

## Cetacean Diversity, Distribution, and Abundance in Northern Veracruz, Mexico

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### Abstract

The distribution and abundance of marine mammals along the United States coast of the Gulf of Mexico are well-documented, but similar studies for the Mexican coast of the Gulf of Mexico are lacking. Furthermore, these animals are important indicators of the marine ecosystem health, and scientific research is needed to develop appropriate conservation strategies. Thus, the objective of this study was to determine the diversity, distribution, and relative abundance of marine mammals in the northern coasts of Veracruz, Mexico. Boat-based surveys and aerial surveys were carried out from March 2005 to August 2006. The following species were observed: bottlenose dolphins (*Tursiops truncatus*), spotted dolphin (*Stenella attenuata*), spinner dolphin (*S. longirostris*), rough-toothed dolphin (*Steno bredanensis*), pilot whale (*Globicephala macrorhynchus*), and an unidentified species of a dolphin. Also, the remains of a sperm whale (*Physeter macrocephalus*) and a humpback whale (*Megaptera novaeangliae*) were observed. The Margalef Diversity Index showed a value of 1.82 for the entire study area. There were differences in the species sightings across seasons. The abundance for the entire study area was 10,824 (%CV 25.05); the density was 1.45 cetaceans/km<sup>2</sup> (%CV 25.05), and the cluster density was 0.71 cetaceans/km<sup>2</sup> (%CV 15.25). The dry season showed a relative abundance of 1.98 cetaceans/h; the rainy season, 1.07 cetaceans/h; and the cold front season, 1.28 cetaceans/h. This is a first glimpse of cetacean population sizes in Mexico. Mexican authorities consider all marine mammal species to be under some conservation status, but they do not have population estimates. Supplementary studies will extend the information presented here for further refinement of cetacean diversity and distribution in Mexican waters of the Gulf of Mexico. Special effort is needed in deeper waters of the Mexican part of the Gulf of Mexico

since there is no information about diversity and abundance of marine mammals for those areas.

**Key Words:** cetacean abundance, cetacean distribution, *Tursiops truncatus*, *Stenella attenuata*, *Stenella longirostris*, *Steno bredanensis*, *Globicephala macrorhynchus*, *Physeter macrocephalus*, *Megaptera novaeangliae*, Gulf of Mexico

### Introduction

The distribution and abundance of marine mammals along the United States coast of the Gulf of Mexico are well-documented, but similar studies for the Mexican coast of the Gulf are lacking (Ortega-Ortíz et al., 2004). Cetacean abundance studies in Mexico have been done using photo identification techniques. On the other hand, in the U.S., distance sampling methodology is used for cetacean abundance studies. Consequently, there are only estimations for bottlenose dolphins (*Tursiops truncatus*) in Mexico. The studies took place in the following places: Corozones Lagoon in Veracruz state (58 dolphins) (Heckel, 1992), Terminos Lagoon in Campeche state (1,400 dolphins) (Delgado-Estrella, 2002), and Yalahua Lagoon and Holbox Island in Quintana Roo state (500 dolphins) (Delgado-Estrella, 1996). In U.S. waters, 34 species of marine mammals have been reported (Würsig et al., 2000), including the extinct Caribbean monk seal (*Monachus tropicalis*) and the introduced California sea lion (*Zalophus californianus*). The bottlenose dolphin and the Atlantic spotted dolphin (*Stenella frontalis*) have been reported as the most abundant species in the continental and shelf break regions. Likewise, 17 oceanic species have been reported to occur in continental slope and pelagic waters throughout the year (Davis et al., 2000).

In Veracruz waters, there have been some unpublished studies on marine mammal diversity,

as well as some studies of stranded animals. From July 1993 to June 1994, there were 21 stranded cetaceans along the coast of Veracruz. The stranded species were sperm whales (*Physeter macrocephalus*), pygmy sperm whales (*Kogia breviceps*), bottlenose dolphins, Atlantic spotted dolphins, and unidentified whales (*Balaenoptera* sp.) (Ortega-Argueta et al., 2005). This is the first systematic study of marine mammal distribution and abundance for the Mexican coast of the Gulf of Mexico. The goal of this study was to document the species of marine mammals that inhabit the northern coast of the state of Veracruz, Mexico, and to determine their distribution and relative abundance.

### Materials and Methods

#### Study Area

The study area consisted of the northern coast of the state of Veracruz, Mexico, which has an approximate area of 7,430 km<sup>2</sup>. The study area is located between the parallels 21° 29' N, 97° 08' W and 20° 09' N, 96° 39' W (Figure 1). The area is characterized by an extended continental shelf, thus shallow waters, and some of the largest rivers in Mexico contributing fresh water and nutrients (Toledo Ocampo, 2005).

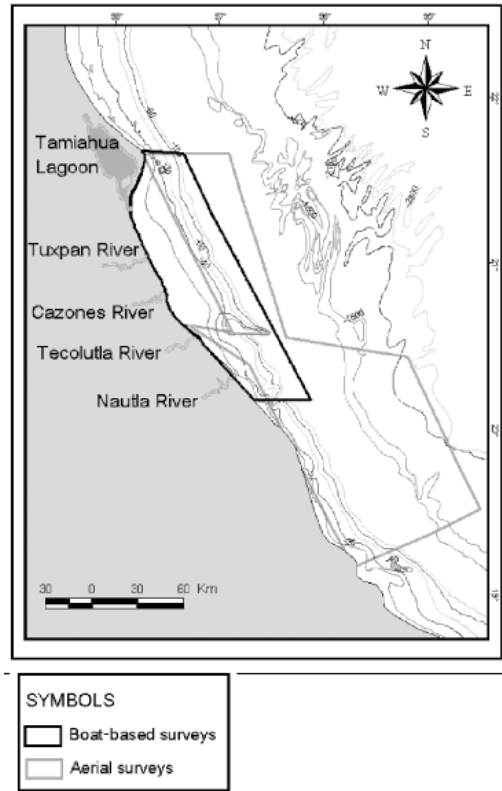
#### Boat-Based Surveys

Biweekly (weather depending) boat-based surveys were carried out from March 2005 to August 2006. The surveys were done on a boat with a 2-m bow, 7 m in length, and two 75 HP outboard engines. Random lineal transects (Buckland et al., 2001) were carried out, and each survey lasted approximately 5.5 h. During the surveys, the boat traveled at approximately 21 km/h, and once the organisms were sighted, they were approached slowly in order to take pictures for the photo-id catalogue. Animals were followed for about 30 min or until it was certain that all organisms were identified and photographed. Organisms were photographed for a home range and site fidelity study.

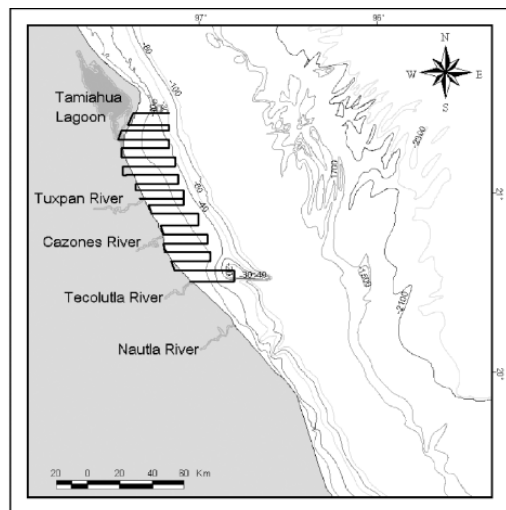
Each time an organism was observed, the following data were recorded: species, number of animals sighted, distance from the boat, angle from the boat, position (taken with a Garmin GPS model Etrex precision  $\pm 5$  m), and water depth (taken with a Humminbird 595c Fish Finder).

#### Aerial Surveys

Two aerial surveys were conducted using the line transect technique. On 31 March 2005, a grid of transects (Buckland et al., 2001) was surveyed between latitudes 21° 28' N, 97° 20' W and 20° 29' N, 97° 00' W, a north-south extent of about 119 km. The grid consisted of 20 east-west transects



**Figure 1.** The study area; the dark area shows the area covered by boat, and the gray area shows the area covered by plane from March 2005 to August 2006.



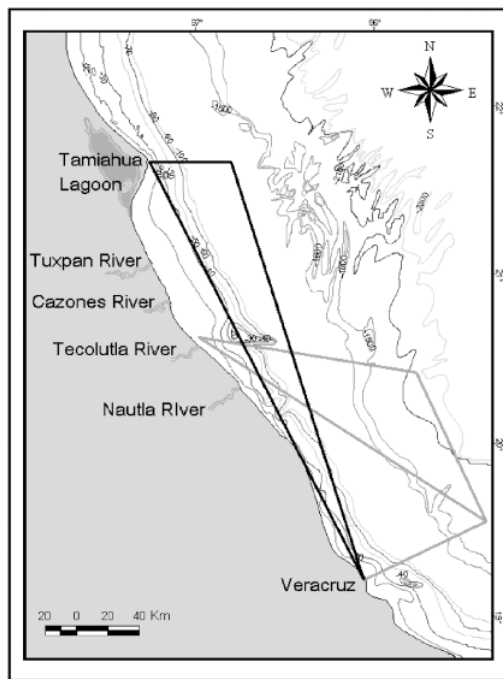
**Figure 2.** Transect design for aerial survey flown in northern Veracruz in 2005; transects were approximately 25 km long and spaced 5 km apart.

spaced 5.0 km apart. Each transect extended from the Veracruz shoreline to roughly 25 km offshore (Figure 2). In total, 542 linear km and 3,238 km<sup>2</sup> were surveyed during this first flight. Water depths ranged from 20 to 100 m. On 29 January 2006, we surveyed seven transects between latitudes 21° 33' N, 97° 20' W and 19° 09' N, 96° 06' W, a north-south extent of about 296 km (Figure 3). Transects were designed to sample a broader area, which extended into deeper waters than the first survey conducted in 2005. Also, it was important to cover the continental slope since the greatest species diversity occurs in the continental slope and pelagic waters throughout the year (Davis et al., 2000). In total, 1,126 linear km and 17,514.5 km<sup>2</sup> were surveyed during this second flight. Water depths ranged from 20 to 2,300 m.

All surveys were conducted with a MAULE MXT-7-180 fixed-wing aircraft. Flights were carried out at an altitude of 91 m (300 ft) above sea level (ASL) and at a ground speed of 222 km/h (120 kts).

#### Data Analyses

**Diversity**—The specific diversity (S) is the simplest form of measuring diversity (Magurran, 1998), and it is estimated as the total number of species observed during a community survey. The



**Figure 3.** Transect design for aerial survey flown in northern Veracruz in 2006

Margalef Diversity Index was used to estimate the diversity of each zone surveyed:

$$DMg = \frac{S - 1}{\ln(N)}$$

Where:

S = number of species observed

N = total number of individuals observed

The Margalef Diversity Index transforms the number of species per sample into a proportion wherein each species is added by the sample expansion. This index assumes that there is a relation between the number of species and the number of individuals:  $S = k\sqrt{N}$  where  $k$  is constant (Magurran, 1988).

**Distribution and Occurrence**—To determine spatial distribution, a GPS was used and geographic positions were plotted using *ArcView*, Version 3.1. To determine seasonal occurrence, three climatic seasons were considered for this study: (1) dry season from March to June; (2) rainy season from July to October; and (3) cold front season from November to February.

**Abundance**—The abundance was estimated using the *Distance Software*, Version 5, Release 2 (Thomas et al., 2006). We used a Half-Normal/Polynomial Model for the data analyses because it was the one that adjusted to our data best (Figure 4).

**Relative Abundance**—The relative abundance was estimated as follows:

$$A = N/Eth$$

Where:

N = total organisms number and Eth = total effort measured in hours (Buckland et al., 2001).

The relative abundance was estimated for the entire study area and for each season considered in this study.

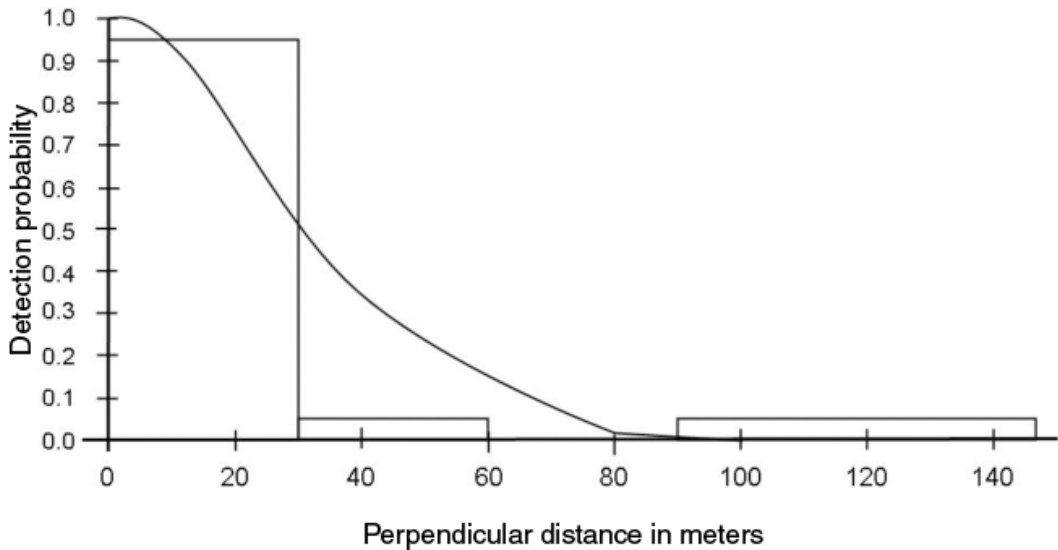
## Results

#### Boat-Based Surveys (Diversity)

The total search effort was 102.47 h distributed in 22 surveys. Seven marine mammal species belonging to three families—Delphinidae, Physteridae, and Balaenopteridae—were identified: bottlenose dolphin, spinner dolphin (*S. longirostris*), Atlantic spotted dolphin, rough-toothed dolphin (*Steno bredanensis*), sperm whale (found stranded), pilot whale (*Globicephala macrorhynchus*, found stranded), humpback whale (*Megaptera novaeangliae*, found stranded), and an unidentified species of dolphin (Table 1). The Margalef Diversity Index showed a value of 1.82 for the entire study area.

#### Spatial and Temporal Distribution

Bottlenose dolphins were observed along the coast of the entire study area at water depths of 5 to 100 m and up to 60 km from the coast. Group



**Figure 4.** Plot showing how the model curve adjusted to the data; the model used was a Half-Normal/Polynomial.

sizes of this species varied between one and 25 individuals. They were usually observed close to river mouths (Tuxpan and Cazonos) and a coastal lagoon (Tamiahua). The unidentified dolphins were observed at water depths of 5 to 40 m; the others were observed at water depths of 40 to 1,500 m (Figure 5).

During the dry season, the most commonly observed species were *Tursiops truncatus* and *S. attenuata*. *Physeter macrocephalus* was found stranded during the dry season. The rainy season was characterized by sightings of *T. truncatus*, *S. attenuata*, and unidentified dolphins. During the cold front season, *T. truncatus*, *Steno bredanensis*, and *Globicephala macrorhynchus* were observed (Table 2).

**Abundance**

The total marine mammal abundance for the entire study area was 10,824 cetaceans (%CV =

25.05), the density was 1.45 cetaceans/km<sup>2</sup> (%CV = 25.05), and the cluster density was 0.71 groups/km<sup>2</sup> (%CV = 25.05) (Table 3).

**Relative Abundance**

The relative abundance for the entire study area was 2.25 cetaceans/h. The dry season showed a relative abundance of 1.98 cetaceans/h; the rainy season, 1.07 cetaceans/h; and the cold front season, 1.28 cetaceans/h.

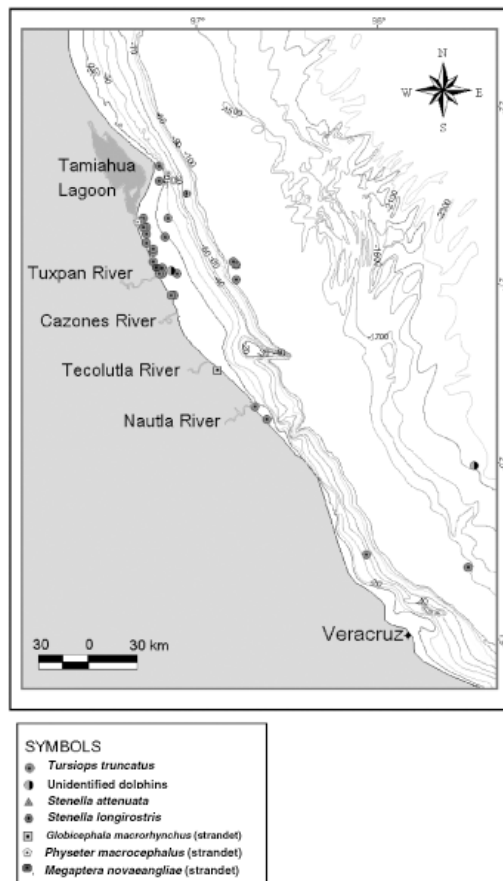
**Aerial Surveys**

During the first survey in March 2005, two groups of bottlenose dolphins (21 individuals), a group of 20 unidentified dolphins, and another group of two unidentified dolphins were observed (Figure 6). These sightings were confirmed during the boat-based surveys. Both bottlenose dolphin groups (8 and 13 individuals) were observed feeding close to river mouths approximately 20 m from the coast and at water depths of 20 m (Figure 6). The group of unidentified dolphins was observed approximately 25 km from the coast and at a water depth of 100 m. The two unidentified dolphins were sighted 1 km from the coast at a water depth of 20 m.

Throughout the second survey in January 2006, unidentified dolphins, bottlenose dolphins, and short-finned pilot whales were observed. A group of 300 unidentified dolphins were observed 95 km from the coast and at a water depth of 2,500 m. A second group of unidentified dolphins (25 individuals of all age classes) was sighted 70 km from the coastline and at a water depth of 1,100 m. Two groups of bottlenose dolphins were observed: one group consisted of 25 individuals, and the other

**Table 1.** Marine mammal species observed and total number of individuals for each species observed during the study from March 2005 to August 2006

Species	Number of individuals
<i>Tursiops truncatus</i>	201
<i>Stenella attenuata</i>	4
<i>Stenella longirostris</i>	2
<i>Steno bredanensis</i>	10
<i>Globicephala macrorhynchus</i>	1
<i>Physeter macrocephalus</i>	1
<i>Megaptera novaeangliae</i>	1
Unidentified dolphin	22



**Figure 5.** Distribution of dolphin sightings during the boat-based surveys

**Table 2.** Cetacean relative abundance by climatic season during boat-based surveys

Species	Cetacean relative abundance by season		
	Dry	Rainy	Cold fronts
<i>Tursiops truncatus</i>	2.22 cetaceans/h	1.38 cetaceans/h	3.19 cetaceans/h
<i>Stenella attenuata</i>	--	0.08 cetaceans/h	--
<i>Stenella longirostris</i>	0.04 cetaceans/h	--	--
<i>Steno bredanensis</i>	0.21 cetaceans/h	--	--
<i>Physeter macrocephalus</i>	--	--	--
<i>Megaptera novaeangliae</i>	--	--	--
Unidentified dolphin	0.48 cetaceans/h	--	--

**Note:** *Globicephala macrorhynchus* was not included in this table because they were observed during the aerial surveys.

**Table 3.** Cetacean density and abundance estimation summary; a Half-Normal/Polynomial Model was used.

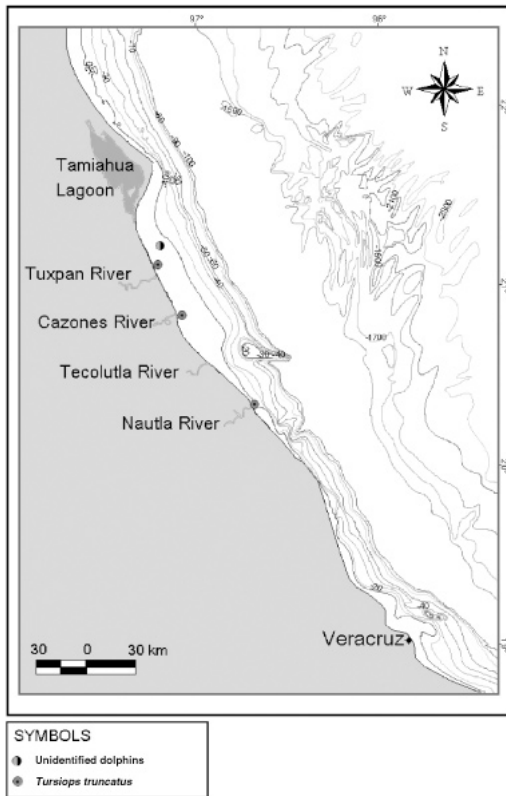
Description	Estimate	%CV	df	95%	Confidence interval
Cluster density	0.71476	15.25	75.43	0.52843	0.96680
Density	1.4568	25.05	123.35	0.89409	2.3738
Abundance	10,824.0	25.05	123.35	6,643.0	17,637.0

consisted of six individuals. Both groups were observed 14 km from the coast and at water depths of 40 to 60 m. A group of 20 short-finned pilot whales were sighted 72 km offshore. The animals were traveling to the south in water depths of 1,900 m (see Figure 7). The Margalef Diversity Index for the entire surveyed area during the flights is 0.35.

After the first flight, the authors estimated a relative abundance for bottlenose dolphins as 3.68 sightings/100 km, and for unidentified dolphins as 3.68 sightings/100 km. The relative abundance for those animals sighted after the second flight was estimated as 13.31 sightings/100 km for unidentified dolphins, as 2.75 sightings/100 km for bottlenose dolphins, and as 1.59 sightings/100 km for pilot whales.

## Discussion

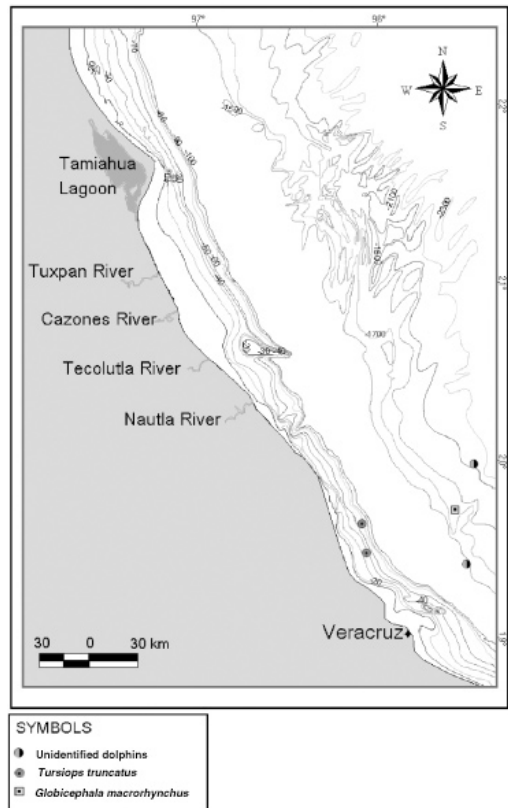
The seven species identified in the study area represent 25% of the species reported for the U.S. waters of the Gulf of Mexico (28 species identified) (Würsig et al., 2000). Even though the study area was small, it showed great marine mammal diversity. Bottlenose dolphins were the most commonly observed organisms during our study. These animals were frequently sighted near to river mouths and the Tamiahua Lagoon. This result confirms Baumgartner et al.'s (2001) results, who reported that bottlenose dolphins in the northern Gulf of Mexico are observed over the continental shelf in water depths of 150 m. Dolphins are commonly observed near river mouths and the Tamiahua Lagoon probably because they utilize these areas as feeding sites (Heckel, 1992).



**Figure 6.** Distribution of dolphin sightings during the aerial survey on 31 March 2005; only water depths where animals were observed are shown in the figure.

*Stenella longirostris*, *S. frontalis*, and *Globicephala macrorhynchus* were observed close to the continental slope in waters of 1,500 m depth. It has been reported that the greatest marine mammal diversity is observed where the continental shelf ends and the continental slope begins (Biggs et al., 2000; Baumgartner et al., 2001; Davis et al., 2002; Ortega-Ortiz, 2002).

*Globicephala macrorhynchus* have been recorded year-round in the Gulf of Mexico, generally in waters 200 to 1,000 m deep, on the continental slope (Würsig et al., 2000). Nevertheless, it was sighted in Mexican waters at 1,900 m depth on the continental slope. It is important to point out that these sightings were confirmed during the boat-based surveys. The authors did not observe a wide range of species during the flights. This could be explained by the fact that the Mexican portion of the Gulf of Mexico has a large continental shelf, and the greatest species diversity occurs in the continental slope and pelagic waters throughout the year (Davis et al., 2000). However, supplementary studies will extend the information presented here for further refinement of cetacean



**Figure 7.** Distribution of dolphin sightings during the aerial survey on 29 January 2006; only water depths where animals were observed are shown in the figure.

diversity and distribution in Mexican waters of the Gulf of Mexico. Special effort is needed in deeper waters of the Mexican part of the Gulf of Mexico since there is no information about diversity and abundance of marine mammals for those areas.

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