Estimates of Cetacean Abundance in the Northern Gulf of Mexico from Vessel Surveys

by

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Introduction

The Southeast Fisheries Science Center (SEFSC) initiated annual, vessel-based visual sampling surveys of northern Gulf of Mexico marine mammals in 1990. The primary goal of these surveys was to meet Marine Mammal Protection Act requirements for estimating abundance and monitoring trends of marine mammal stocks in United States waters. The surveys were designed to collect: 1) marine mammal sighting data to estimate abundance and to determine distribution and diversity; and 2) environmental data to evaluate factors which may affect the distribution, abundance and diversity of marine mammals. The analyses for abundance estimation from the 1991-l 994 surveys *are* presented in this report.

Survey Methods

The Gulf of Mexico surveys were conducted during the spring-summer period (April-June), lasting from 15 to 55 days. The 1990 and 1991 surveys were the shortest; surveys during 1992-l 994 were all approximately 50 days in length. The 1990 and 1991 surveys were conducted in one leg which sampled the off-shelf waters of the northern Gulf between 83°-96° W with a survey track similar to that shown in Figure 1. The 1992-l 994 surveys were conducted in three separate legs, with one or two legs similar to the track shown in Figure 1, and one or two legs sampling the area between 87°-96° W with a survey track similar to that shown in Figure 2. There was a major difference in sampling between the two tracks. The track shown in Figure 1 was based on a pre-determined track for sampling ichthyoplankton stations and was transited 24 hours a day. Daylight transects on this track could be latitudinal or longitudinal. or a combination of both. The track shown in Figure 2 was designed specifically to collect marine mammal sightings along transects perpendicular to the depth gradient. This resulted in visual sampling on only longitudinal transects.

Visual marine mammal sighting data were collected by two teams of three observers during daylight hours, weather permitting (i.e., no rain, Beaufort sea state <6), utilizing standard vessel survey data collection methods for cetaceans developed by the Southwest Fisheries Science Center (e.g., see Holt and Sexton 1987). Each team had at least two members experienced in shipboard marine mammal observation and identification techniques. Two observers searched for marine mammals using high-power (25X), large format "Bigeye" binoculars mounted on the ship's flying bridge. The third observer maintained a search of the area near the trackline without visual aids and with handheld binoculars, and recorded data. Sighting data were recorded with a computer data acquisition program and included species, herd-size, bearing and reticle (a measure of radial distance) of a sighting, and data on environmental conditions (i.e., Beaufort sea state, sun position, etc.) which could affect the observers' ability to sight animals. The reticle relative to a sighting was measured using an eyepiece with a graduated scale in the binoculars. The bearing of a sighting relative to the trackline was measured using a 360" graduated scale attached to the base of the binoculars. Ancillary data also collected included, but were not limited to, time of day, position, behavior, and associated animals. If necessary, the vessel was diverted from the trackline to identify species and obtain herd size estimates.

In general, environmental stations were located every 30 minutes of latitude or longitude along the cruise track. The stations included CTD/STD hydrocasts to just off the bottom, or to 500m when depth exceeded 500m. An XBT sample was obtained halfway between the environmental stations. A thermo-salinograph operated throughout the entire cruise; surface water salinity and temperature were recorded every minute of time. Analysis of environmental data and possible relationships with cetacean abundance and distribution are not included in this report.

The sighting and effort data were summarized by survey for the line transect distance sampling analysis. The basic sample unit considered in the analyses was one day's survey effort with associated herd size and sighting distance for each sighting. Effort and sighting data were pooled across environmental conditions which may have had different sighting rates because of effects on observers' abilities to sight animals (i.e., sighting rates tended to decrease as wind and wave height increased).

Analytical Methods

The abundance of cetacean species sighted during the surveys was estimated using distance sampling analysis for line transect surveys (Buckland et al. 1993). Northern Guff of Mexico abundance was estimated for the 1991- 1994 surveys combined, and separately for each survey, for every species of cetacean sighted on effort. The 1990 survey was a pilot survey, and was not used in the analysis due to inconsistencies with the other surveys. Abundance estimates were made using program DISTANCE (Laake et al. 1993). The formula used to estimate density ($\hat{D}$) was

$$\hat{D} = \frac{n \cdot \hat{S} \cdot \hat{f}(0)}{2 \cdot L}$$

where n = number of on-effort group sightings

$\hat{S}$ = mean group size or expected group size

$\hat{f}(0)$ = sighting probability density function at 0 perpendicular distance

L = length of transects sampled within a stratum.

Abundance was estimated as the density times the size of the survey area, and the log-normal 95% confidence intervals were computed for each abundance estimate. The northern Gulf of Mexico survey area was considered to be the waters between the 100m isobath and the EEZ boundary, a total of approximately 398,960km^2.

The parameter $\hat{f}(0)$ was estimated using a hazard-rate model and a half&normal model (Buckland 1985, Buckland et al. 1993). The $\hat{f}(0)$ parameter was estimated using a maximum likelihood algorithm applied to exact sighting distances. Model selection of $\hat{f}(0)$ was determined using Akaike's Information Criterion (AIC, see Buckland et al. 1993).

The length of line sampled *was* determined using LORAN positions (latitude and longitude) collected at regular intervals (usually every two minutes) along the transect

In some cases, the LORAN readings were known to be in error and L for these cases was determined using the elapsed time and average vessel speed of 18km per hour.

No attempt was made to estimate the probability of sighting animals on the trackline (g_0), which was assumed equal to one for all species. The resulting estimates do not account for animals that were not sighted due to observer error or that may have been unavailable for sighting (e.g., on the transect, beneath the water's surface). This effect could result in conservative estimates of abundance. However, it is not clear that biases due to assuming g_0 = 1 would not be countered by other effects, such as under-estimation of average group size or attraction of animals to the survey vessel.

Variance of $\hat{D}$ was estimated as

$$v\hat{a}r(\hat{D}) = \hat{D}^2 \left[\frac{v\hat{a}r(n)}{n^2} + \frac{v\hat{a}r(\hat{S})}{\hat{S}^2} + \frac{v\hat{a}r[\hat{f}(0)]}{\hat{f}(0)^2} \right]$$

and coefficient of variation (cv) estimated as

$$c\hat{v}(\hat{D}) = \frac{\sqrt{v\hat{a}r(\hat{D})}}{\hat{D}}$$

The variance of n was based on the variation in the number of on-effort group sightings between sampling units within each stratum. The sampling unit for the ship surveys was a day's visual sighting effort. The variance of $\hat{S}$ *was* based on the variation in group size within each stratum. The variance of $\hat{f}(0)$ was based on the variation between expected versus actual perpendicular sighting distance (PSD) distributions pooted across strata.

The group sizes for some species tended to be inversely related to PSD, a feature which can result from size bias (i.e., larger groups are easier to see at distance than are small groups). Therefore, the arithmetic mean of group size could overestimate the true mean group size and could have lead to positively biased abundance estimates. The program DISTANCE used a regression of the group size by sighting distance to generate a mean "expected group size." The expected group size was used in the density estimation if it was significantly different from the arithmetic mean group size ($p<0.15$, Student's t test, see Buckland et al. 1993). The sample size, herd size estimate, and other parameters used in the distance sampiing analysis are given in Table I.

An exploratory analysis indicated that sightings made at small radial distances (generally <0.247nm) resulted in a poor fit of the sighting probability density function. Exclusion of these sightings resulted in relatively better fits and more precise estimates of $f(0)$. It was felt that most of these sightings were of animals that were attracted to the vessel to bow ride. *One* requirement for unbiased estimates of abundance is that the sighting target(s) should not move in response to the observer or the observation platform (Buckland et al. 1993). To reduce the potential for bias due to attraction to the vessel, only sightings made at radial distances of >=0.247nm were included in the data summarized for the distance sampling analysis.

Examination of the bearing and reticle measurements indicated that most were rounded to the nearest 5 units (5 degrees for bearing, 0.5 for reticle readings). The bearing and reticle reading data for each sighting were smeared by adding a randomly selected value between -5 and 5 for the bearing, and between -0.5 and 0.5 for the radial distance. This was done to reduce the potential for artificial grouping of sighting distances due to rounding of measurements by observers.

The formula used for calculating radial sighting distances *(R),* from Smith (1982), was

$$R = h \cdot \tan\left[\arctan\left(\frac{Y_{1,2}}{\sqrt{h_{1,2}}}\right) - B \cdot r\right]$$

where h_1 = 0.003508, modeled height of binoculars above surface in nautical miles for $r < 5.0$

h_2 = 0.004818, modeled height of binoculars above surface in nautical miles for $r >= 5.0$

Y_1 = 76.756, modeled declination parameter for $r > 5.0$

Y_2 = 29.228, modeled declination parameter for $r > 5.0$

B = 0.0623, a constant

r = reticle measurement.

A non-linear model (SAS 1988) was used to produce least squares estimates of parameters h and Y, using empirical data on reticle readings and distances. Estimates generated using the entire range of empirical data (for r from 0.0 to 15.0) provided a good fit for distances greater than measured at $r = 5.0$, but underestimated distances measured at $r = 5.0$. Therefore, two addition sets of estimates were generated, one with using the ground truth measurements for $r < 5.0$ (Model 1) and another for $r >= 5.0$ (Model 2). A plot of these two sets of estimates against the mean empirical distances (Figure 3) indicated Model 1 predicted distances best fort < 4.0 and Model 2 predicted distances best for $r >= 4.0$. Thus, two sets of estimates were used for h and Y; one set for $r < 4.0$, and another set for $r >= 4.0$. Perpendicular sighting distances (P) were calculated as

$$P = R \cdot \sin(b)$$

where b = angle between sighting and trackline.

The sample sizes (number of groups sighted) of most species were considered insufficient to obtain accurate and precise estimates of $\hat{f}(0)$. Sightings of species with similar sighting characteristics (i.e., body size, group size, behavior) were pooled to estimate $\hat{f}(0)$ (Table II). For instance, $\hat{f}(0)$ for Cuvier's beaked whale (*Ziphius cavirostris*) was estimated by pooling with sightings of Blainville's beaked whale (*Mesoplodon densirostris*), unidentified beaked whales (family Ziphiidae), and dwarf and pygmy sperm whales (*Kogia* spp.) of group sizes less than five. Seven species did have sufficient sightings (30 or more, including non-GulfCet sightings) to estimate species $\hat{f}(0)$ without pooling; these were the sperm whale (*Physeter macrocephalus*), dwarf sperm whale (*K. simus*), Atlantic spotted dolphin (*Stenella frontalis*), pantropical spotted dolphin (*S. attenuata*), striped dolphin (*S. coeruleoalba*), Risso's dolphin (*Grampus* *griseus*), and bottlenose dolphin (*Tursiops truncatus*). The estimated values of $\hat{f}(0)$ and associated statistics are listed in Table III.

Survey Results

The northern Gulf of Mexico surveys total transect kilometers sampled each survey during 1991-94 varied from 3,491-6,386 km, for a total over all the surveys of 22,041 km. More than 850 sightings of at least 21 cetacean species were made during the 1991-l 994 surveys. Of these, 616 sightings, identified to species (or the genus *Kogia* or the family Ziphiidae), were used in the distance sampling analysis. The number of sightings by species and *survey* year are fisted in Table IV.

Analytical Results

The northern Gulf of Mexico abundance estimates for all species observed are listed in Table V with associated statistics. The all-surveys-combined (ASC) abundance estimates ranged from fewer than 1000 for most species to about 31,000 for pantropical spotted dolphins. The coefficient of variation (cv) of the ASC estimates was relatively large (>50%)for most species, but was about 30% or less for sperm whales, dwarf sperm whaies (*K. simus*), pantropical spotted dolphins, and grampus. The cv's of the abundance estimates by-survey were considerably larger for most species, although the cv's for the by-survey abundance estimates of the pantropical spotted dolphin ranged from about 29% to 48%. The by survey abundance estimates and associated statistics are given in Table VI.

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Table I. Sighting and group-size statistics used for estimating cetacean species abundance for pooled 1991-94 shipboard surveys. Abbreviations are. as follows: n = number of sightings, n/L = groups encountered per 1000km (survey effort given in column heading), G = mean group size, S = size-bias adjusted group size, CV = % coefficient of variation. Group sizes denoted with an * indicate which size estimate was used in density calculations.

SPECIES	SPRING					
	n	n/L 22040km	c v n/L	G	S	c v she
Balaenoptera edeni	3	0.000140	97.65	-2.67	11.00	45.07
Physeter macrocephalus	60	0.002720	22.09	2.58	-2.13	7.87
Kogia simus	34	0.001543	23.75	-2.21	2.14	13.77
Kogia *breviceps*	10	0.000454	34.00	'2.24	2.13	11.75
Kogia sp.	61	0.002768	23.38	7.08	2.02	9.41
Ziphius cavirostris	5	0.000230	46.06	'1.20	1.39	16.67
Unidentified Ziphiidae	12	0.000540	35.00	'1.92	1.86	13.56
Stenella frontalis	20	0.000907	31.83	*21.25	28.04	15.69
Stenella attenuata	158	0.007169	14.43	57.73	'43.37	7.67
Stenella coeruleoalba	29	0.001316	22.42	36.74	41.67	11.63
Stenella longirostris	20	0.000907	33.57	70.80	72.34	24.62
Stenella clymene	23	0.001044	23.61	63.70	'55.30	26.67
Lagenodelphis hosei	1	0.000045	89.11	-34.00	-	-
Steno bredanensis	11	0.000499	27.96	'14.36	13.66	12.18
Orcinus orca	7	0.000318	36.29	'10.00	11.75	15.28
Pseudorca crassidens	5	0.000227	43.63	*20.40	33.27	42.07
Feresa attenuata	4	O-000182	48.94	79.25	90.68	62.44
Peponocephala electra	9	0.000408	29.63	'119.56	115.75	22.50
Grampus griseus	75	0.003403	23.34	10.73	'10.10	9.44
Globicephala macrorhynchus	5	0.000227	44.67	'16.60	14.19	21.16
Tursiops truncatus	107	0.004855	19.49	13.96	*9.01	11.81

Table . Pooling categories for estimating f_0. Sightings pooled are indicated by "X" for case [when] all sightings were used, or by <# and/or ># which indicates the range of herd [size] of sightings used. Abbreviations are as follows: Bede=Bryde's whale, Pmac=Sperm whale, Ksim=dwarf sperm whale, Kbre=pygmy sperm whale, KsKb=*Kogia* sp., Zcav=Cuvier beaked whale, Ziph=Unidentified Ziphiidae, Sfro=Atlantic spotted dolphin, Satt=pantropical spotted dolphin, Scoe=striped dolphin, Slon=spinner dolphin, Scly=Clymene dolphin, Lhos=Fraser's dolphin, Sbre=rough-toothed dolphin, Oorc=killer whale, Pcra=false killer whale, Fatt=pygmy killer whale, Pele=melon-headed whale, Ggri=Risso's dolphin, Gmac=short-finned pilot whale, Ttru=bottlenose dolphin, TtSf=bottlenose/Atlantic spotted dolphin, FaPe=pygmy killer/melon-headed whale, Ular=unidentified large whale, Usml=unidentified small whale.

Pool	Bede	Pmac	Ksim	Kbre	KsKb	Zcav	Ziph	Sfro	Satt	Scoe	Slon	Scly	Lhos	Sbre	Oorc	Pcra	Fatt	Pele	Ggri	Gmac	Ttru
	SPECIES																				
Bede																					
Pmac	X																				
Ksim				X	X	<5	<5														
Kbre					X	<5	<5														
KsKb				X		<5	<5														
Zcav							X														
Ziph						X															
Sfro														<21							
Satt											X	X	>29					>29			
Scoe											X	X	>29					>29			
Slon												X	>29					>29			
Scly											X		>29					>29			
Lhos																		>29			
Sbre																					
Oorc																X				X	
Pcra															<16					X	
Fatt																					
Pele													>29								
Ggri															<16	X	>9 <30			>8 <30	
Gmac															<16	X	<30				
Ttru														<21			>9 <30				
TtSf														<21							
FaPe																	<30	>29			
Ular	X																				
Usml						<5	<5														

Table III. The estimated value of f_0 and associated statistics. ESW = effective strip half-width ($1/f_0$), CV = % coefficient of variation, $n(f_0)$ = number of sightings used to estimate f_0 (* indicates species which required pooling with other species to estimate f_0), n(D) = number of sightings used for estimating density and abundance.

SPECIES	f_0 (km^{-1})	ESW (km)	CV (f_0)	$n(f_0)$	Spring $n(D)$
Balaenoptera edeni	0.4777	2.0933	21.07	*87	3
Physeter macrocephalus	0.4588	2.1795	19.69	69	60
Kogia simus	0.5025	1.9901	13.95	34	34
Kogia breviceps	0.4755	2.1028	12.80	*62	10
Kogia sp.	0.4756	2.1028	12.80	-63	61
Ziphius cavirostris	0.5601	1.7854	7.84	75	5
Unidentified Ziphiidae	0.5624	1.7780	7.72	76	12
Stenella frontalis	0.8353	1.1972	26.55	58	20
Stenella attenuata	IO.5050	1.9802	11.77	170	158
Stenella coeruleoalba	0.5122	1.9524	36.42	31	29
Stenella longirostris	0.4928	2.0291	9.64	757	20
Stenella clymene	0.4840	2.0660	9.59	259	23
Lagenodelphis hosei	0.4112	2.4318	10.17	‘183	1
Steno bredanensis	0.5961	1.6775	7.30	*284	11
Orcinus orca	0.4366	2.2905	14.41	*83	7
Pseudorca crassidens	0.4128	2.4223	12.80	*107	5
Feresa attenuata	0.4890	2.0449	15.73	*104	4
Peponocephala electra	0.4072	2.4559	10.14	'182	9
Grampus griseus	0.4024	2.4852	10.42	77	75
Globicephala macrorhynchus	0.4701	2.1271	16.83	73	5
Tursiops truncatus	0.6439	1.5529	11.97	140	107

Table IV. On-effort Cetacean sightings collected during 1991-1994 annual, spring-summer vessel surveys of the northern Gulf of Mexico.

SPECIES	SURVEY				
	1991	1992	1993	1994	ALL
Balaenoptera sp.	-	2	-	1	3
Balaenoptera physalus	-	-	-	1	1
Balaenoptera edeni	3	-	-	-	3
Physeter macrocephalus	5	18	8	29	60
Kogia simus		16	12	6	34
Kogia breviceps	3	4	2	1	10
Kogia sp.		12	6	-	18
Ziphius cavirostris	-	-	3	2	5
Mesoplodon densirostris	-	1	-	-	1
Ziphiidae	1	7	7	12	27
Stenella frontalis	1	7	9	6	23
Stenella attenuata	21	37	53	68	179
Stenella coeruleoalba	3	7	8	11	29
Stenella longirostris	-	6	5	9	20
Stenella clymene	3	6	9	7	25
Stenella sp.	-	1	4	5	10
Lagenodelphis hosei	-	1	-	-	1
Steno bredanensis	1	4	4	2	11
Orcinus orca	-	1	4	2	7
Pseudorca crassidens	1	1	1	2	5
Feresa attenuata	1	2	1	-	4
Peponocephala electra	-	3	2	4	9
Grampus griseus	2	22	15	39	78
Globicephala marcorhynchus	-	3	1	1	5
Tursiops truncatus	8	46	47	20	121
Unidentified large whale	-	1	6	3	10
Unidentified small whale	2	2	2	5	11
Unidentified odontocete	6	17	12	8	43
Unidentified dolphin	15	26	38	24	103
ALL	76	253	259	268	856

Table IV. On-effort cetacean sightings collected during 1991-1994 annual, spring-summer vessel surveys of the northern Gulf of Mexico.

SPECIES	SURVEY				
	1991	1992	1903	1994	ALL
Balaenoptera sp.	-	2	-	1	3
Balaenoptera physalus	-	-	-	1	1
Balaenoptera edeni	3	-	-	-	3
Physeter macrocephalus	5	18	8	29	60
Kogia simus		16	12	6	34
Kogia breviceps	3	4	2	1	10
Kogia sp.		12	6	-	18
Ziphius cavirostris	-	-	3	2	5
Mesoplodon densirostris	-	1	-	-	1
Ziphiidae	1	7	7	12	27
Stenella frontalis	1	7	9	6	23
Stenella attenuata	21	37	53	68	179
Stenella coeruleoalba	3	7	8	11	29
Stenella longirostris	-	6	5	9	20
Stenella clymene	3	6	9	7	25
Stenella sp.	-	1	4	5	10
Lagenodelphis hosei	-	1	-	-	1
Steno bredanensis	1	4	4	2	11
Orcinus orca	-	1	4	2	7
Pseudorca crassidens	1	1	1	2	5
Feresa attenuata	1	2	1	-	4
Peponocephala electra	-	3	2	4	9
Grampus griseus	2	22	15	39	78
Globicephala marcorhynchus	-	3	1	1	5
Tursiops truncatus	8	46	47	20	121
Unidentified large whale	-	1	6	3	10
Unidentified small whale	2	2	2	5	11
Unidentified odontocete	6	17	12	8	43
Unidentified dolphin	15	26	38	24	103
ALL	76	253	259	268	856

Table V. Abundance estimates (N) and density estimates (D. per 1000km²) by species for the northern Gulf of Mexico for 1991-1994 surveys combined with % coefficient of variation (CV) and log-normal 95% confidence intervals (CI).

SPECIES	SPRING			
	N	*D* per 1000km²	CV	CI
Balaenoptera edeni	35	0.08660	109.59	6-205
Physeter macrocephalus	530	1.32840	30.64	295 - 953
Kogia simus	341	0.85490	30.80	189-615
Kogia breviceps	56	0.14024	38.18	27-115
Kogia sp.	547	1.37000	28.27	317 - 941
Ziphius cavirostris	30	0.07620	49.61	12 - 70
Ziphiidae	117	0.29350	38.32	57 - 242
Stenella frontalis	3213	8.05350	44.39	1399 - 7378
Stenella attenuata	31320	78.50500	20.14	21118 - 46298
Stenella coeruleoalba	4858	12.17700	44.33	2038 - 11330
Stenella longirostris	6316	15.83000	42.77	2828 - 14104
Stenella clymene	5571	13.96500	36.87	2734-11355
Lagenodelphis hosei	127	0.31716	89.69	28-570
Steno bredanensis	852	2.13670	31.37	468 - 1554
Orcinus orca	277	0.69327	41.93	126 - 609
Pseudorca crassidens	381	0.95525	61.95	115 - 1262
Feresa attenuata	518	1.29790	80.88	101 - 2659
Peponocephala electra	3965	9.93890	38.57	1883-8350
Grampus griseus	2749	6.89120	27.25	1627-4645
Globicephala macrorhynchus	353	0.88520	52.39	133-939
Tursiops truncatus	5618	14.08000	25.74	3419 - 9229

Table VI. Annual abundance estimates (N) by species for the northern Gulf of Mexico for 1991-1994 spring-summer surveys with % coefficient of variation (CV), and log-normal 95% confidence intervals (CI).

SPECIES	1991			1992			1993			1994		
	N	cv	CI	*N*	CV	CI	*N*	CV	CI	*N*	CV	CI
Balaenoptera edeni	218	101.12	39-1235	-								
Physeter macrocephalus	143	58.14	48-428	931	47.53	378-2290	229	52.30	88-614	771	41.54	347-1709
Kogia simus	-	-		541	42.50	240-1223	502	49.17	198-1275	154	64.00	47-504
Kogia breviceps	109	68.35	31-386	60	53.33	22-165	59	70.36	15-234	16	107.60	3-w
Kogia sp.	109	68.35	31-386	1010	40.10	468-2189	580	44.61	247-1359	162	81.28	52-505
Ziphius cavirostris		.		.			70	52.56	22-225	38	60.23	9-159
Ziphiidae	129	78.15	31-530	18	126.66	2-129	53	78.43	12-223	267	47.96	114-719
Stenella frontalis	.			4527	65.16	1378-14876	4618	62.36	1464-14571	2186	85.36	493-9693
Stenella attenuata	19767	45.20	8302-47066	15280	36.45	7555-30904	29414	26.82	16762-51615	71847	31.52	38886-132750
Stenella coeruleoalba	3463	75.73	865-14025	2574	52.25	966-6861	4160	63.08	1313-13183	8147	59.69	2711-24479
Stenella longirostris	.			2593	62.69	812-8280	2336	62.49	719-7587	15995	07.28	4670-54791
Stenella clymene	1936	68.94	540-6944	3390	47.59	1365-8417	6466	46.70	2693-15621	12255	62.27	3838-39132
Lagenodelphis hosei	,	.		443	91.62	91-2157			.			
steno *bredanensis*	545	114.67	83-3581	759	56.26	230-2490	1192	49.03	4752987	527	65.93	85-3250
Orcinus orca	-		.	138	95.52	27-705	641	50.36	246-1670	193	Ill.70	11-3380
Pseudorca crassidens	661	88.17	139-3131	196	99.61	37-1053	77	108.08	13-458	744	113.56	41-13462
Feresa attenuata	2347	80.86	549-10032	356	73.43	95-1341	153	112.99	24-954			
Peponocephala electra	-	-		3174	54.15	1141-8833	027	69.95	231-2961	10588	47.65	4245-28400
Grampus griseus	667	95.37	726217	2325	34.40	1192-4534	1408	41.33	638-3118	6332	44.63	2683-14944
Globicephala macrorhynchus	-			909	62.05	267-2662	103	120.07	15-694	240	102.75	43-1338
Tursiops truncatus	2392	52.71	645-6742	6937	40.14	4130-19338	6149	39.69	2822-13167	5487	56.96	1822-16523

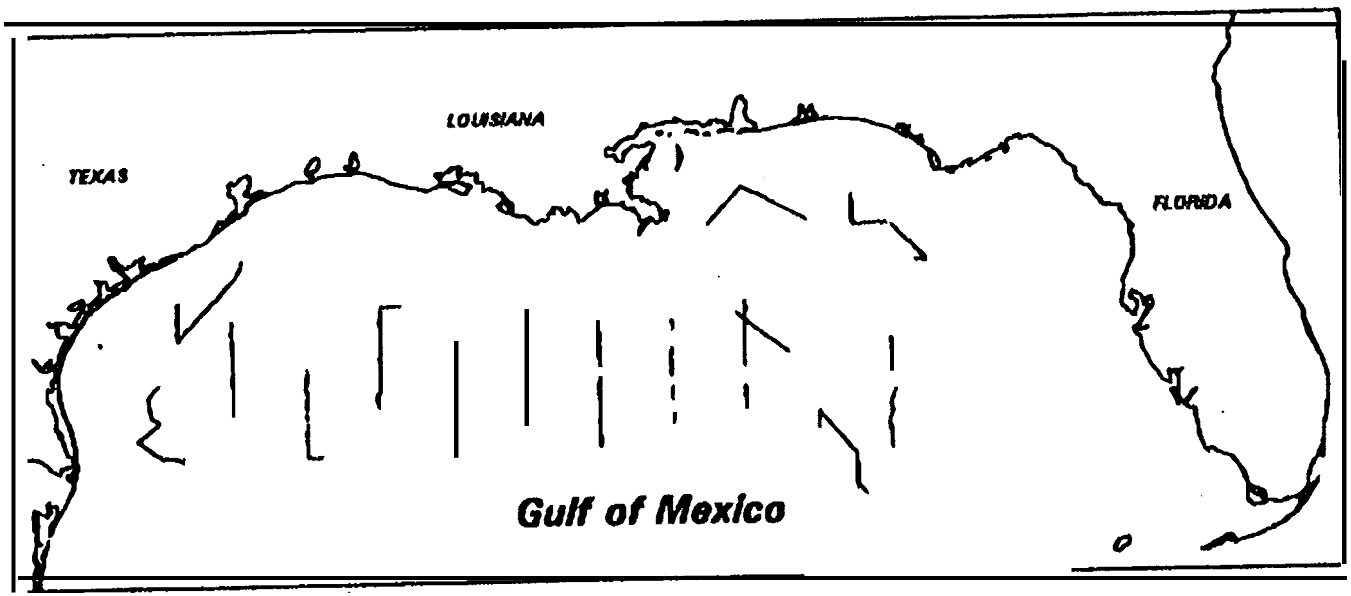

Figure 1. Map of the northern Gulf of Mexico with an example of on-effort survey track that occurred during a survey leg which was sampled both visually for cetaceans, and for ichthyoplankton at predetermined stations.

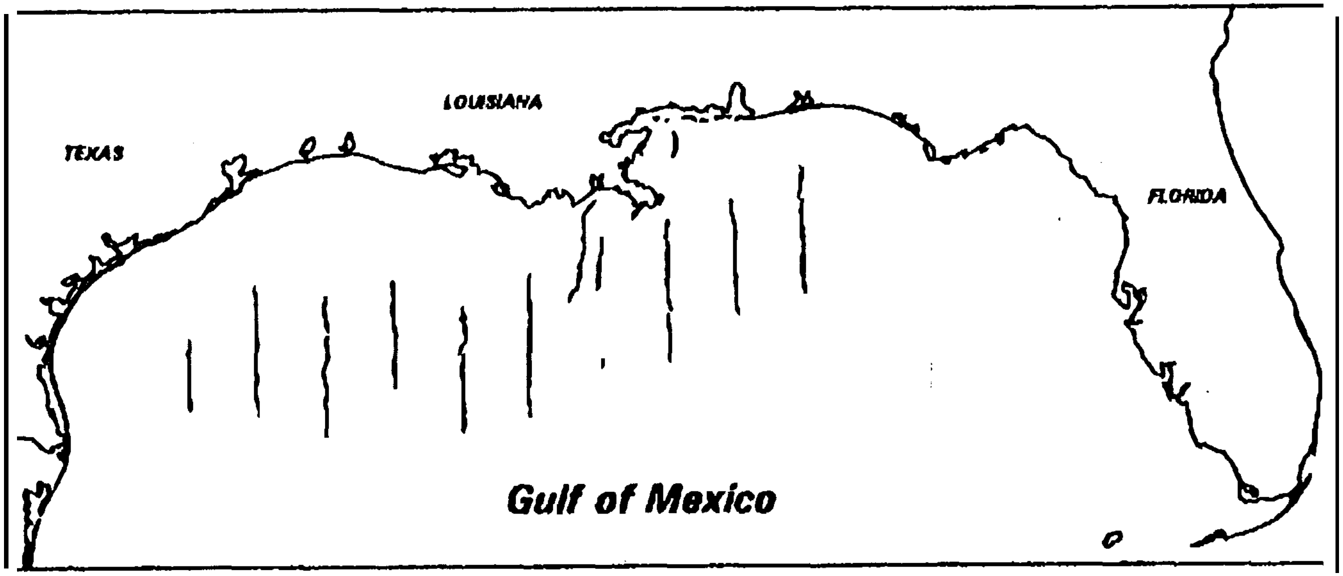

Figure 2. Map of the northern Gulf of Mexico with an example of on-effort survey heck that occurred during a survey leg which was designed specifically to collect marine mammal sightings along transects perpendicular lo the depth gradient,

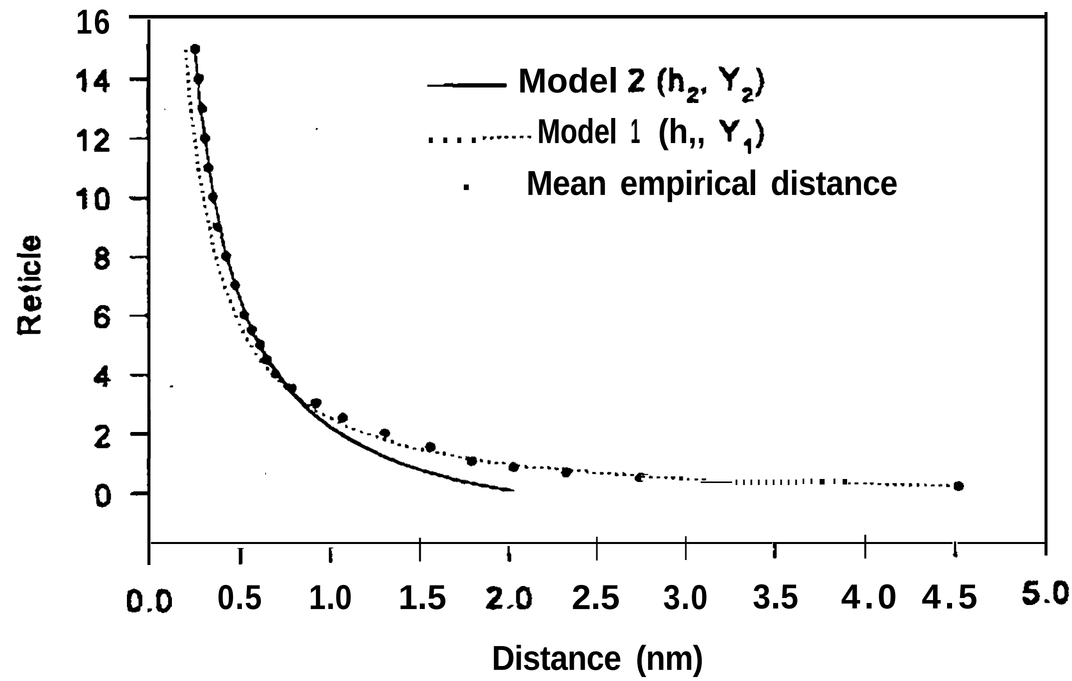

Figure 3. Estimated radial sighting distances, based on two sets of modeled estimates of binocular height and declination, with mean empirical radial distances.