NOAA TECHNICAL MEMORANDUM
NMFS-SEFSC-356

PRELIMINARY ESTIMATES OF BOTTLENOSE DOLPHIN ABUNDANCE IN SOUTHERN U.S. ATLANTIC AND GULF OF MEXICO CONTINENTAL SHELF WATERS

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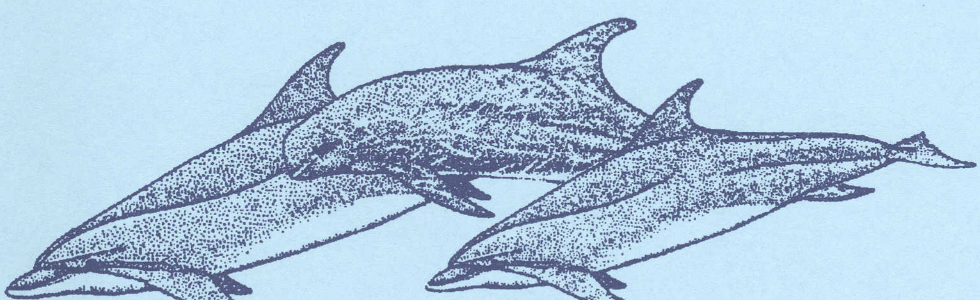

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Science Center
Miami, Florida 33149

October 1994

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U.S. DEPARTMENT OF COMMERCE
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NATIONAL MARINE FISHERIES SERVICE
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NOTICE

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Preliminary Estimates of Bottlenose Dolphin Abundance in Southern U.S. Atlantic and Gulf of Mexico Continental Shelf Waters [1]

By Robert A. Blaylock [2] and Wayne Hoggard [3]

ABSTRACT

Aerial surveys were conducted over U.S. Atlantic coastal waters south of Cape Hatteras and in the U.S. Gulf of Mexico from the Mexican border to approximately Cape St. George to estimate bottlenose dolphin abundance. Atlantic regional surveys, conducted in winter 1992, covered the continental shelf from Cape Hatteras to mid-Florida. Gulf of Mexico regional surveys, conducted in autumn of 1992 and 1993, covered approximately the western two-thirds of U.S. Gulf of Mexico bays, sounds and continental shelf. Line transect analytical methods were employed to model the probability density function for each survey stratum and estimate dolphin density which was extrapolated to abundance. Estimated bottlenose dolphin abundance in the U.S. coastal Atlantic survey area from Cape Hatteras to mid-Florida during the winter was 12,435 dolphins with a log-normal approximate 95% confidence interval (95% CI) of 9,684 - 15,967 bottlenose dolphins. Bottlenose dolphin abundance in the Gulf of Mexico combined bay and sound survey strata was 3,554 dolphins (95% CI = 2,924 - 4,319). Estimated bottlenose dolphin abundance in the Gulf of Mexico coastal survey stratum was 7,690 dolphins (95% CI = 5,749 - 10,286). The Gulf of Mexico outer continental shelf survey stratum contained an estimated 22,496 bottlenose dolphins (95% CI = 17,520 - 28,885).

INTRODUCTION

This report presents the results of preliminary analyses of bottlenose dolphin, *Tursiops truncatus*, sighting data which were collected during the Southeast Cetacean Aerial Survey (SECAS) of the U.S. continental shelf between Cape Hatteras, North Carolina and mid-Florida and Gulf of Mexico regional aerial surveys (GOMEX92 and GOMEX93). SECAS was conducted in January-March 1992, GOMEX92 was conducted in the western Gulf during September-October 1992, and GOMEX93 was conducted in the northern Gulf in September-October 1993. GOMEX94 is scheduled for September-November 1994 in the eastern Gulf of Mexico and results of that survey will be reported at a later date. Refer to Anon. (1991 and 1992a) for a discussion of the survey objectives, design, and methods of SECAS. See Anon. (1992b) for GOMEX92 survey objectives, design, and data collection methods and Blaylock (1993) for the GOMEX92 survey data report. Anon. (1993) contains GOMEX93 survey objectives, design, and data collection methods.

METHODS

Sampling Methods

SECAS was conducted using a twin-engine Beechcraft AT-11 aircraft outfitted with a clear nose cone from which two observers visually monitored the track line. Surveys were flown at altitudes alternating between transects at 152 m and 229 m, except in survey blocks 1 and 5, which were flown at 152 m altitude. SECAS (Figure 1) replicated the survey block design used in the Southeast Turtle Surveys in the winter of 1983 (SETS, Shoop and Thompson 1983), except that SETS block 10 was not surveyed. Transects were flown orthogonally from the shore out to approximately 9.25 km past the shoreward edge of the Gulf Stream.

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Survey effort was designed to obtain a coefficient of variation ≤ 0.20 on the dolphin herd encounter rate and was estimated using bottlenose dolphin sighting data from the SETS surveys. The estimated sample size (L in km of survey transect) needed was estimated for each survey block as:

$$L = \frac{b}{(cv(\hat{R}))^2} \cdot \frac{L_k}{n_k}$$

(from Burnham *et al.* 1980, pg. 35),

where:

$cv(\hat{R})$ is the desired coefficient of variation;
L_k = the line length flown in block k during the winter SETS survey;
n_k = the number of herd sightings in block k during the winter SETS survey; and
$b = n_k(cv(\hat{R}_k))^2$, where
$\hat{R}_k$ = the herd sighting rate in block k during the winter SETS survey.

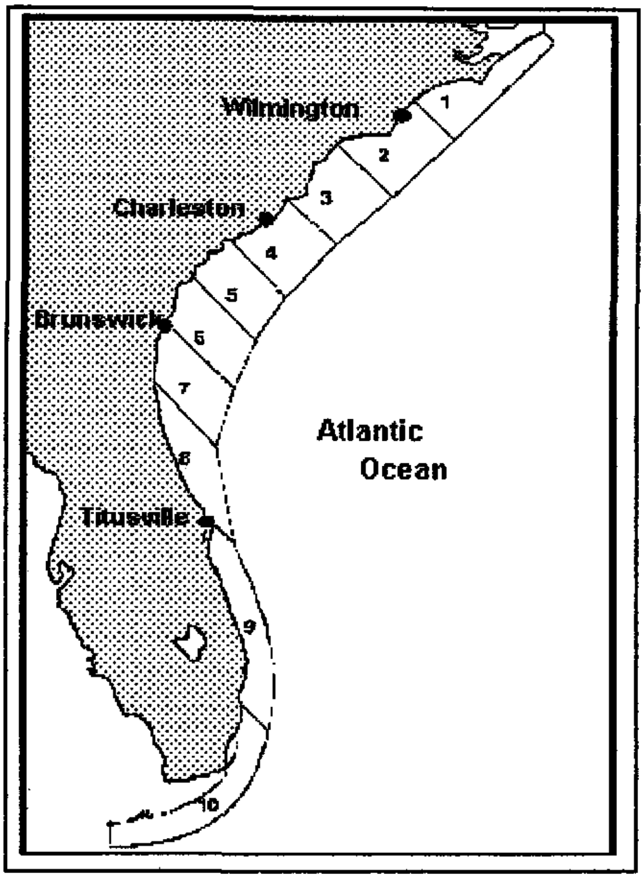

Figure 1. *Southeast U.S. aerial survey blocks. Blocks 1-9 were surveyed in winter January-March 1992.*

GOMEX survey design replicated the design of regional aerial surveys which were conducted in the fall of 1984 and 1985 in U.S. Gulf of Mexico bays, sounds, coastal waters and outer continental shelf. The survey area (Figure 2) was divided into strata and survey blocks replicating fall Gulf of Mexico regional aerial surveys conducted west of the Mississippi River mouth in 1983 and east of the Mississippi River in 1985 (Scott *et al.* 1989) and survey coverage was similar in intensity. Surveys were flown in a NOAA-owned and operated DeHavilland DH-6 Twin Otter aircraft outfitted with a concave plastic window on each side of the fuselage through which an observer visually monitored the track line. All GOMEX surveys were conducted at 229 m altitude. The coastal stratum, denoted by the prefix "I" in Figure 2, was sampled using transects flown orthogonally from the shoreline to the 18.3 m isobath. Outer continental shelf (OCS) strata, denoted by the prefix "O" in Figure 2, covered the area between the 18.3 m isobath and 9.3 km past the 183 m isobath with transects generally orthogonal to the isobaths. Bay and sound survey blocks are denoted by the prefix "B" in Figure 2.

Perpendicular Sighting Distance Measurement

The perpendicular sighting distance (PSD) of each bottlenose dolphin herd sighting was estimated by using a hand-held digital inclinometer to measure the angular declination from the transect and converting the angle to distance in meters using standard trigonometry. Taped 10^0 markings on the concave windows were used to estimate the approximate PSD for herds sighted beyond the $0\text{-}60^0$ range of the inclinometers and occasionally when it was not possible to measure a sighting. PSD was calculated for interval-only data using the midpoint of the interval; thus a sighting in interval one, for which the actual angle was not measured, was assigned an angle of 5^0 and the PSD calculated using that value.

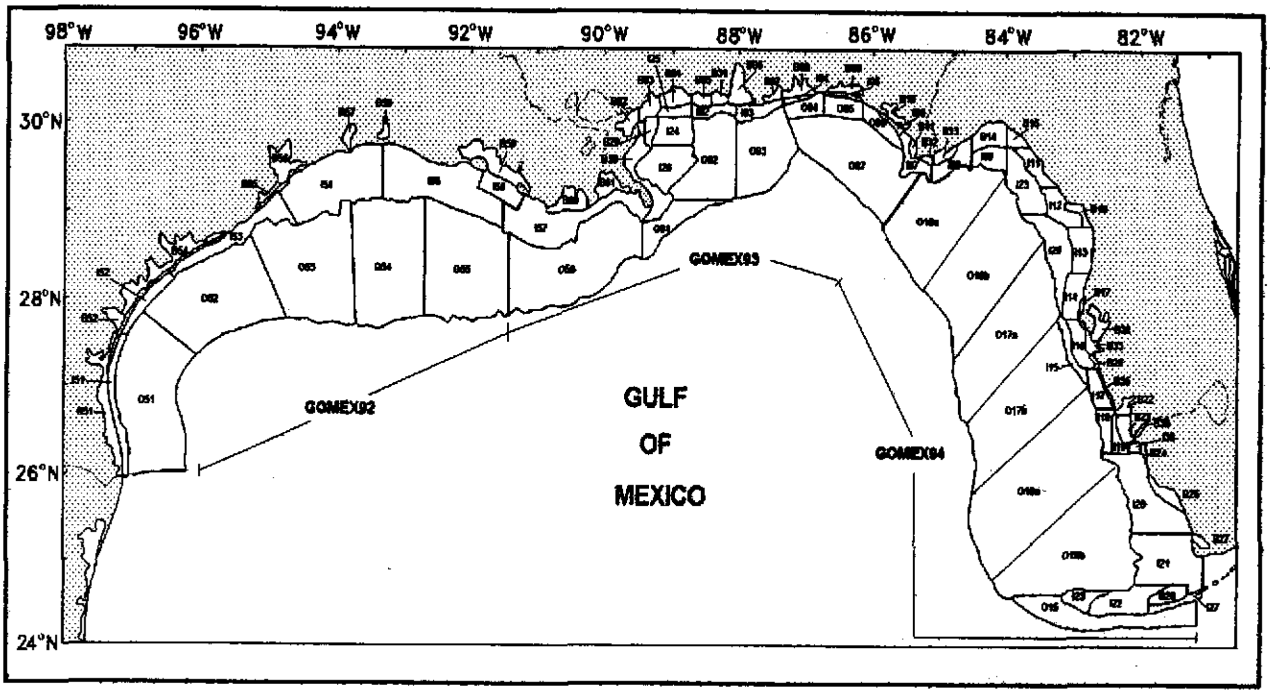

Figure 2. *Gulf of Mexico regional survey (GOMEX) areas. Offshore survey blocks are denoted by the prefix "O", inshore survey blocks by the prefix "I", and bays and sounds are denoted by the prefix "B".*

Analytical Methods

Bottlenose dolphin sighting data were analyzed using the computer program DISTANCE (Laake *et al.* 1993) to estimate dolphin density. Each transect was treated as a replicate unit of sampling effort. The effective strip half-width was determined using the computer program DISTANCE (Laake *et al.* 1993) to fit the PSD data to a uniform distribution function, a half-normal, and the hazard-rate model and evaluating the probability density function (PDF) model at the transect [g(0)] (Buckland *et al.* 1993). A separate PDF was modeled for each of the two SECAS altitudes and for each GOMEX stratum using PSD data pooled within strata.

Akaike's Information Criterion (AIC, Akaike 1973) incorporates the log-likelihood function and the number of parameters for each candidate model to identify a model that fits the data well with fewest parameters (Buckland *et al.* 1993). DISTANCE was instructed to choose the PDF model having the lowest AIC value to estimate $\hat{f}(0)$ — the reciprocal of the effective strip half-width (in km). The PDF model was constructed using the measured PSD data; however, for the χ^2 goodness-of-fit test, used here to illustrate how well the chosen model fit the data, the PSD data were grouped into unequal sized intervals corresponding to the 10^0 declination intervals with some pooling. In modeling the PDF for the GOMEX surveys, DISTANCE extrapolated to g(0) through the 0-50 m interval because there were few sightings in that interval (i.e. PSD data were left-truncated). SECAS and GOMEX data were right-truncated for analyses at differing distances depending upon the PSD distribution (Buckland *et al.* 1993).

Linear regression was used to determine if the log-transformed herd size and g(x) were related. DISTANCE adjusted the mean herd size to compensate for PSD-herd size bias if the correlation was significant at $\alpha \leq 0.15$. No attempt was made in these analyses to correct for biases which may have resulted due to excessive solar glare or high sea states except that surveys were not conducted when seas exceeded 3-4 feet with numerous whitecaps.

Where each transect is treated as a replicate sample Buckland *et al.* (1993, pg. 91) defined density:

$$\hat{D}=\frac{n\hat{f}(0)\hat{E}(S)}{2l_i},$$

where: $i = 1..k$, for k transects;
n_i = the number of bottlenose dolphin herd sightings on transect i;
$\hat{E}(S)$ = the expected herd size; and
l_i = the length of transect i.

Dolphin density was calculated for each stratum using the line length-weighted density estimates (Buckland *et al.* 1993, pg. 92, eq. 3.14) :

$$\hat{D}=\frac{[\sum_{i=1}^{k} l_i\hat{D}_i]}{L},$$

with total line length L. Dolphin abundance is the product of bottlenose dolphin density and the survey area. Variance was estimated using 500 bootstrapped sample density means (Efron 1982).

RESULTS

Southern U.S. Atlantic Coast

The southern U.S. Atlantic coastal survey area (blocks 1-9 in Figure 1) encompassed approximately 89,856 km^2 and was surveyed at approximately 3.3% visual coverage of the water surface. Survey results are summarized in Table I. The half-normal model with no adjustment terms (Figure 3) provided the best fit to the survey data collected at 152 m altitude and the hazard rate model with no adjustment terms fit the 229 m altitude data best (Figure 4). Truncation resulted in discarding 3 of 51 sightings (6%) at 152 m altitude and 4 of 79 sightings (5%) at 229 m altitude. The effective strip width at 152 m altitude was 0.291 km and at 229 m altitude it was 0.535 km. The relationship between g(x) and the natural logarithm of observed herd size was significant at both altitudes, therefore the expected herd size [$\hat{E}(S)$], calculated using the PDF model, was used in estimating dolphin density. The observed mean herd size at 152 m altitude was 4.15 (SE = 0.860) and at 229 m altitude the observed mean herd size was 5.17 (SE = 0.823). $\hat{E}(S)$ using the PDF models (Table I) did not differ significantly between altitudes (t-test, $P > 0.50$); however, estimated dolphin density ($\hat{D}$, Table I) did differ significantly between altitudes (t-test, $P < 0.005$). Pooled bottlenose

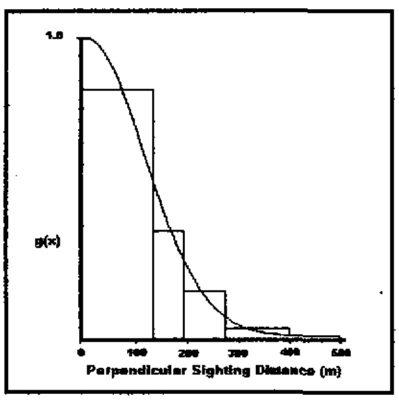

Figure 3. *Half-normal model (curve) fit to the perpendicular sighting distance distribution of bottlenose dolphin herd sightings from SECAS surveys at 152 m altitude (histogram).*

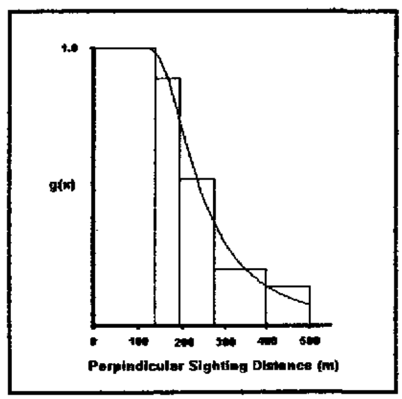

Figure 4. *Hazard rate model (curve) fit to the perpendicular sighting distance distribution of bottlenose dolphin herd sightings from SECAS surveys at 229 m altitude (histogram).*

dolphin abundance (Â), weighted by effort at survey altitude, in the survey area in winter 1992 was estimated to be 12,435 dolphins (cv = 0.18). The approximate 95% confidence interval, assuming a log-normal distribution with standard normal deviate $Z_{0.05}$= 1.96 , was 9,684 < Â < 15,967.

Gulf of Mexico

Table I summarizes GOMEX survey data for each stratum. On-transect survey effort totaled 5,578 km in bays and sounds, 4,806 km in the coastal stratum, and 7,678 km in the OCS stratum. GOMEX bay and sound herd sighting data were right-truncated at 500 m from the transect, coastal stratum sightings were truncated at 450 m, and offshore sightings were truncated at 650 m. All were left truncated at 50 m because of a low sighting rate in the interval 0-50 m. Abundance was estimated for each survey block in GOMEX92 and GOMEX93 shown in Figure 2 (Table II).

Comparison of the results of Gulf of Mexico regional aerial surveys in 1984-85 with 1992-93 results shows a general increase in bottlenose dolphin numbers in all strata (Table II); however, this increase was not statistically significant in the pooled coastal stratum (*t*-test, P > 0.10). Pooled bay and sound stratum estimates were significantly higher in 1992-93 than in 1984-85 (*t*-test, P < 0.0005), as were the pooled bottlenose dolphin abundance estimates in the outer continental shelf stratum (*t*-test, P < 0.025).

Bays and Sounds

The uniform model with two cosine adjustment terms provided the best fit to the PSD data (Fig. 5) in the Gulf of Mexico bays and sounds. Truncation resulted in the elimination of 16% (29 of 175) of the sightings in that stratum. The estimated effective strip width was 0.441 km and areal coverage was approximately 11.4%. The relationship between g(x) and the log-normal transformed mean herd size (4.68 dolphins/herd, SE = 0.348) was statistically significant, so Ê(S) (Table I) was estimated using the uniform PDF model. The pooled bottlenose dolphin abundance estimate in Gulf of Mexico bays and sounds was 3,554 (95% CI = 2,924 - 4,319; Table I) and ranged from 0 to 508 (Table II).

Coastal Stratum

A hazard rate model with no adjustment terms fit the coastal stratum bottlenose dolphin PSD data best (Fig. 6). Data truncation resulted in the elimination of 17 of 93 herd sightings or 18%. Estimated effective strip width was 0.547 km and areal coverage was approximately 5.0%. The log-normal transformed mean herd size and g(x) were not significantly related, therefore Ê(S) was estimated as observed mean herd size in calculating dolphin density (Table I). Bottlenose dolphin abundance in the pooled Gulf of Mexico coastal survey stratum was estimated at 7,690 dolphins (95% CI = 5,749 - 10,286; Table I). Individual survey block estimates ranged between 0 and 2,056 dolphins (Table II).

Outer Continental Shelf

A hazard rate model with no adjustment terms provided the best fit to the PSD data (Fig. 7). Data truncation resulted in discarding 11 of 92 herd sightings (12%). Estimated effective strip width was 0.546 km and areal coverage was approximately 3.3%. The log-normal transformed mean herd size was not significantly related to PSD, therefore Ê(S) for calculating bottlenose dolphin density was the observed mean herd size (Table I). Estimated bottlenose dolphin abundance in individual Gulf of Mexico OCS survey blocks (Fig. 2) ranged between 0 and 6,592 (Table II). The pooled bottlenose abundance estimate (Â) for the northern and western U.S. Gulf of Mexico OCS area surveyed during GOMEX92 and GOMEX93 was 22,496 dolphins (cv = 0.18) with a log-normal approximate 95% confidence interval of 17,520 < Â < 28,885 dolphins (Table I).

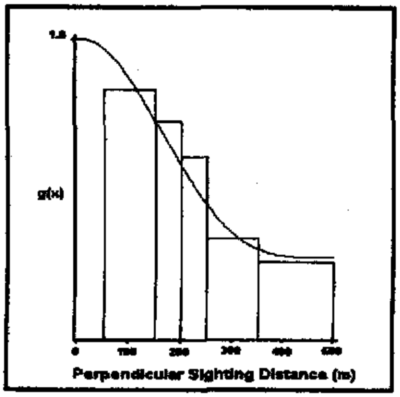

Figure 5. *Uniform model with two cosine adjustment terms (curve) fit to the perpendicular sighting distance distribution of bottlenose dolphin herd sightings in Gulf of Mexico bays and sounds (histogram).*

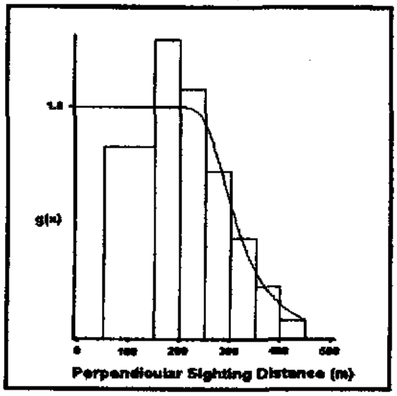

Figure 6. *Hazard rate model (curve) fit to the perpendicular sighting distance distribution of bottlenose dolphin herd sightings in Gulf of Mexico coastal survey blocks (histogram).*

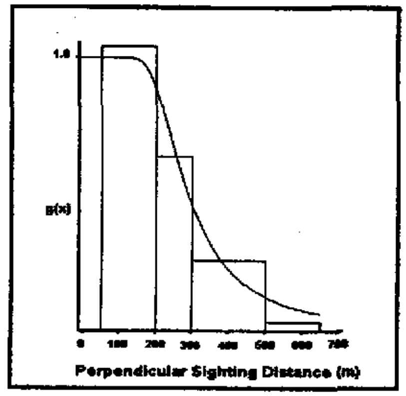

Figure 7. *Hazard rate model (curve) fit to the perpendicular sighting distance distribution of bottlenose dolphin herd sightings in Gulf of Mexico outer continental shelf survey blocks (histogram).*

Table I. *Survey summary data. N is the number of transects (samples), L is total on-effort transect length, n is the number of bottlenose dolphin herd sightings, $\hat{f}$ (0) is the detection function evaluated at the transect followed by the associated χ^2 statistics, $\hat{E}$ (S) is the expected herd size, $\hat{D}$ is the average bottlenose dolphin density throughout the stratum, cv is coefficient of variation of $\hat{D}$ based upon 500 bootstrapped replicate samples, and $\hat{A}$ is bottlenose dolphin abundance. The pooled SECAS abundance estimate was weighted by survey effort. The approximate 95% confidence interval (95% CI) is based on a log-normal distribution with Z = 1.96.*

Survey stratum	N	L (km)	n	$\hat{f}(0)$	cv($\hat{f}(0)$)	χ^2	*df*	P >χ^2	$\hat{E}$(S)	cv($\hat{E}$(S))	$\hat{D}$	cv$\hat{D}$	$\hat{A}$	95% CI
SECAS:														
152 m altitude	51	4,719	48	6.880	0.10	0.1027	3	0.99	3.54	0.15	0.124	0.26	11,142	7,789-15,939
229 m altitude	33	3,017	75	3.741	0.11	0.5296	2	0.77	3.52	0.14	0.164	0.28	14,736	10,031-21,648
pooled	84	7,736	123	—	—	—	—	—	—	—	0.139	0.18	12,435	9,684-15,967
GOMEX:														
bays and sounds	383	5,578	146	4.538	0.14	1.2020	2	0.55	3.30	0.07	0.164	0.14	3,554	2,924-4,319
coastal	207	4,806	76	3.657	0.07	2.3307	4	0.68	6.09	0.12	0.146	0.21	7,690	5,749-10,286
OCS	103	7,678	82	3.664	0.12	1.9576	1	0.16	9.32	0.14	0.169	0.18	22,496	17,520-28,885

DISCUSSION

Southern U.S. Atlantic Coast

The primary rationale behind conducting the SECAS surveys during the winter was to obtain an abundance estimate for the shallow, warm water Atlantic bottlenose dolphin ecotype (as described by Hersh and Duffield 1990) in U.S. Atlantic coastal waters. This ecotype is not believed to generally occur north of Cape Hatteras during the winter (Mead 1975, CeTAP 1982) in the United States. A recent exception to this pattern was numerous sightings of two bottlenose dolphins at Cape Cod and Plymouth Harbor, Massachusetts from May 6, 1990 to January 17, 1992, reported by Wiley *et al.* (1994); however, it could not be determined to which ecotype these belonged. Individual bottlenose dolphins appearing to be of the shallow, warm water ecotype have remained in coastal Virginia waters far beyond their normal seasonal residency period on at least two occasions in recent years (Blaylock, personal observation). The possibility therefore exists that the dolphins wintering in coastal Massachusetts were extralimital strays of the shallow, warm water ecotype; however, this phenomena has little bearing on the normal pattern of coastal bottlenose dolphin abundance.

Table II. *Estimated bottlenose dolphin abundance (Â) in Gulf of Mexico from regional aerial surveys conducted in autumn 1984-85 and September-October 1992 and 1993. Approximate confidence limits for 1992-93 survey block abundance estimates assumed a log-normal distribution using the variance estimated from 500 bootstrapped replicate samples with $Z_{0.05}$ = 1.96 and $Z_{0.20}$ = 1.28. Abundance estimates from regional aerial surveys conducted in autumn 1984 and 1985 (Scott et al. 1989) are provided for comparison. Refer to Figure 2 for survey block locations.*

Block	Â (1984-85)	cv(Â) (1984-85)	Â (1992-93)	cv(Â) (1992-93)	Lower 95% confidence limit	Upper 95% confidence limit	Lower 80% confidence limit	Upper 80% confidence limit
B02	33	0.18	117	0.53	58	236	66	206
B03	0	—	266	0.25	188	377	201	353
B04	260	0.15	508	0.23	372	694	395	654
B05	39	0.18	104	0.49	55	198	62	175
B06	36	0.18	122	0.34	77	194	84	178
B07	0	—	0	—	—	—	—	—
B08	0	—	33	0.80	12	88	15	73
B09	59	0.24	242	0.31	159	368	172	340
B10	42	0.24	124	0.57	59	259	68	225
B11	48	0.30	0	—	—	—	—	—
B12	51	0.31	19	0.63	8	43	10	37
B13	0	—	368	0.36	225	602	247	548
B14	211	0.22	491	0.39	291	829	322	750
B15	0	—	0	—	—	—	—	—
B29	94	0.14	291	0.24	210	404	223	379
B30	0	—	0	—	—	—	—	—
B31	165	0.16	115	0.38	68	194	76	175
B51	136	0.33	80	1.57	17	382	23	283
B52	0	—	58	0.61	26	128	31	110
B53	87	0.24	55	0.82	20	150	25	123
B54	57	0.27	61	0.45	33	111	38	99
B55	0	—	29	1.10	8	101	11	80
B56	0	—	152	0.43	85	271	95	242
B57	0	—	0	—	—	—	—	—
B58	0	—	0	—	—	—	—	—
B59	0	—	0	—	—	—	—	—
B60	121	0.26	100	0.53	50	201	57	176
B61	132	0.30	219	0.55	107	448	123	390
Bays	1,571	0.07	3,554	0.14	2,924	4,319	3,036	4,161
I02	0	—	243	0.67	103	571	122	484
I03	0	—	331	0.58	155	707	179	611
I04	10	0.21	0	—	—	—	—	—
I05	46	0.16	0	—	—	—	—	—
I06	332	0.18	263	1.08	77	900	97	711
I07	630	0.18	64	0.79	24	169	29	140
I08	109	0.25	275	0.49	143	529	162	467
I09	192	0.15	292	0.53	145	588	166	514
I24	0	—	574	0.47	308	1,070	347	949
I25	0	—	93	0.89	32	271	39	221
I26	0	—	2,056	0.34	1,295	3,264	1,415	2,987
I51	305	0.21	953	0.37	577	1,574	635	1,429
I52	203	0.16	280	0.46	151	519	170	461
I53	0	—	409	0.30	272	615	294	569
I54	2,259	0.17	1,404	0.40	824	2,393	913	2,160
I55	1,424	0.19	359	0.67	153	842	180	715
I56	0	—	94	0.94	31	286	38	231
I57	527	0.15	0	—	—	—	—	—
Coastal	6,037	0.08	7,690	0.21	5,749	10,286	6,079	9,727
O01	no survey	—	0	—	—	—	—	—
O02	973	0.21	1,915	0.36	1,177	3,116	1,292	2,838
O03	883	0.19	902	0.46	486	1,674	547	1,487
O04	209	0.17	0	—	—	—	—	—
O05	646	0.16	374	0.57	179	784	206	680
O06	694	0.21	0	—	—	—	—	—
O07	2,794	0.19	969	0.68	407	2,307	481	1,954
O51	1,418	0.16	339	0.92	113	1,013	140	821
O52	1,470	0.14	6,210	0.23	4,491	8,587	4,779	8,069
O53	2,065	0.16	3,859	0.32	2,495	5,969	2,713	5,490
O54	730	0.22	595	0.59	277	1,277	321	1,103
O55	4,302	0.18	741	0.59	343	1,601	398	1,381
O56	0	—	6,592	0.21	4,906	8,858	5,192	8,370
OCS	16,184	0.07	22,496	0.18	17,520	28,885	18,381	27,532

The U.S. mid-Atlantic coastal migratory bottlenose dolphin stock, presumably a component of the shallow, warm water ecotype population, is believed to generally migrate northward during the summer to at least southern New Jersey (Kenney 1990). It was historically found as far north as Long Island in the summer (Mead 1975) and apparently resides south of Cape Hatteras during the winter (Mead 1975, CeTAP 1982, Kenney 1990), but how far south its winter range extends is unknown.

Stock definition is problematic; there are a variety of possible stock structures within the coastal Atlantic bottlenose dolphin population. The simplest hypothesis treats the shallow, warm water ecotype as a single stock throughout its range in the western North Atlantic. Other hypotheses divide the population into multiple stocks — one or more coastal migratory stocks, ranging from mid-Florida to Long Island in the summer, and a number of localized, resident stocks. It seems clear from a number of photo-identification studies underway along the U.S. Atlantic coast that there are numerous localized, resident stocks south of Cape Hatteras.

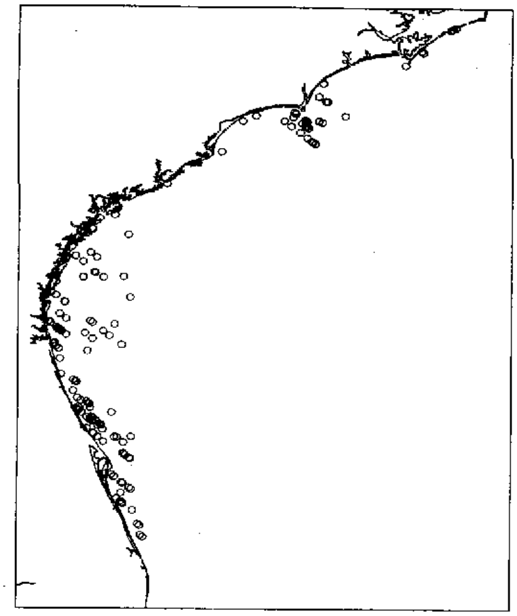

Figure 8. *Bottlenose dolphin sightings from SECAS winter surveys. Note that there is no apparent longitudinal gap in sightings.*

Another confounding factor affecting interpretation of the results of the SECAS surveys is the possible co-occurrence of the deep-water ecotype of bottlenose dolphin with the shallow, warm water ecotype in the area south of Cape Hatteras. It is apparent, based on genetic and morphological studies, that both ecotypes occur south of Cape Hatteras (Hersh and Duffield 1990). Kenney (1990) reported a disjunct longitudinal distribution between inshore and offshore sightings of bottlenose dolphins at the 25 m isobath during the CeTAP surveys north of Cape Hatteras; however, the offshore distribution of bottlenose dolphins has not been described south of Cape Hatteras and no longitudinal separation of sightings was apparent in the SECAS survey area (Figure 8). Data collected during SEFSC marine mammal survey cruises in 1985 and 1992 suggests that the deep-water ecotype inhabits waters along and beyond the outer continental shelf edge in this area (NMFS, unpublished data).

The SECAS abundance estimate for the southeastern U.S. coastal bottlenose dolphin population probably includes some resident dolphins and may include some of the deep-water ecotype as well; however, the contribution of these stocks to the abundance estimate reported here is unknown.

U.S. Gulf of Mexico

Genetic studies being conducted by SEFSC personnel indicate that there is also a shallow, warm water ecotype and a deep-water ecotype of bottlenose dolphin in the Gulf of Mexico; however, SEFSC survey data suggest that the deep-water ecotype inhabits the edge of the outer continental shelf and slope waters (NMFS, unpublished data). GOMEX survey strata and many of the survey blocks were based on historical management units (Scott *et al.* 1989) which were developed considering the possibility of localized, resident bottlenose dolphin stocks in the Gulf of Mexico. However, detailed genetic, behavioral, and other biological data are currently lacking for most of the Gulf of Mexico bays and virtually all of the inshore and OCS strata and there may be no biological basis for separating bottlenose dolphin stocks in terms of all of the GOMEX survey strata.

There is reason to believe that some genetic exchange may occur between dolphins inhabiting the inshore stratum and dolphins from bays and sounds in the Gulf of Mexico. Radio tracking experiments in Texas showed limited movement of tagged individuals within Matagorda Bay, but this study was of short duration (Würsig and Lynn, unpublished draft contract report). A bottlenose dolphin which was captured in Matagorda Bay and freeze-branded for identification purposes was recently reported as having been seen near the mouth of the Brazos River near Freeport, Texas (W. Teas, SEFSC, personal communication, 1994). Movement between these bays would require traversing through the inshore stratum. Groups of female bottlenose dolphins in Sarasota Bay, Florida, appear to have rather limited home ranges, but the male social groups are wide-ranging (Wells *et al.* 1980) and probably maintain some genetic diversity among the bay resident groups (Dowling and Brown 1993). In addition, mixing occurs between Sarasota Bay resident groups and dolphins from the adjacent Gulf of Mexico and Tampa Bay community on the periphery of the Sarasota community's home range (Scott *et al.* 1990). It is likely that bottlenose dolphins in other enclosed systems in the Gulf of Mexico maintain genetic diversity through similar social systems.

Stock Structure

The problem of bottlenose dolphin stock structure is particularly relevant to the potential biological removal (PBR) concept established by enactment into public law of the 1994 amendments to the Marine Mammal Protection Act on April 30, 1994 (Pub. L. 103-238). PBR was defined as the number of animals, not including natural mortalities, that may be removed from a stock while allowing the stock to reach or maintain its optimum sustainable population level (OSP). The MMPA defined OSP as, "with respect to any population stock, the number of animals which will result in the maximum productivity of the population or the species, keeping in mind the carrying capacity of the habitat and the health of the ecosystem of which they form a constituent element".

Stock definition is important for current management strategies because both PBR and OSP determinations are likely to be sensitive to stock delineation. The MMPA defined "stock" as a group of animals in common spatial arrangement that interbreed. Unfortunately, the concept of a common spatial arrangement is not well defined. Sufficient genetic exchange may occur among the shallow, warm water ecotype to consider them a single stock along the U.S. Atlantic coast. The level of genetic diversity necessary to separate bottlenose dolphin populations into stocks for successful management is a technical problem which requires a greater understanding of the population's genetic and social structure.

The MMPA also required that a stock be maintained as a functioning element of the ecosystem. Depending upon one's point of view, an ecosystem could range from a single embayment to an expanse of ocean. Bottlenose dolphins inhabiting relatively small and confined enclosed systems in the U.S. might be subject to increased anthropogenic mortality due to their proximity to humans. Such dolphins could be at increased risk of being affected by catastrophic events or by chronic, cumulative exposure to anthropogenic activities or compounds. Assigning the PBR level for all dolphins as a single stock, instead of assigning a PBR level for each local resident stock, incurs the risk of allowing the incidental removal of an excessive number of the dolphins within a particular bay or sound. While this might produce an interesting experiment in recolonization, it could instead lead to the removal of the entire bottlenose dolphin stock from within that ecosystem.

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