed east of 90°00.0′W.

Shipboard observations

We searched for cetaceans from the flying bridges of the vessels NOAA Ship *Oregon II*, 53 m long, 10.1 m above sea level; R/V *Longhorn*, 32 m, 7.7 m above sea level; and R/V *Pelican*, 32 m, 8.9 m above sea level. Two primary observers scanned 90° sections to the right and left of the bow through *Fujinon* 25 × 150 binoculars, while a third observer scanned the entire search path with naked eye and 7-power or 10-power binoculars, and recorded data. Details of observation and survey protocol are given by Hansen *et al.* (1995), Davis *et al.* (1996), and Jefferson (1996).

Behavioral reactions could not be determined for many sightings. But for those with adequate behavioral notes, responses were categorized as: avoidance, no response, approach to vessel, and bowriding. The school behavior was defined as that response displayed by the majority of the animals in the school. Our analyses only included clear reactions, for which we could unequivocally assign a behavioral response.

An 'avoidance' assignation was given when an individual or school moved away from the vessel or appeared to dive in response to the vessel, in either case making it more difficult to identify the animals. A 'no response' assignation meant that the animal(s) showed no apparent response relative to the approach or pass-by of the vessel. This is to be distinguished from the many cases during which we could not tell whether or not there was a response; no such cases are presented. An 'approach' indicated that the animal(s) moved toward the vessel during at least part of the observation period. It is likely that the approach enhanced identifiability if the animals were seen at distance. However, an approach response was given even if the animals were not identified because of the positive response; only their actions were of importance. Finally, 'bowride' is a special case of an approach response.

Distance to the animals at initial sighting was calculated from reticles etched into the right eyepiece of the 25 × binoculars (Barlow & Lee, 1994), or estimated 'by eye' for sightings too close to record a reticle reading (<0.5 km). Differences in initial sighting distance were analyzed with a Kruskal-Wallis test, followed by Fisher's LSD.

Aerial observations

The survey platform was a NOAA-operated DeHavilland Twin Otter (twin-engine turbo-prop) aircraft. The aircraft was modified with a large bubble window on each side, providing observers with track-line visibility. A similarly modified Partenavia aircraft was used in one survey. Surveys were conducted from an altitude of 229 m (750 ft) and at a speed of 204 km/hr (110 kn). Two observers searched through bubble windows on either side of the aircraft. A third observer recorded all sighting and environmental data on a computer. At least two of the three observers on each flight were trained and experienced in aerial survey techniques for marine mammals. Observers searched waters primarily on and near the track-line and scanned periodically out to the horizon. Melon-headed whales and pygmy killer whales were grouped together for aerial surveys. Further details are given in Davis *et al.* (1996).

Behavior was recorded in a more detailed manner from the aircraft than from the ships. When a school was sighted, the observer started making an assessment of the behavioral state of the school immediately and continued while the aircraft approached the school. Behaviors were recorded as: resting, feeding, complex social, milling, spyhopping, traveling (north, south, east or west), traveling fast, diving, breaching, and other. Behaviors were categorized approximately by the definitions of Shane (1990), with the understanding that 'feeding' is especially problematic unless animals are actually seen with prey in their mouths.

School behavior was defined as the most frequently displayed behavior of the majority of the animals in the school. Schools were usually circled for the minimum time necessary to make species identification and to estimate the number of animals in the school (ca. 10 min, maximum = 50 min).

The data recorder logged each sighting angle and monitored altitude of the aircraft after communicating with the pilots. It was noted when the aircraft approached within 305 m (1000 ft), straight-line distance, of the school. Since survey altitude was 229 m (750 ft), the aircraft was within 305 m if the perpendicular sighting distance (PSD) was less than or equal to 202 m (661 ft) (sighting angle of 41 degrees or less). In some cases, the pilots were asked to increase altitude while approaching and before circling in an attempt to increase the observation period of species that were known to be cryptic (e.g., *Kogia* spp. and beaked whales). In some cases, for photographic purposes or identification, pilots were asked to make several fly-bys at less than 229 m.

If the behavior of the majority of the animals in the school changed during the remainder of the observation period, a change in behavior was recorded. Often, while circling a school, dives occurred at the same time that the aircraft passed overhead or closest to the school. This was considered a change in behavior, as was a change in direction of travel. The new behavior was assessed in the same manner as the initial behavior.

Data on the reaction of cetaceans to survey aircraft constitute a second behavioral database, independent of shipboard observations. Frequencies of change in behavior provided an initial evaluation of sensitivities of species and behaviors to disturbance. For further procedural details, see Davis *et al.* (1996).

Results

Shipboard observations

Initial sighting distances were estimated for 655 sightings in which cetaceans were identified to species or species category (Fig. 1). Overall, initial sighting distance was $\bar{X}$=2.3 km (SD=1.77, n=655), with mean sightings as close as 1.6 km (SD=1.50, n=384) for bottlenose dolphins, 1.6 km (SD=1.33, n=46) for beaked whales, and as far as 4.2 km (SD=1.46, n=6) for killer whales. Differences among species were significant (P<0.0001, Kruskal-Wallis, H=76.24, df=17).

Killer whales were sighted at significantly greater distances than all other animals, except for melon-headed whales (Fisher's LSD, P<0.0001 for all comparisons). *Kogia* spp. and beaked whales, Category 1, were not sighted at distances significantly different from Atlantic spotted dolphins and bottlenose dolphins (Categories 3 and 4, respectively) (Table 2). Members of these three categories were initially sighted closer to the ship than the small delphinids, large delphinids, or sperm whales (Categories 2, 5, and 6, respectively). There was not a significant difference between small- and large-delphinid initial sighting distances, though there was between small delphinids and sperm whales. Large delphinids and sperm whales were not seen at different initial sighting distances.

Category 1: Pygmy and Dwarf Sperm Whales, and Beaked Whales

Schools in this category were first sighted at $\bar{X}$=1.7 km (SD=1.28, n=86) (Fig. 1). Eleven of 15 sightings (73%) involved animals avoiding the

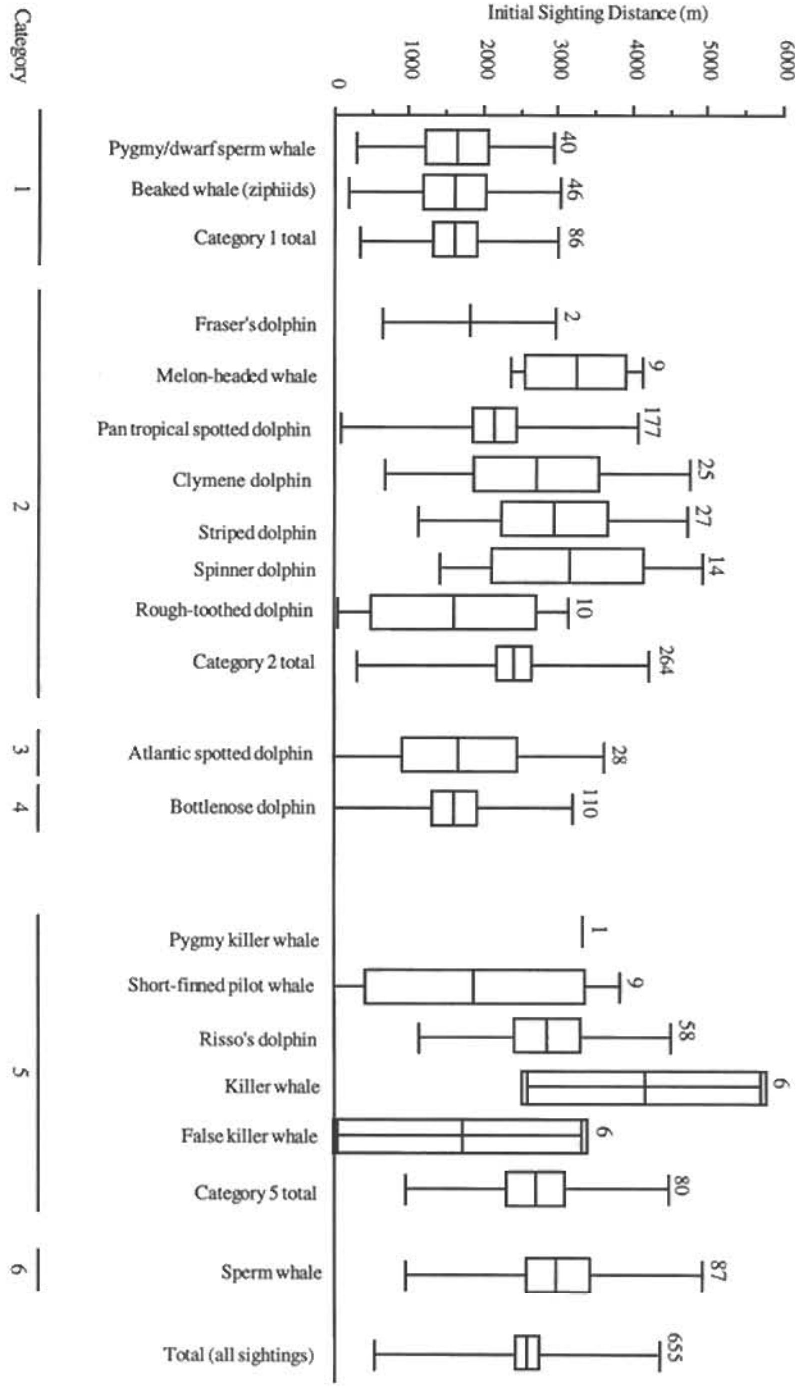

Figure 1. Initial shipboard sighting distances by species and category. Mean=central bar, standard deviation=outer bars, 95% confidence interval=box, and number=sample size.

Table 2. Paired comparisons (Fisher's LSD) of initial sighting distances for six categories of cetaceans

Comparison	Mean difference	Critical difference	*P*-value
Category 1 vs. Category 2	−724.427	414.556	0.0006
Category 1 vs. Categories 3 & 4	58.121	458.708	0.8036
Category 1 vs. Category 5	−1096.615	518.633	<0.0001
Category 1 vs. Category 6	−1312.496	507.709	<0.0001
Category 2 vs. Categories 3 & 4	782.549	350.729	<0.0001
Category 2 vs. Category 5	−372.187	426.121	0.0868
Category 2 vs. Category 6	−588.068	412.755	0.0053
Category 5 vs. Categories 3 & 4	1154.736	469.185	<0.0001
Category 6 vs. Categories 3 & 4	1370.617	457.081	<0.0001
Category 6 vs. Category 5	215.881	517.195	0.4127

Table 3. Frequencies of behavioral reactions of cetaceans relative to the survey ship. Reactions: (−) indicates avoidance of the vessel by orienting away or abrupt diving, (0) indicates no response, (+) indicates approach, (b) indicates bowriding, %(b) indicates percentage of bowriding per total number of reactions

		Reaction					
	Species	(−)	(0)	(+)	(b)	%(b)	Total
Category 1	Pygmy/dwarf sperm whales	6	1	0	0	0	7
	Beaked whales (ziphiids)	5	3	0	0	0	8
	Subtotal	11	4	0	0		15
Category 2 (smaller delphinids)	Fraser's dolphin	1	0	0	1	50	2
	Melon-headed whale	1	1	2	3	43	7
	Pantropical spotted dolphin	1	9	18	137	83	165
	Striped dolphin	9	2	2	14	52	27
	Spinner dolphin	0	0	0	14	100	14
	Clymene dolphin	1	0	1	22	92	24
	Rough-toothed dolphin	0	0	2	6	75	8
	Subtotal	13	12	25	197		247
Category 3	Atlantic spotted dolphin	0	2	2	22	85	26
Category 4	Bottlenose dolphin	0	14	6	68	77	88
	Subtotal	0	16	8	90		114
Category 5 (larger delphinids)	Pygmy killer whale	1	0	0	0		1
	Short-finned pilot whale	1	4	0	1	17	6
	Risso's dolphin	5	13	7	5	17	30
	Killer whale	0	2	0	4	67	6
	False killer whale	0	1	1	3	60	5
	Subtotal	7	20	8	13		48
Category 5	Sperm whale	4	11	0	0		15

vessel by orienting away; in no instance did members of this category appear to approach the vessel, and none bowrode (Table 3). Overall, *Kogia* spp. and beaked whales showed the greatest percentage of avoidance reactions (73%). The designation of 'cryptic' is certainly appropriate, and it is unknown how many *Kogia* spp. and beaked whales were unseen or unidentified because of their behavior.

Category 2: Small Delphinids

Initial sighting distance for members of this category was $\bar{X}=2.4$ km (SD=1.83, n=264) (Fig. 1). All species of the genus *Stenella*, except for striped dolphins, habitually approached the vessel and rode the bow (Table 3). Approach reactions and bowriding, combined, accounted for 90% of Category 2 sightings. The overall reaction for striped dolphins was dramatically different, however, with only 14 of

27 sighted schools (52%) riding the bow, and nine of the 13 avoidance reactions for the entire small delphinid category exhibited by this species (Table 3).

Categories 3 and 4: Bottlenose Dolphin and Atlantic Spotted Dolphin

These two species of dolphins, occurring primarily over the broad continental shelf of the study area, have similar sighting characteristics and at times school together (Jefferson, 1996). They were first seen at a distance of $\bar{X}$=1.6 km (SD=1.58, n=138) (Fig. 1); and, overall, members of 79% of sighted schools came to the ship and rode the bow pressure wave for at least one minute, and—at times—for over 30 min (Table 3). Fourteen of 88 behavioral descriptions for bottlenose dolphins and two of 22 for Atlantic spotted dolphins were classified as no reaction, and none were categorized as avoidance. Overall, approach reactions and bowriding, combined, occurred in 86% of these sightings.

Category 5: Large Delphinids and Small Whales

The mean distance at first sighting was 2.7 km (SD=1.65, n=80, Fig. 1), with killer whales sighted at greater distances, $\bar{X}$=4.1 km (SD=1.46 km, n=6), than any other species. Pilot whales and Risso's dolphins exhibited the least attraction to the vessel, with only one of six and 12 of 30, respectively, moving towards the vessel or bowriding (Table 3).

Category 6: Sperm Whales

Sperm whales were sighted at a mean distance of 3.0 km (SD=1.86, n=87, Fig. 1). Generally, sperm whale reaction was not described in the sighting notes, but our overall impression was that reactions tended to be non-existent for all but approaches to within several hundred meters. Eleven of 15 sightings with behavioral notes were labeled as no reaction; none as approach; and four as avoidance, the whales diving abruptly, all within 200 m of the ship.

Aerial observations

Aerial surveys encountered many of the same species as the ship-based surveys. Additionally, aerial observers saw one sei whale (*Balaenoptera borealis*) or Bryde's whale (*B. edeni*). Species which were found to respond to the ship (either positively or negatively) were also found to change behavior in response to the survey aircraft's activities. *Kogia* spp. changed their behavior in response to the survey airplane during 40% of their sightings (n=30 sightings) and beaked whales during 89% (n=9 sightings) (Table 4). Several of the smaller delphinids also showed sensitivity to disturbance by the airplane. Pantropical spotted, clymene, striped, and spinner dolphins all were judged to have changed their behavior in response to the airplane during over 40% of their respective sightings.

Species' reactions to the airplane differed (Table 5). Greater than 85% of the responses of *Kogia* spp. and beaked whales was to dive. Many of the small delphinids dove approximately 50% of the time, or exhibited an undefined 'other' behavior. While 'diving' and 'other' were the most common responses by cetaceans to disturbance from the airplane, 33% of bottlenose dolphin responses was to begin traveling or to change direction of travel.

As a generalization (over all cetacean species), the behavioral states 'milling' and 'resting' appeared to be sensitive to disturbance; over 39% of initial observations of these behavioral states were followed by observations of a new behavior (Table 4). Cetaceans changed from these behaviors to new behaviors from 40–100% of the time, except for melon-headed/pygmy killer whales, rough-toothed dolphins, and Risso's dolphins, which never responded while in these behavioral states. Some species were also sensitive to disturbance while traveling (e.g., clymene, striped, and spinner dolphins) (Table 4).

Discussion

Sperm whales, killer whales, and several delphinid species that occur in large herds were detected at the largest distances. Beaked whales, *Kogia* spp., and most of the larger delphinids had smaller initial sighting distances. Many species showed avoidance or neutral reactions to the survey platform, but (with the exception of the striped dolphin) most of the smaller delphinids showed strong positive reactions, approaching the ship to ride the bow wave.

Aerial survey data concerning the sensitivity to disturbance support conclusions from the shipboard observations. Cryptic species, such as *Kogia* spp. and beaked whales, which were seen resting on most occasions, responded to the airplane a high proportion of the time, and responded by diving over 85% of the time. From the air, responses of striped dolphins were not distinguishable from those of other stenellids. Less cryptic species, such as the small delphinids, may respond as often, but their response does not necessarily make them harder to identify. Additionally, certain behavioral states, such as resting or milling, appear to be more sensitive to disturbance than others, and this also varies by species.

We assume that the noise of the survey vessel, both from the engines and propeller cavitation, alert cetaceans to the vessel's presence (Richardson *et al.*, 1995). Distances at which ship noises are heard are variable by ship type, weather conditions

Table 4. Sensitivity of cetaceans and initial behaviors to disturbance by survey aircraft. The proportion of times an initial behavior changed to the total number of times that behavior was seen is expressed

	Dive	Feed	Mill	Rest	Socialize	Travel	Unknown	Other	Overall	n
Pygmy/dwarf sperm whale	0			0.50		0	0	1	**0.40**	30
Beaked whale (ziphiids)				1		0.50			**0.89**	9
Fraser's dolphin						0			**0**	1
Melon-headed whale and pygmy killer whales[1]				0		0.17	1		**0.25**	8
Pantropical spotted dolphin			0	0		0.48	0.67	0	**0.43**	42
Clymene dolphin						0.71			**0.71**	7
Striped dolphin						0.71		1	**0.75**	8
Spinner dolphin						1			**1**	4
Rough-toothed dolphin		0	0.50	0	0	0	0		**0.13**	8
Atlantic spotted dolphin		0.50		1		0.13			**0.27**	11
Bottlenose dolphin		0	0.63	0.57	0	0.20	0.25		**0.28**	72
Short-finned pilot whale			1			0.25	0		**0.29**	7
Risso's dolphin			0	0	0	0.19	0.40		**0.16**	37
False killer whale							0		**0**	1
Sperm whale				0.40		0	0.50		**0.28**	25
Sei and Bryde's whale							1		**1**	1
										271
Mean (over all cetaceans)	**0**	**0.17**	**0.43**	**0.39**	**0**	**0.31**	**0.38**	**0.67**		
n	1	3	5	9	3	14	10	3		

[1]Note: Melon-headed whale and pygmy killer whale sightings were pooled for aerial surveys.

(i.e., sea state and rain), oceanography, depth of dive of the target species, frequencies of sensitivity, general ambient noise conditions, and angle of animals from the bow (Greene, 1995; Malme, 1995; Richardson *et al.*, 1995). These variable factors make it very difficult to summarize distances of potential noise influence. However, we know that supply vessels of the approximate sizes of our survey vessels have sound levels in the range from 20–1000 Hz of about 120–150 dB re 1 μPa at a distance of 0.2 km, and about 105 to as high as 125 dB re 1 μPa at a distance of 9-10 km, while underway (Greene & Moore, 1995). The major hearing sensitivities of toothed whales involved in the present study are well above 100 Hz, with the smaller delphinids doing almost all communicating and echolocating well above 1000 Hz (Au, 1993).

Cetaceans that approach the ship may be curious or gauging the possibility of riding bow or stern pressure waves. Cetaceans also habituate to vessels, and much of the absence of response to vessels may be due to habituation to a propeller-noisy environment. It is unclear why some cetaceans, even those not known to have been harassed or killed by humans on any large scale, are habitually or at times evasive. Perhaps the noise of the vessel is disruptive to feeding, resting, or other activities.

Due to the small sample size of behavioral reactions, we made no formal attempts to separate reactions relative to the three observation vessels. However, our impression was that differences among vessels, if they exist, were much smaller than differences among species and species categories.

Line transect analysis was used to compute abundance estimates from the data collected during this project (Davis *et al.*, 1995). There are several assumptions of line transect analysis (Burnham *et al.*, 1980; Buckland *et al.*, 1993). Of these, an important assumption relative to the data in this paper is that the probability of detecting an object is a function of perpendicular distance from the track line (Palka, 1993). However, factors other than distance alone can affect detection probability; for instance, the behavior of the animals. At a given distance, dolphins that are leaping and splashing have a greater probability of detection than a school that is rafting at the surface, creating little surface disturbance. Wade & Gerrodette (1993) found that dolphin species that are showy in their behavior tend to have wider effective strip widths

Table 5. Responses of cetaceans, grouped by species categories, to the survey aircraft. The number of times a species responded with a particular behavior is expressed as a proportion of its total number of responses

	Diving	Feeding	Milling	Resting	Social	Travel	Unknown	Other	Total number of responses
Pygmy/dwarf sperm whales	1	0	0	0	0	0	0	0	12
Beaked whales (ziphiids)	0.87	0	0	0	0	0	0.12	0	8
Fraser's dolphin	0	0	0	0	0	0	0	0	0
Melon-headed whale and pygmy killer whales[1]	0	0	0.50	0	0	0	0.50	0	2
Pantropical spotted dolphin	0.28	0	0.11	0	0	0.11	0	0.50	18
Clymene dolphin	0.40	0	0	0	0	0	0	0.60	5
Striped dolphin	0.50	0	0	0	0	0	0	0.50	6
Spinner dolphin	0.50	0	0	0	0	0	0	0.50	4
Rough-toothed dolphin	0	0	0	0	0	0	1	0	1
Atlantic spotted dolphin	0.33	0	0	0	0	0.33	0.33	0	3
Bottlenose dolphin	0.48	0	0	0	0	0.14	0	0.33	20
Short-finned pilot whale	0	0	0	0	0	0	0	1	2
Risso's dolphin	0.17	0	0	0	0	0.17	0	0.67	6
False killer whale	0	0	0	0	0	0	0	0	0
Sperm whale	0.86	0	0	0	0	0	0	0.14	7
Sei and Bryde's whale	1	0	0	0	0	0	0	0	1
Total	0.53	0	0.03	0	0	0.07	0.04	0.33	95

[1]Note: Melon-headed whale and pygmy killer whale sightings were pooled for aerial surveys.

than those that are less active. Showy species may, then, have abundance estimates that are biased upwards relative to other species, while those of more sedate species would be biased downwards, relatively. Turnock *et al.* (1995) used a helicopter in combination with the main observation vessel to estimate correction factors due to responsive movements of their study animals before sighting from the vessel.

One needs to consider not only the probability of detection, but also the probability of identification to species. As an example, although the probability of detection for different continental slope species of *Stenella* may be similar at the same perpendicular distance, their probability of being accurately identified to species may be quite different. A case in point is the pantropical spotted dolphin, which, in the Gulf of Mexico, generally is attracted to the ship to bowride, versus the striped dolphin, which also bowrides, but in the present study often appeared to ignore or run from the ship. Even if we assume that because responsive movements occur after detection and recording of sighting angle and distance they do not directly bias estimates, a problem remains. If most pantropical spotted dolphin schools approach the bow, they will be identified to species and population estimates will be relatively unbiased. However, if the majority of striped dolphin schools avoid the ship at a great distance, many may not be identified to species and may be placed into the 'unidentified dolphin' category (all nine negative reactions that were scored in this study nevertheless resulted in identifications, because the dolphins were leaping at distance, and therefore their clearly marked flanks were seen). Striped dolphin population estimates will then be correspondingly biased downwards. Thus the behavior of the animals, not only as it affects the probability of detection, but also the probability of identification, is important in interpreting population estimates.

Behavior is even more variable than discussed in this paper, with potential differences by school size, age and sex, time of day, season, weather, and other factors. For example, we know that spinner dolphins in Hawaiian waters are shy and cryptic while resting in early morning, while more aerially demonstrative in the afternoon (Würsig *et al.*, 1994). Dusky dolphins (*Lagenorhynchus obscurus*) of the southern hemisphere show marked differences in human interaction responses relative to age and sex, and to seasonality. They attune their human interactions, including approaches to boats, closely to school size and to whether or not they have fed in the previous several hours (Würsig & Würsig, 1980). Sperm whales and several species of baleen whales may increase their aerial activity prior to, and in the initial stages of, a rapid weather change (Whitehead, 1985; B. Würsig, personal observation). It is likely that similar differences exist for the cetaceans of the northern Gulf of Mexico, but our behavioral data base, gleaned literally while transiting past the animals, is at present too meager for more definitive statements.

Behavioral differences may have effects on resulting density estimates. These data indicate that the sightability and identification of cetaceans may change with the variable behavior of species. Transect-based abundance estimates for long-diving cetaceans, such as sperm whales, and species which often react negatively to the survey vessel, such as striped dolphins, may tend to be biased downwards. Cetaceans which react positively to the vessel may have a greater probability of detection or be more easily identified to species, tending to bias relative abundance estimates upward.

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