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Harbor Porpoise, *Phocoena phocoena*, in the U. S. Coastal Waters of the Gulf of Maine: A survey to determine seasonal distribution and abundance

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Abstract

A shipboard survey to assess the distribution and abundance of harbor porpoise (Phocoena phocoena) in the U. S. coastal waters of the Gulf of Maine was conducted in July of 1982. The distribution of porpoise during that season extended from Port Clyde, Maine, northeastward to at least the Maine/New Brunswick border. Density estimates for the areas in which Phocoena were observed ranged from 4.02 to 5.96 porpoise per square mile. Statistical analysis of all sightings recorded from the coastline to three miles beyond the 50 fathom contour results in a minimum population estimate of 7,956 $\pm$ 1,327 (95% C.I.) and a maximum estimate of 15,300 $\pm$ 2,552 harbor porpoise for the survey area.

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Introduction

Although harbor porpoise (Phocoena phocoena) are among the most studied cetaceans, a review of published and unpublished material (Prescott and Fiorelli, 1980) revealed that little is known of the current distribution and abundance of this species in the coastal and offshore waters of the United States northwest Atlantic region. Research in the Canadian northwest Atlantic, conducted for more than ten years in the Bay of Fundy by Dr. David Gaskin, University of Guelph, Ontario, Canada, includes studies on behavior, activity patterns, habitat use, and levels of environmental contaminants (Gaskin, 1977; Gaskin et al 1976, 1975). Limited information is available from this work on local abundance, summer distribution, and daily movement.

Records from the New England Aquarium stranding and salvage network, established in 1974, indicate that harbor porpoise are the most frequent single stranded cetacean along the East Coast north of Cape Hatteras (Prescott and Fiorelli, 1980). In addition, the species is particularly susceptible to entrapment and entanglement in gill nets, is subject to some direct take, and may be affected by environmental contaminants. In the Baltic and North Seas, the harbor porpoise population decline has been associated with pollution and habitat degradation (Anderson, 1975).

Since 1980, the New England Aquarium has conducted a series of research programs to address information needs for this species. In 1980, studies on habitat use, subsistence hunting, and survey methodology were completed. This paper reports on our most recent work, a survey designed to estimate the size and summer distribution of harbor porpoise in the coastal waters of the Gulf of Maine.

Methods

Harbor porpoise were surveyed from July 1-15, 1982, in a 3,047 nm^2 study area that extended from Boston, Mass., to Cutler, Maine, and included the coastal waters out to three miles beyond the 50-fathom depth contour. The choice of this study area was based on historical distributions for that time of year (Stone, et al, 1982; CeTAP, 1982; Ramsdell, 1977; Gaskin, 1974; Katona, 1973, 1974, 1975, 1976; Katona et al, 1977).

Forty-five (45) survey lines were laid out perpendicular to the coast on a nautical chart. The placement of survey lines was determined by identifying 30 potential survey lines, one every 0.5 nm, within the first fifteen miles of coastline from Boston to Cape Ann, Mass. Three survey lines were then randomly chosen from this pool of 30 possible transects. The spacing of these three lines was then repeated every fifteen miles along the coast to determine the remaining 42 lines (Figs 1, 2, and 3).

The following areas were not sampled with a randomized design: Jeffrey's Ledge (offshore from Massachusetts and New Hampshore), and Casco, Penobscot, Blue Hill, and Frenchman's Bays in Maine. In these areas systematic search patterns were used to make minimum counts.

After the survey lines had been chosen, the study area was divided into three sub-areas (I, II, III) and one survey vessel was assigned to each. The 30' R/V Nereid was used in area I, the 34' M/V Gatherer in area II, and the 34' R/V Beluga in area III. Navigation was done by dead reckoning and bottom sounding in areas II and III, while Loran C was used in area I. Survey speeds were 9-10 knots in areas II and III, and twelve knots in area I. On all three vessels, eye level for observers was between 9 and 12 feet.

Observers were trained in the survey methods at the New England Aquarium and in Boston Harbor, Mass., prior to the survey (copies of training material and field forms are included in Appendix I). While on survey transects, two observers were on watch, each covering a forward quarter (90^{o}) of the field of view. Observers scanned the sea surface with the naked eye and only used binoculars to verify sightings and species identifications. A third researcher recorded

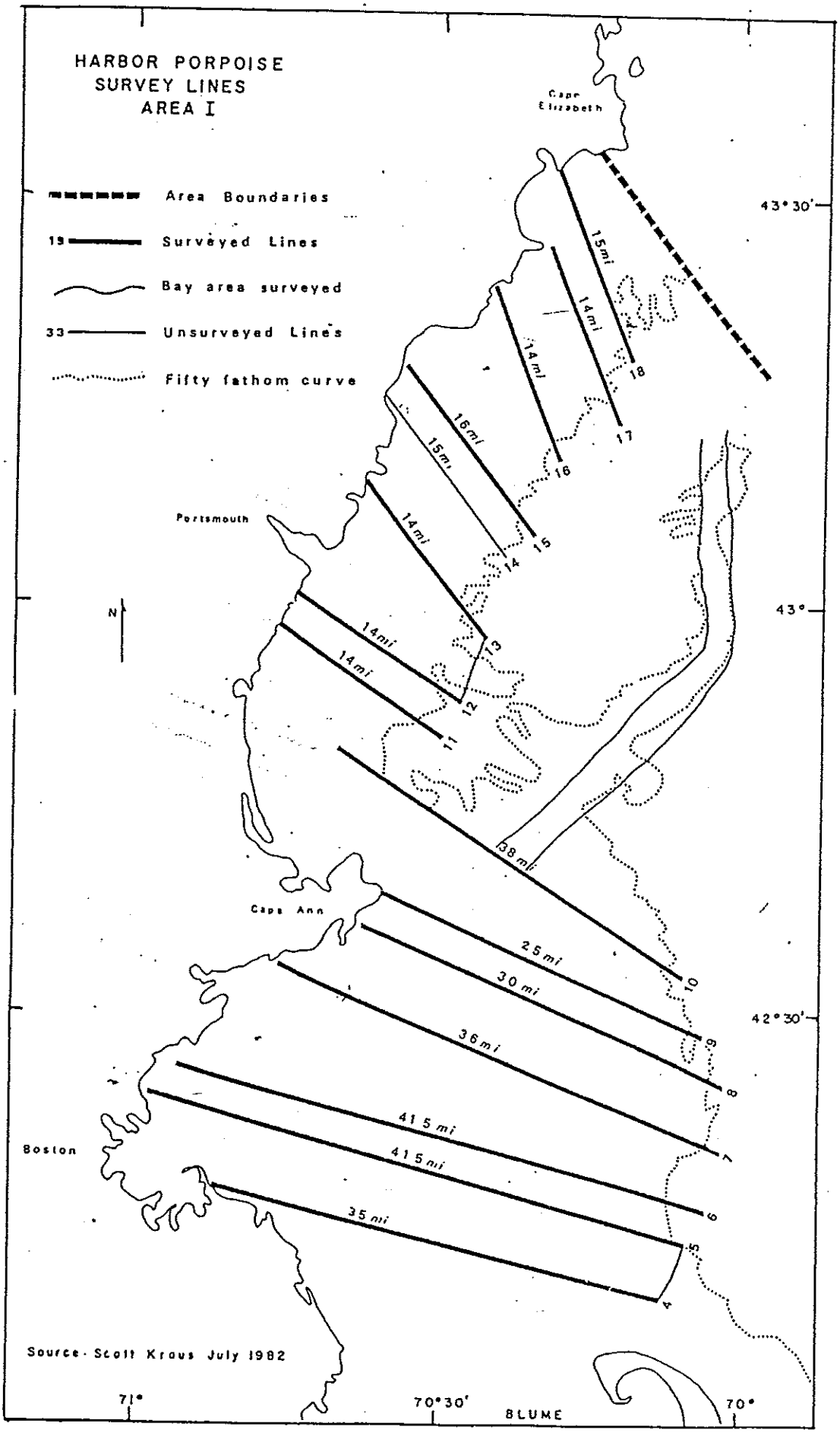

Figure 1. Harbor porpoise survey lines for Area I

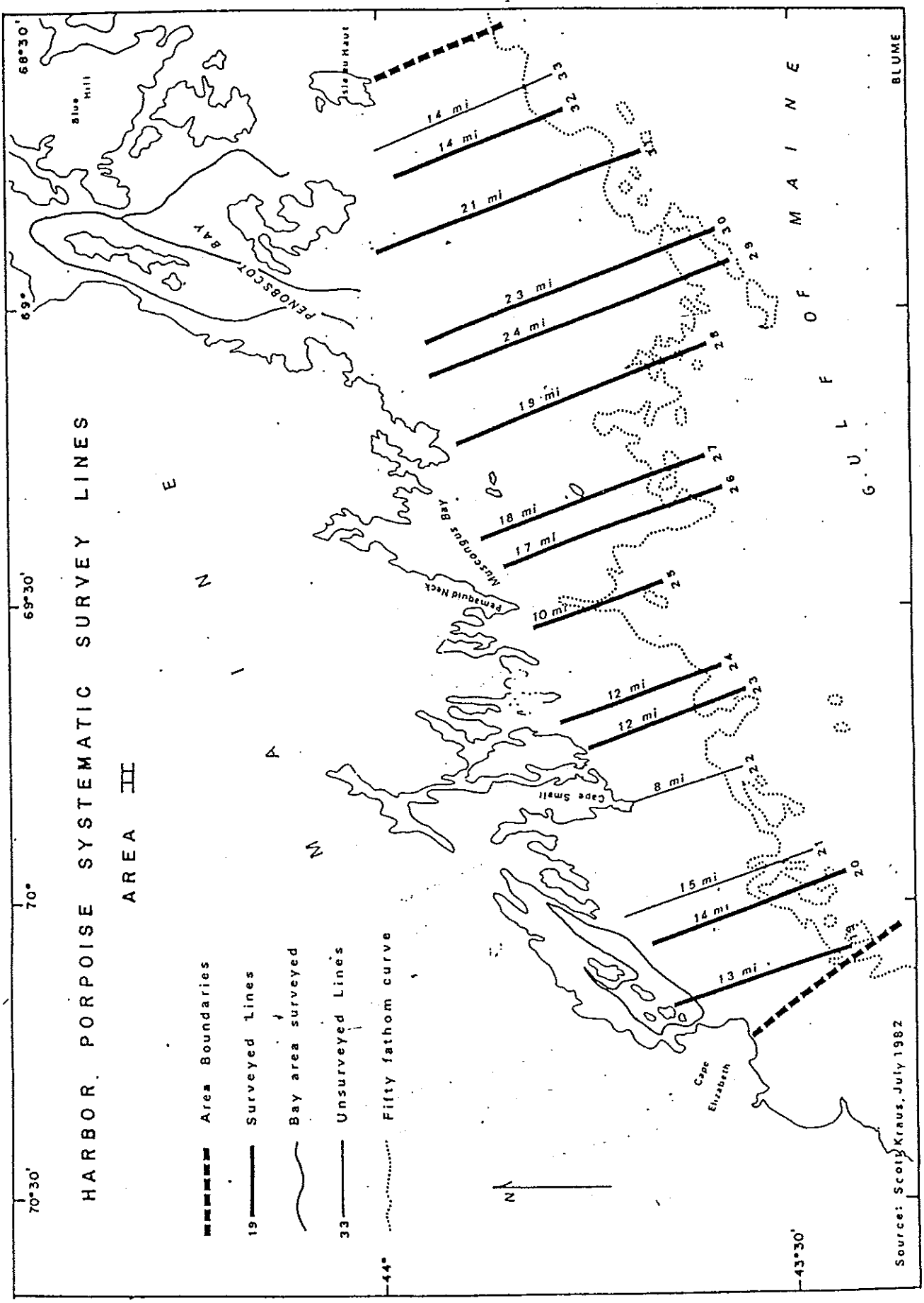

Figure 2. Harbor porpoise survey lines for Area II

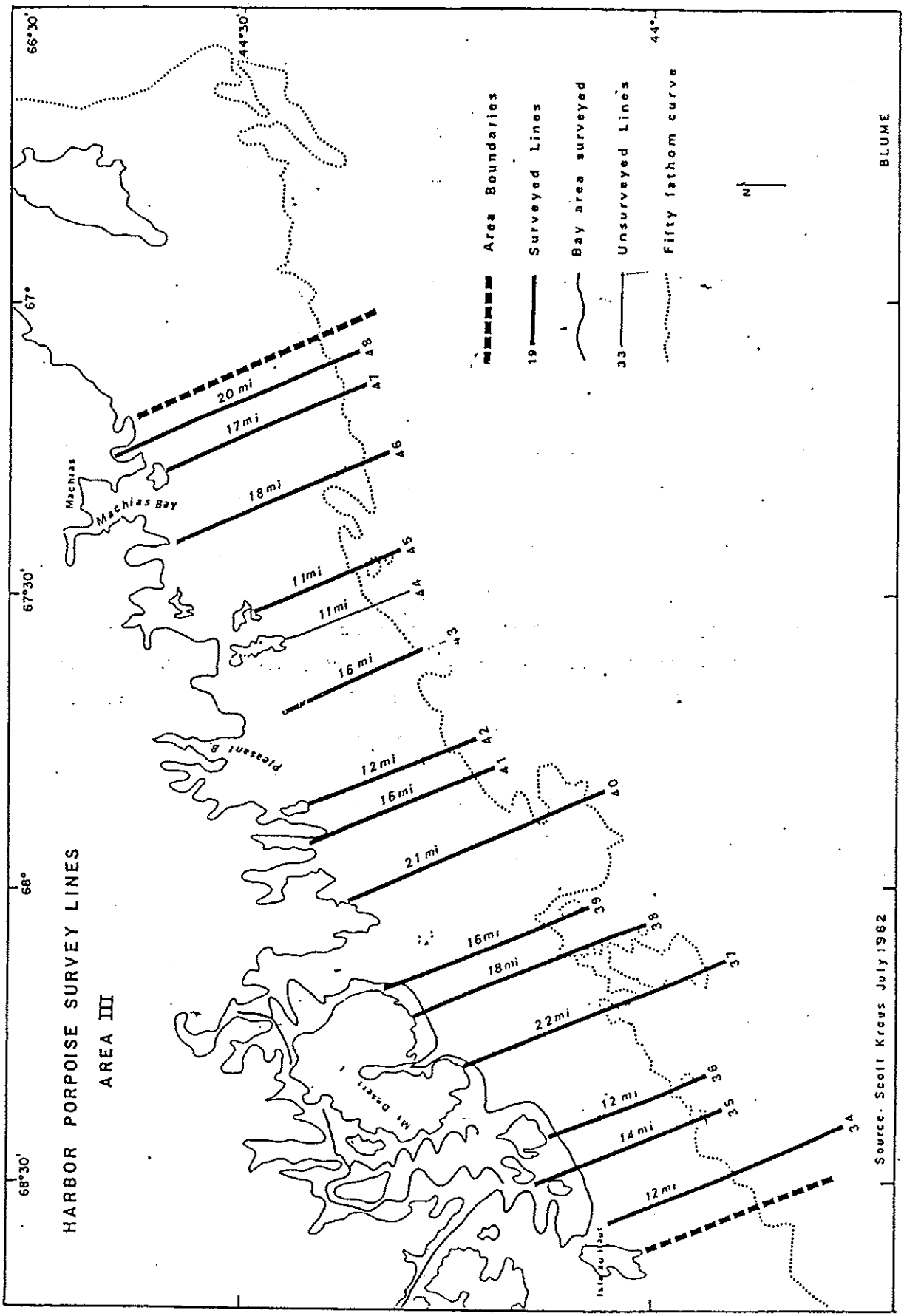

Figure 3. Harbor porpoise survey lines for Area III

the following data on standardized field forms: time of the sighting, position, number of animals, animal heading, right angle distance from trackline, sea state and weather. The right angle distance of porpoise from the trackline was estimated when the position of the porpoise sighting came abeam of the vessel. Right angle distances were grouped into five categories:

A. Less than 100m
B. 100-199m
C. 200-299m
D. 300-399m
E. 400m and over.

A frequency distribution of right angle distances for all porpoise sightings (Fig. 4) indicated that the effective strip width was 800m (0.5nm). Using this strip width, the survey sampled approximately 10% of the study area. Observers were trained in estimating distances with objects of known distance such as buoys and landmarks. To maintain accuracy, observers practiced estimating distances each day while transiting to survey lines. Surveys were conducted when the sea state was two or less on the Beaufort scale. If the sea state rose above a Beaufort two during a survey line, the line would be completed and the remaining survey terminated. Observers were changed every 0.5 hours to minimize fatigue and all observers rested during crosslegs. During two days in area I, observers did not rotate because no additional observers were available; however, 10-minute rest periods were taken between each transect.

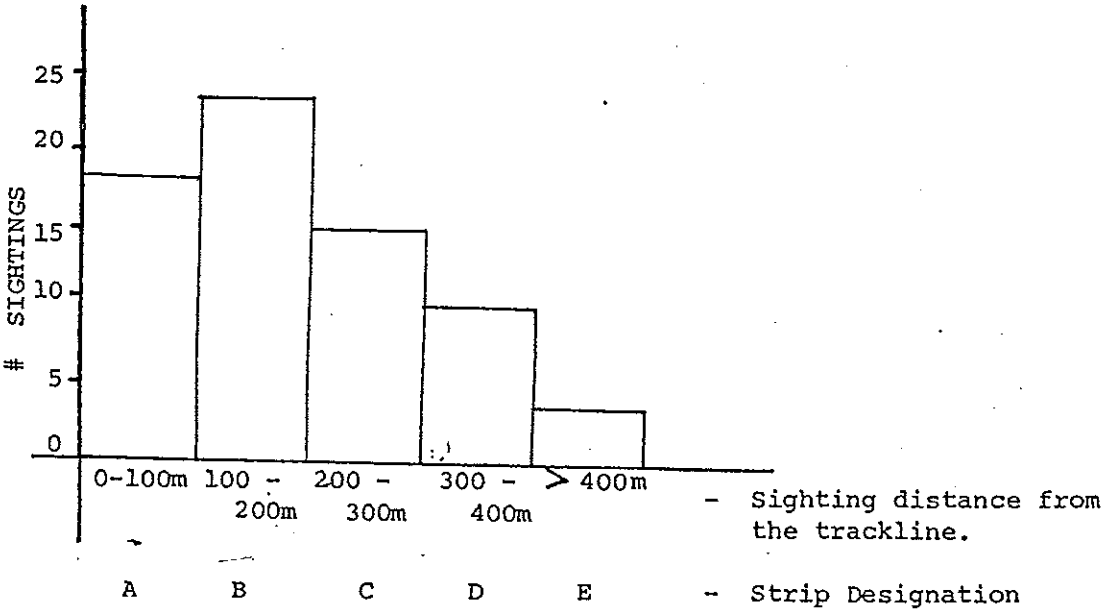

Figure 4. Frequency distribution of right angle distances of harbor porpoise from survey transects during July 1982 shipboard surveys.

Table 1

Summary of Results

% of Area Sampled	10%
Total Trackline Mileage	764.5
Analysis Area Mileage	289.5
% Surveyed in Sea State 0	34%
% Surveyed in Sea State 1	50%
% Surveyed in Sea State 2	15%
% Surveyed in Sea State 3	1.3%
Total Number of Sightings on Transect	78
Total Number Individuals on Transect	119
Total Number Individuals Sighted in Bays	38
Mean Group Size	1.5 $\pm$ 0.7
% of Immature Animals	9.5%
*Cox-Eberhardt Population Estimate (Eberhardt, 1978)	7,956 $\pm$ 1,327
*Corrected Population Estimate (Kraus et al)	15,300 $\pm$ 2,552

Results

Among the three vessels, 15 days of ship surveys were completed between July 1-15, 1982. Forty (40) lines were surveyed totaling 764.5 transect miles (Figs 1, 2, and 3). Sea state and visibility were excellent for most of the survey because of high pressure weather systems that stalled over the area. Results are summarized in Table 1. A total of 78 harbor porpoise sightings and 119 individuals were recorded on transects. Additionally, 38 harbor porpoise were observed in the Bays of Maine during minimum count surveys. The mean group size for all harbor porpoise sightings was 1.5 $\pm$ 0.7 (95% confidence) and 9.5% of animals observed were immature.

* See text for discussion of two estimates.

Distribution

Harbor porpoise were observed on 17 lines in a continuous area from Port Clyde to Cutler, Maine. No harbor porpoise were observed to the southwest of this area and no surveys were conducted to the northeast. Because porpoise distribution was confined to this region (1519 nm^2), we consider this the analysis area and the population estimate is for this area only.

In order to evaluate inshore and offshore harbor porpoise distribution, each survey line was divided into four equal parts. Sightings for corresponding segments of each line were then compiled into four groups, each representing a proportional distance from shore. Chi-square analysis showed no significant difference in the distribution of harbor porpoise on this inshore/offshore axis ($X^2 = 1.04$, $p > 0.1$).

Another test was used to assess the distribution of harbor porpoise densities along the Southwest/Northeast axis of study area. Porpoise densities per trackline mile were calculated for each group of 3 survey lines. If harbor porpoise were distributed randomly, the expected density would have been 0.24 porpoise/trackline mile. Chi-square analysis showed no significant difference between the expected density and the actual densities ($X^2 = .5149$, $p > 0.1$).

Population Estimate

Sighting data from all survey lines northeast of Port Clyde, Maine, were randomly divided into four groups (G_1, G_2, G_3, G_4; Table 2). Data from each group were then analyzed to calculate independent harbor porpoise densities using

$$D = n/wL$$

where

D = porpoise/nm^2

n = total number of individuals seen

w = transect width (nm)

L = length of transect sampled (nm).

The Cox-Eberhardt method (Eberhardt, 1978) was applied to these density results to correct for differences in the sightability of porpoise at varying distances from the vessel ($f(0) = 6.35$). The four independent density estimates were then multiplied by the square mileage of the analysis area to obtain four population estimates. Averaging these population numbers yielded a mean population estimate of 7,956 $\pm$ 1,327 harbor porpoise (95% confidence).

Table 2

Densities and Population Estimates Based on Randomly Grouped Results of Survey Lines

	Groups			
	G_1	G_2	G_3	G_4
Uncorrected Densities Porpoise/nm^2	.91	.63	.82	.94
Corrected Densities Porpoise/nm^2 ($f(0) = 6.35$)	5.77	4.02	5.20	5.96
Population Estimates	8,765	6,106	7,899	9,053

The Cox-Eberhardt method (Eberhardt, 1978) as applied here takes into account variations in sightability of porpoise at different distances from the vessel, but only applies to animals at the surface, i.e., those available and seen by observers at any given time. An experiment on harbor porpoise survey methodology (Prescott et al, 1981; Kraus, Prescott and Gilbert, in press) indicated that shipboard surveys record an average of 52% of the porpoise in an area. In that study, daily variations in the percentage of porpoise sighted by shipboard observers ranged from 20% to 100%, perhaps due to variations in sighting conditions. Since this survey was mostly conducted in nearly ideal conditions (85% in sea states of 1 or less, see Table 1), the percentage of porpoise seen vs. porpoise available may be higher than the average. However, since we have no way of evaluating the sighting variability on this survey, 52% has been applied to this data as the best correction factor.

If data from the porpoise experiment is utilized, and 7,956 represents 52% of the coastal population of harbor porpoise during July, an estimate of 15,300 is a reasonable correction. Aerial survey data collected by the Cetacean and Turtle Assessment Program of the University of Rhode Island from 1979 to 1981

resulted in a population estimate of 2,240 ± 2,208 harbor porpoise in the Gulf of Maine during the summer (CeTAP, 1982). The survey methodology experiment indicated that aircraft sighted about 14% of available porpoise (Kraus, Gilbert and Prescott, in press). Application of the 14% figure to the CeTAP summer estimate of 2,240 results in an estimate of 16,000, close in agreement with our corrected shipboard estimate of 15,300.

In both the aerial and shipboard corrected estimates, the variances will increase correspondingly, i.e., 16,000 ± 15,771, and 15,300 ± 2,552. However, because of the small sample size in the porpoise survey methodology experiment, the sighting averages (52% for shipboard and 14% for aircraft) represent best estimates. Therefore, although 16,000 and 15,300 agree closely, they must be viewed cautiously as estimates of population size for harbor porpoise in the region surveyed.

Analysis of inshore/offshore distribution density did not show a significant difference between the coastal ends and the offshore ends of the survey lines, indicating the survey does not reach the offshore limits of harbor porpoise distribution. Further, sporadic sightings have been reported during July from the waters east of Cape Cod and the offshore waters of the Gulf of Maine outside of the 50-fm contour (S. Mayo, pers. comm.; CeTAP, 1982, 1981; Katona, 1976; Stone, Katona and Beard, 1983). Population estimates for July from the lower Bay of Fundy range from 810 (Gaskin, 1977)* to 967 (Prescott et al, 1981). These numbers are in reasonable agreement and probably accurately reflect the size of the porpoise population in the lower Bay of Fundy not surveyed during this assessment. These factors show that porpoise certainly inhabit other regions not surveyed by us during this time.

Thus, the distribution data from this survey, and the reported sightings from other regions ensure that the lower estimate given here (7,956 ± 1,327) represents a minimum population estimate for the Gulf of Maine and northeastern U. S. coastal waters. Application of corrective sighting factors to this estimate suggests that the harbor porpoise population for this region may be as large as 15,300.

* This estimate is based upon Gaskin's (1977) mean porpoise sightings per unit of effort (SPUE) data for 7 years (1969-1975); he estimates 1,240 porpoise for the region south of Pt. Lepreau in mid-August, and his mean SPUE data for the same time period indicate porpoise are approximately 2/3 as abundant during July.

Movements

The seasonal changes in the distribution of harbor porpoise in the survey region suggests a northeasterly coastwise movement of the population from May to July. Harbor porpoise were frequently sighted in Cape Cod Bay, on the northwestern arm of Stellwagen Bank, and along Jeffrey's Ledge in April and May of 1982 (New England Aquarium unpublished data; Dr. C. Mayo, S. Mercer, M. Weinrich, pers. comm.). Porpoise disappeared from that region by mid-June, and were limited to waters east of Port Clyde, Maine, during the July survey. On the other end of the study area, Gaskin's (1977) data, and surveys conducted in the Bay of Fundy during 1980 show a complementary trend (Kraus and Prescott, 1981). Porpoise abundance is low during May and June, gradually rising to a peak in mid-August.

Because the survey was accomplished within two weeks, by three vessels working simultaneously southwest to northeast within each area, porpoise movements are not likely to have affected the reliability of the survey counts. By the same token, no information is available from this survey on sho t-term movements. However, a second survey was attempted in late August in certain areas to look for changes in porpoise distribution and abundance. High winds resulted in the cancellation of any large scale survey attempts, but a few lines were completed (lines 31, 32, 40, 41, 42) in suitable conditions. Far fewer porpoise sightings were made than in the first survey along the same lines (36 during July 1-15, 7 on August 22 and 27). These data reflect a change in distribution of harbor porpoise population, but the limited August surveys were insufficient to indicate a direction of movement.

Discussion

This estimate of harbor porpoise abundance is the result of the first open-ocean shipboard random sampling effort for small cetaceans in the western North Atlantic. The estimates of 7,956 and 15,300 can probably be considered minimum and maximum estimates of harbor porpoise abundance in the region surveyed. The effects of seasonal porpoise movements upon the distribution data and population estimates given here are not known. There is clear seasonal and yearly variation in porpoise distribution and abundance in some regions (Gaskin, 1977).

Historical and recently collected CeTAP data suggest that most harbor porpoise are found within the 50-fm contour in the coastal waters of the Gulf of Maine during the summer months. However, porpoise are sometimes sighted in offshore and southern waters during this time, and certainly several hundred inhabit the Bay of Fundy during July (Gaskin, 1977; Prescott et al, 1980). Nevertheless, this survey did cover that portion of the population that seasonally inhabits the coastal waters of Maine, and therefore may be most vulnerable to human activities.

These relatively large estimates must be examined in light of recently discovered information on the apparent incidental take levels of this species from the offshore waters of New Hampshire and northern Massachusetts. S. Mercer (pers. comm.) estimates that perhaps as many as 600 Phocoena die in gill nets in this limited area each year. Incidental take in other portions of their range, some subsistence take, and other habitat related factors may combine to push mortality rates for this species to very high levels.

Further work on the status of harbor porpoise in U. S. Atlantic waters should focus on the sources and magnitude of incidental take, winter distribution and abundance, and the effects of habitat degradation on this species distribution and habitat use. To monitor this population's health, this type of survey should be repeated after an interval of perhaps 3-4 years.

Acknowledgements

The success of this survey is due to the extraordinary efforts of the primary field staff, Porter Turnbull, Nancy Gunnlaugson, Kathy Hazard, Heidi Hilgartner, Matt Hare, and Phil DeGoyler. Additional assistance was provided by Liz Kay, Linda Fogg, Lauri Rothstein, Steven Sweeney, and Katrina Van Dine. We are grateful to Dr. James Gilbert for his assistance with sampling design and data analysis, and to Eleanor Jensen who helped with several revisions of this report. Support for this work was provided by the National Marine Fisheries Service under Contract #NA-82-FA-C-00027, and the New England Aquarium.

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APPENDIX I-1

1982 HARBOR PORPOISE SURVEY PROCEDURES

OVERVIEW

The harbor porpoise survey will be conducted from July 5 to July 17 and cover an area from Cape Cod to Machias Seal Island out to the 50 fathom contour line. This region has been divided into three sub-areas and we will have one boat working in each. A randomized transect sampling plan will be used in the off-shore areas. In the bays of Maine and on Jeffreys Ledge we'll use non-random search patterns to make minimum counts.

There are 48 off-shore survey lines and they are divided among the three areas as follows:

AREA I

lines 1-18

499 nt. track miles
80 nt. X leg miles

577 total ÷ 80 nt. miles/day = 7 days (aprox.)

AREA II

lines 19-33

234 nt. track miles
40 nt. X leg miles

279 total ÷ 80 nt. miles/day = 3.5 days (aprox.)

AREA III

lines 34-48

236 nt. track miles
60 nt. X leg miles

302 total ÷ 80 nt. miles/day = 4 days (aprox.)

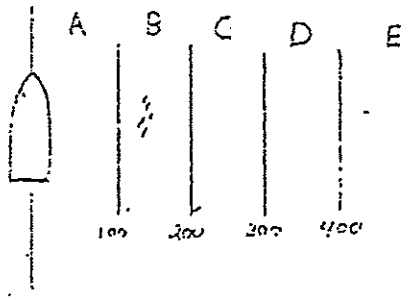
Our priority will be to survey the off-shore areas first because when the weather is bad there it's likely to be OK in the Bays.

SURVEY METHODOLOGIES

While on survey the boat should be run at a constant speed of 10 knots with one observer looking to port covering 270° - 000° and one looking to starboard covering 000° - 090°. Another person will be recording. Observers should be rotated every hour or every survey line, whichever comes first. Scan with your eyes and use a binocular only to check what you see.

When a sighting is made note the time, position, number and species. As the position of the sighting comes abeam of the boat estimate its right angle distance from the track line. Estimate distances in 100 meter intervals using the following catagories:

A = within 100 meters
B = between 100 and 200 meters
C = between 200 and 300 meters
D = between 300 and 400 meters
E = over 400 meters (¼ mile)



Also note which side of the boat the sighting was made using P (port) and S (starboard). Thus an entry might look like this:

TIME	POSITION	#	SPECIES		COMMENTS	PHOTOGRAPHER
0935	42 37, 67 24	5	P. phocoena	B/s	heading NW	no photographs

If the boat has loran, copy the position down at the time of the sighting. With no loran we can estimate position from the time of the sighting provided the boat maintains a constant speed and course. As you cruise around, plot all transits and cross legs on your charts. This will prove helpful during analysis.

Record information on other cetaceans and seals as your time will allow. Harbor porpoise are the priority and information concerning them should come first.

We are looking for a sea state of 2 or better and visibilty of at least ½ mile in order for the survey to be valid. If the weather deteriorates during a track line, complete the line before aborting the day.

DAILY SUMMARYS

At the end of each day, as you are going over the field forms, fill out a summary sheet. Summarize the weather, sightings, and survey lines that you did. Keep all information for each day in a separate manila folder.

Good luck with the weather and boats and Enjoy the survey!

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1982 HARBOR PORPOISE SURVEY GENERAL INFORMATION

AREA I

R/V NERIED

call letters: WQZ 3509
Staff: Scott Kraus and Porter Turnbull
working out of Boston Harbor

AREA II

M/V Gatherer

call letters: WRX 3950
Staff: Nancy Gunnlagsson and Heidi Hilgartner
Capt. Mark Sewell
working out of Boothbay Harbor

Area III

R/V Beluga

call letters: WXU 3943
staff: Greg Stone and Matt Hare
working out of Bar Harbor

TELEPHONE NUMBERS

New England Aquarium: (617) 742-8830
Scott Kraus (home): (617) 391-0942
College of the Atlantic: (207) 288-5015
Portland Weather Service: (207) 288-773-0352

APPENDIX I-3

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HARBOR PORPOISE SURVEY DATA SHEET

Date _____ Vessel _____

Observers _____ Transect # _____

Sea State _____ Cloud Cover _____ Visibility _____ Wind _____

Time	Location	#	Species	Δ dist.	Comments	Photographer

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DAILY SUMMARY SHEET

1982 Harbor Porpoise Survey

DATE _____ AREA AND LINES _____

OBSERVERS _____ VESSEL _____

PORT OF DEPARTURE _____ PORT OF ENTRY _____

SUMMARY OF WEATHER AND SIGHTINGS