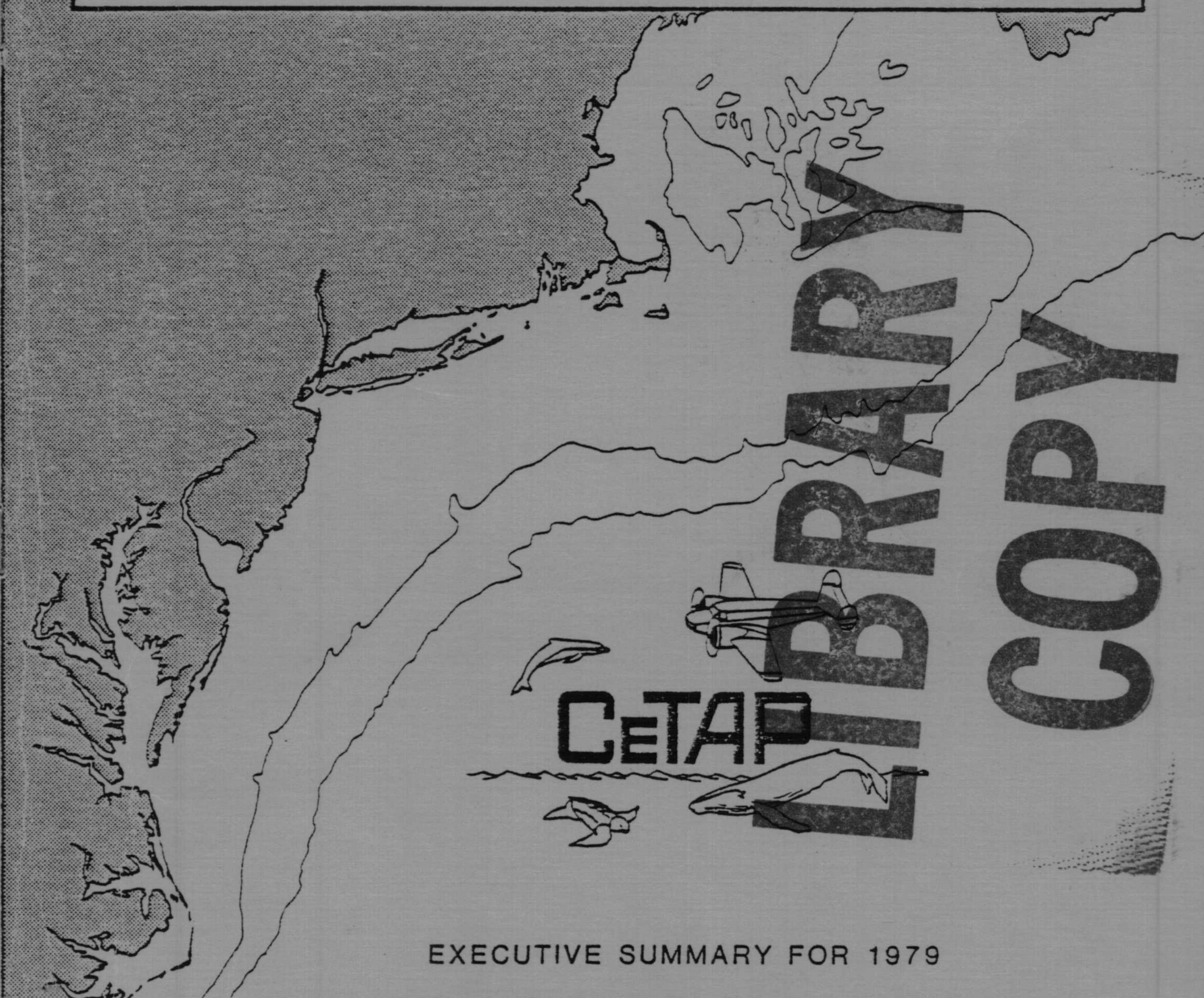
A CHARACTERIZATION OF MARINE MAMMALS AND TURTLES IN THE MID- AND NORTH- ATLANTIC AREAS OF THE U.S. OUTER CONTINENTAL SHELF



EXECUTIVE SUMMARY FOR 1979

CETACEAN AND TURTLE ASSESSMENT PROGRAM

UNIVERSITY OF RHODE ISLAND

SPONSORED BY THE BUREAU OF LAND MANAGEMENT

UNDER CONTRACT AA551-CT8-48

A CHARACTERIZATION OF MARINE MAMMALS AND TURTLES IN THE MID- AND NORTH-ATLANTIC AREAS OF THE U.S. OUTER CONTINENTAL SHELF

EXECUTIVE SUMMARY FOR 1979

for the

Cetacean and Turtle Assessment Program

University of Rhode Island

Kingston, Rhode Island 02881

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Prepared for:

U.S. Department of the Interior
Bureau of Land Management
18th and C Street, NW, Room 2455
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Under Contract #AA551-CT8-48

EXECUTIVE SUMMARY

INTRODUCTION

Program History

The Cetacean and Turtle Assessment Program (CETAP) began at the University of Rhode Island after receipt of a Request For Proposal (RFP) from the Bureau of Land Management (BLM) in June of 1978. CETAP's proposal was submitted in competition with other offerors. After a series of negotiations, the BLM awarded a contract to CETAP entitled "A Characterization of Marine Mammals and Turtles in the Mid- and North-Atlantic Areas of the U.S. Outer Continental Shelf." Staff hiring and other startup procedures began immediately. A comprehensive program for training marine mammal and turtle observers was put together within one month. Several training flights were conducted before the end of 1978, and by January 1979, a full-scale field data collection effort was underway.

Program Purpose

The BLM determined a lack of information on marine mammals and turtles in the mid- and north-Atlantic outer continental shelf areas. As a result, the general objectives of CETAP were defined to be an inventory which will:

a. Determine which species of marine mammals and marine turtles inhabit and/or migrate through the mid- and north-Atlantic regions;

b. Identify, delineate, and describe areas of importance (feeding, breeding, calving, etc.) to marine mammals and marine turtles in these regions;

c. Determine the temporal and spatial distributions of marine mammals and marine turtles in these regions;

d. Determine behavioral characteristics of marine mammals and marine turtles in these regions;

e. Estimate the size of and extent of marine mammal and marine turtle populations in these regions;

f. Emphasize all items "a" through "e" above for those species classified as threatened or endangered by the Departments of Interior and of Commerce.

Data collected by this inventory is deemed necessary for responding to various legislation (Outer Continental Shelf (OCS) Lands Act, 1953; National Environmental Policy Act, 1969; Marine Mammal Protection Act, 1972; Endangered Species Act, 1973), and for making effective management decisions concerning OCS development.

METHODS AND TECHNIQUES

CETAP was designed with four program elements: Administration, Field Research Operations, Data Management Operations, and Scientific Analysis/Reporting Operations. These program elements are interactive in that many people have multiple roles: a person is often responsible for duties within two, three, or all four program elements. The advantages of this structure are that talent, knowledgeability, and technical expertise are spread throughout the program without incurring a cost-penalty derived from having a staff that is too large and therefore unwieldy. Furthermore, communication is fostered and scientific feedback encouraged. The four program elements are interdependent, yet each has its own specific function.

Administration

The administration, composed of a scientific director, program manager, assistant program managers, fiscal clerk, and secretaries, is responsible for ensuring compliance to stated scientific goals, contractual obligations, and the many federal, state, and university regulations. Scientific goals are established by an executive committee consisting of scientists who are both internal and external to the program. They bring the variety of backgrounds, interests, and expertise necessary to objectively design research projects which respond to BLM's needs, monitor progress, and effectively evaluate the results.

Field Research Operations

This program element, headed by an assistant program manager, is responsible for implementing the field data collection methods designed by the scientists. CETAP field research is both active and passive. The active aspects involve the use of aircraft and ships as platforms for the collection of marine mammal, marine turtle, and environmental information by staff observers and scientists. Passive aspects involve the collection and compilation of marine mammal and turtle data obtained by non-CETAP personnel. This latter data source includes programs conducted by other researchers and agencies with the only provision being that the information must be pertinent to the CETAP study area.

The study area (Figure 1) is the Outer Continental Shelf (OCS) between Cape Hatteras, North Carolina, and Cape Sable, Nova Scotia. The shelf boundaries are defined as the shoreline and the smoothed surface projection of the 2000 m isobath or depth contour line.

The active survey efforts use both aircraft and ships. Because each platform provides different opportunities in terms of the quality and quantity of data that can be collected, the respective data from each often receive somewhat differing treatments.

The principal survey method is called the Dedicated Aerial Survey. An extensively rebuilt Beechcraft AT-11 aircraft is chartered by CETAP for the survey. Dedicated aerial survey methods are conducted according to a rigorously defined sampling plan. The plan is statistically designed so that all study area components, and therefore cetacean and turtle habitats within the study area, have an equal probability of being sampled. In 1979, eight semi-seasonal surveys were made. Each survey attempted to sample 7½% of the sea surface area within the study area. From the cetacean

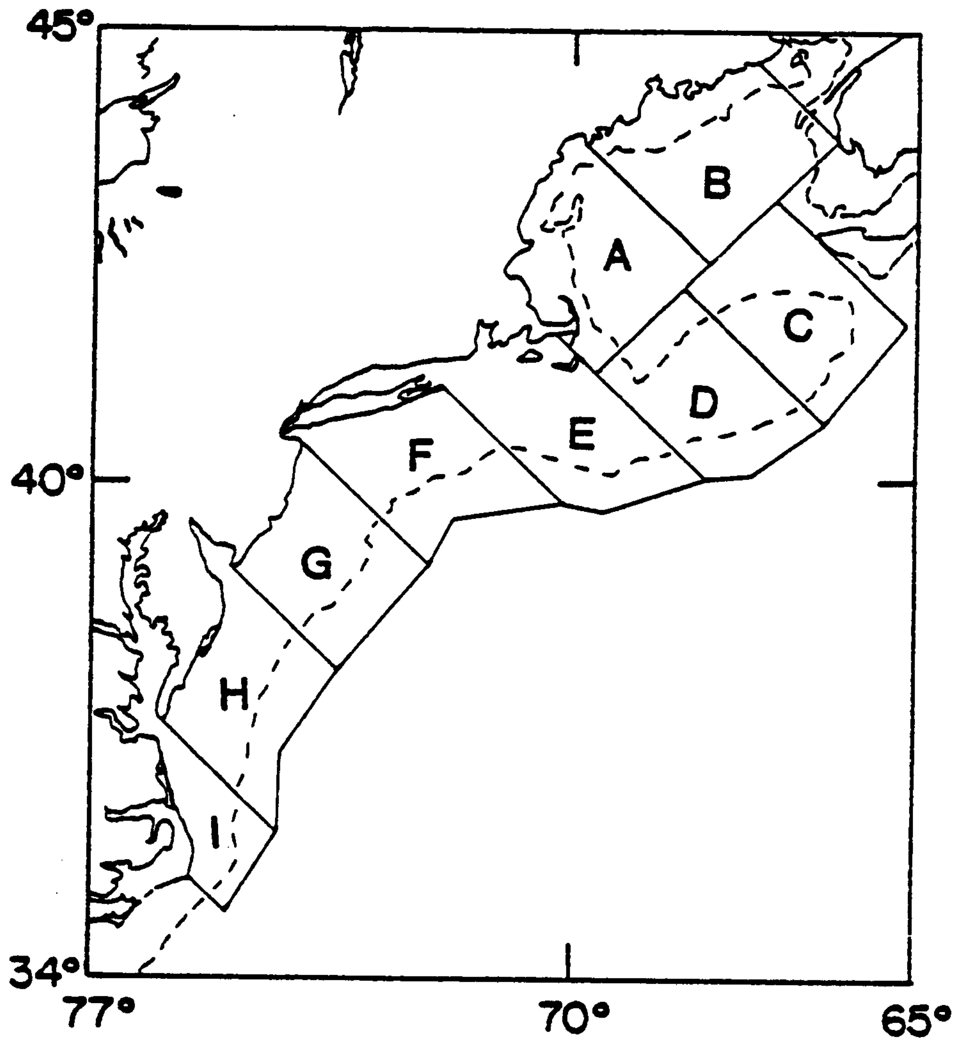


Figure 1. The study area ranged from Cape Hatteras, North Carolina, to Nova Scotia, Canada, and between the coastline to the surface projection of the 2,000 m depth contour. For sampling purposes, the study area was divided into nine sampling areas or blocks denoted by letters A through I. The dashed line depicts the 200 m depth contour.

and turtle sightings, and the environmental measurements made while flying along the designated transect lines, CETAP obtained information pertinent to the occurrence of cetacean and turtle species within the study area, their temporal and spatial distributions, apparent density of cetaceans and turtle species within the sampled areas, correlations between cetacean and turtle occurrence and environmental variables, and relative abundance of cetacean and turtle species both semi-seasonally and geographically. Factors affecting the sightability and/or countability of cetaceans and turtles were also measured and recorded for later analysis.

Platforms-of-opportunity surveys were conducted simultaneously. These surveys were conducted by the placement of one or more CETAP observers on board aircraft or ships known to be operating within the study area. Normally the aircraft or ship has a primary mission for another research institution, federal agency, or commercial group. Therefore, the only control CETAP has over where and when observations are to be made is via stringent selection of the platform in advance of the flight or cruise. Once an acceptable platform is identified, one or more CETAP observers is assigned to the platform. Each observer is provided with standardized field data collection instructions and forms in order to obtain the best possible sighting data on cetaceans and turtles, as well as environmental and operational information. After the flight or cruise, the data are reduced and converted to a standardized form for further analysis.

A number of special surveys using both aerial and ship platforms were undertaken in 1979. These surveys were performed for either or both of two reasons: (1) Certain species were not adequately sampled by the regular aerial or ship surveys; and (2) certain areas were unique or events of short duration, and thus, not adequately sampled by the regular surveys. The most extensive special survey was the Right Whale Survey and Right Whale Minimum Count. This special survey was conducted in May, 1979, over the entire Gulf of Maine and OCS regions immediately south of Georges Bank. The goal of the survey was to offset the paucity of data on the northern right whale's population size and distributions in time and space.

Additional special aerial surveys termed Hot Spot Flights were conducted several times in order to further investigate a small geographical area and the endangered cetaceans reported therefrom. For example, one Hot Spot Flight became an oil spill response when the area under study was determined by the sinking of the M/V REGAL SWORD and its subsequent leakage of fuel oil. The area of sinking/leakage was east of Cape Cod in a region of regular occurrence and feeding by at least two endangered species of cetaceans.

Data Management Operations

This program element, headed by a Coordinator for Data Management, is responsible for coordinating the data related activities of CETAP and the Data Projects Group. This involves establishment and maintenance of a data base followed by preliminary product generation. First-year activities included the development of the field forms onto which field observers would record their data. These forms had to be tailored to the different types of field effort since each collected data in a unique way. This is due to a number of causes such as platform type, sampling design, altitude, speed, observer skill level, and the various kinds of environmental information collected during the surveys. Other activities involved the establishment of formats for tables, graphs, and plots of synthesized data pertinent to the interpretation and report-writing tasks carried out by the scientists. The generation of preliminary tables and graphs was begun in 1979 along with negotiations with NODC/EDIS for developing magentic storage tape for archival purposes.

Scientific Analysis/Reporting Operations

This fourth program element, headed by the Scientific Director's Executive Committee, is responsible for designing the format for, and writing of, annual and final reports. First-year activities included developing report format and selecting data reduction and analysis procedures. Reduced data in the form of tables and graphs were then used to make interpretations and write the reports required under the contract.

It was determined early during the first year that many functional specialities were required to properly address the BLM's requirements. These functional specialities are areas of scientific expertise. For this reason the Scientific Director oversaw the designation of Task Groups. Each Task Group consisted of a Task Leader and one or more Task Members. Each Task Leader is a scientist with experience in the particular speciality As such, the Task Leader acts as the investigator in charge of the analyses and report writing for the speciality. All reports are then reviewed and edited by the scientific leadership and finally integrated to form the Annual Report.

The Annual Report and this Executive Summary are therefore arranged by functional speciality. A listing of functional speciality section headings follows.

Functional Specialities - Task Group Reports

In the remainder of this Executive Summary, the results of the first year activities are presented in ten sections. Each section has its own title and combination of authors. These are listed below.

General Distribution of Cetaceans in the Continental Shelf Waters of the Northeastern U.S. - James H.W. Hain, Richard K. Edel, Herbert E. Hays, Steven K. Katona, John D. Roanowicz

Calibration of the Beechcraft AT-11 Forward Observation Bubble for Population Estimation Purposes - Robert D. Kenney, Gerald P. Scott

Estimates of Cetacean and Turtle Abundance in the CETAP Study Area with an Analysis of Factors Affecting Them - Gerald P. Scott, James R. Gilbert, Robert D. Kenney, Richard K. Edel

Spatial and Temporal Distribution of Humpback Whales in the CETAP Study Area - Robert D. Kenney, Donna R. Goodale, Gerald P. Scott, Howard E. Winn

Right Whale Sightings and the Right Whale Minimum Count - Howard E. Winn, Donna R. Goodale, Martin A.M. Hyman, Robert D. Kenney, Carol A. Price, Gerald P. Scott

Correlations Between Cetacean Sightings and Selected Environmental Variables - Richard K. Edel, Michael Cagan, James H.W. Hain, Peter W. Sorensen

Feeding Behavior of the Humpback Whale - James H.W. Hain, Gary R. Carter, Scott D. Kraus, Charles A. Mayo, Howard E. Winn

Sea Turtles in the Region Between Cape Hatteras and Nova Scotia in 1979 - C. Robert Shoop, Thomas L. Doty, Nancy E. Bray

Photogrammetric Investigation of Cetacean Morphometry - Gerald P. Scott, Mary Ratnaswamy, Howard E. Winn

Cetacean Responses in Association with the REGAL SWORD Oil Spill - Donna R. Goodale, Martin A.M. Hyman, Howard E. Winn

Reminder:
The data and interpretation thereof contained in this report are based on observations made by CETAP personnel during 1979 in the defined study area. Any exceptions are individually noted.

GENERAL DISTRIBUTION OF CETACEANS IN THE CONTINENTAL SHELF WATERS OF THE NORTHEASTERN UNITED STATES

James H.W. Hain, Richard K. Edel, Herbert E. Hays,
Steven K. Katona, John D. Roanowicz

1. This section describes the temporal and spatial distribution of 21 species of cetaceans (whales, dolphins, and porpoises) in the continental shelf waters of the northeastern United States. The section is based on data collected during the initial 14 months of field studies by the Cetacean and Turtle Assessment Program (CETAP) at the University of Rhode Island, from 1 November 1978 through 9 January 1980. The study area is defined as the continental shelf waters of the northeastern United States between Cape Hatteras, NC, and Cape Sable, Nova Scotia; and from the coastline to 5 n. mi. seaward of the 1000 fathom depth contour.

2. While the study reported here is the most comprehensive and well supported work of this type for the area to date, the results are influenced by three major factors: sighting or search effort, the inherently imperfect nature of sampling, and the natural variability of biological systems. For example, in the latter case, the observations reported here represent a relatively modest sample taken over a relatively short time period. The natural variability of biological systems is well described and might be depicted as:

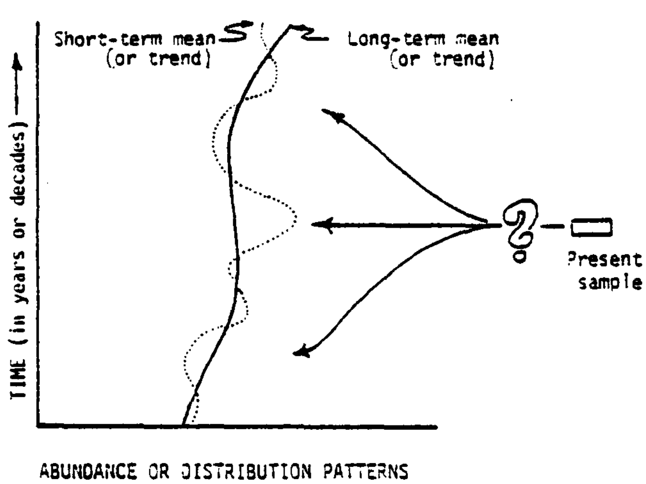


Figure 2. The conceptual relationship of short-term sampling to long-term biological systems. When a modest sample of relatively short duration is drawn from a biological system exhibiting a high degree of natural variability, one often does not know from where within the system the sample was taken.

Therefore, the sample on which these results are based has been taken from an unknown point within the overall system, and may not necessarily represent the average, or generalized, case. This factor should be kept firmly in mind when considering the present results.

3. Over 143,700 nautical miles of trackline were surveyed during 16,400 on-watch hours in the period described. Due to various sampling schemes, logistical constraints, and weather considerations, this survey effort was non-uniform--both temporally and geographically. Since the sighting effort influences considerably the distributional data, a quantifiable measure of sighting effort was prepared. The question to be answered was; did a ship or aircraft pass through an area with one or more on-watch observers searching at least a two-mile swath under satisfactory sighting conditions? If so, how often? To determine this, the density of tracklines searched was evaluated both visually and numerically, and the results compared and integrated. This treatment (detailed in Chapter II of the CETAP Annual Report for 1979) produced a sighting effort index for each 1^{o} quadrat in the study area. As a result, each quadrat was assigned a rating of poor, fair, good, or excellent coverage.

When all sighting effort was totalled over each 45-day survey period, the sighting effort analysis showed that, on the average, 47% of the total study area was covered on each of the nine survey periods. This was considered to be "fair" coverage. Of all quadrats in all time periods, 75% were surveyed at or below this level. In general, wintertime coverage for the entire study area, average coverage to the south of Long Island, and average coverage of the northeastern Gulf of Maine and eastern Georges Bank was at the lower levels--generally in the "poor" or "fair" category. The best average coverage for the study area was in the waters to the south, east, and north of Cape Cod--where coverage for the late spring, summer, and early fall was considered "good" or "excellent".

The sighting effort summed and averaged for the year (10 January 1979 to 9 January 1980) is shown in Figure 3. Note that the sampling period prior to 10 January 1979 is not included in this treatment since low sighting effort during the program startup period would

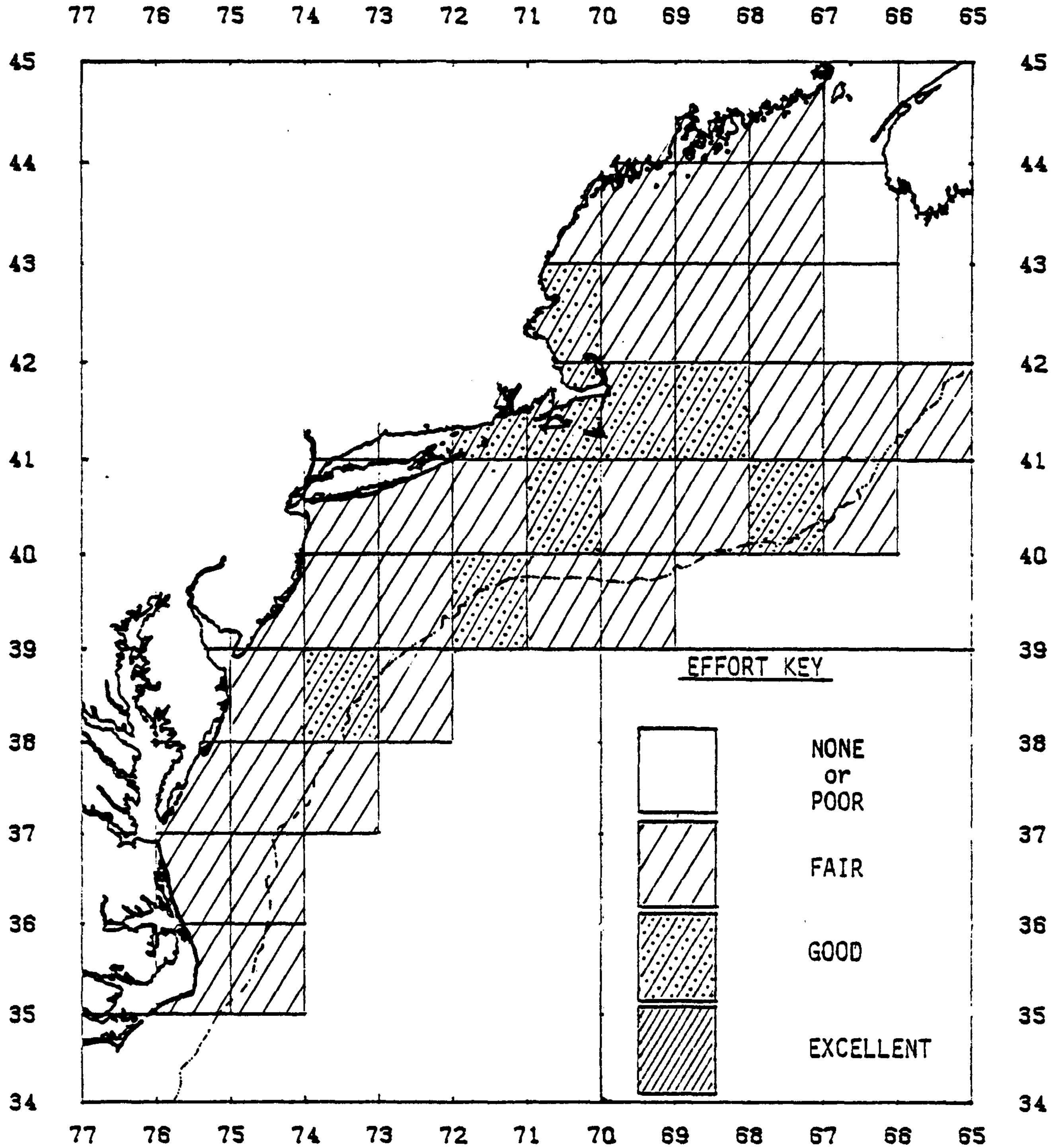


Figure 3. Average sighting effort for the period 10 January 1979 through 9 January 1980--derived from the summed and averaged sighting effort index values for individual Survey Periods 1 through 8.

unfairly bias the averages. This treatment provides a general impression of the average coverage, or sighting effort, for the year.

With specific regard to the BLM Lease Sale Areas, the southwestern portion of Lease Sale Areas 40, 49, and 59, and the eastern portion of 42, were covered at the "good" to "excellent" level on four of nine surveys. Proposed Lease Sale Area 52 received coverage at this level on two of nine surveys, and partial coverage at this level on an additional four of nine surveys. Sighting effort was weakest in all lease areas in the winter. There was "poor" or "fair" coverage of the northeast portion of 40, 49, and 59 during all seasons. There was "poor" or "fair" coverage of the western portion of 42 during all seasons, except late summer. Lease Sale Area 52 received only partial coverage at the "good" to "excellent" level in spring, early summer, and fall.

4. In the 14 months of data collection reported in this chapter, 4,405 sightings of 69,026 individuals, representing 21 species of cetaceans were made. Of the total sightings, 3,245 (or 72%), were identifiable to species. Table 1 presents a list of the species sighted, sighting frequencies, and the number of individuals of each species sighted. The listing is arranged in order from the most commonly sighted to those rarely sighted. Of the 21 species sighted, 13 were relatively common, and were encountered on a regular and widespread basis. As noted above, 28% of all sightings were not identifiable to species.

5. For a broad examination of the distribution of cetaceans in the study area, the total sightings were treated as large whales (average length > 25 feet or 7.6 m) and small whales (average length < 25 feet or 7.6 m), and are shown for each of the four seasons (Figure 4a-d and 5a-d). For the large whales, 2,111 sightings of 5,048 individuals, representing seven species, were reported. Also included in this summary are such categories as "unidentified large whale", "unidentified rorqual", or "either a fin or a sei whale". For the small whales, 2,294 sightings of 63,978 individuals, representing 14 species were reported. As above, categories such as

Table 1. Sighting frequency and number of individuals, totalled over all data classes (except Historical) for the period 1 November 1978 to 9 January 1980.

COMMON SPECIES	No. of Sightings	No. of Individuals		No. of Sightings	No. of Individuals
Large whales			Small whales		
*Balaenoptera physalus**	734	2175	*Tursiops truncatus*	477	6466
*Megaptera novaeangliae**	416	1054	*Globicephala* spp.	275	5190
Balaenoptera acutorostrata	158	280	*Lagenorhynchus acutus*	190	10109
*Physeter catodon**	144	485	*Phocoena phocoena*	187	702
*Eubalaena glacialis**	119	197	*Grampus griseus*	183	3911
Subtotal	1571	4191	*Delphinus delphis*	164	7674
			Stenella spp. (spotted)	67	4916
			Stenella coeruleoalba	67	4341
			Subtotal	1610	43309
UNCOMMON OR RARE SPECIES					
Large whales			Small whales		
*Balaenoptera borealis**	7	16	*Lagenorhynchus albirostris*	15	136
Orcinus orca	4	13	*Ziphius cavirostris*	2	9
Subtotal	11	29	*Stenella longirostris*	2	90
			Steno bredanensis	2	65
			Delphinapterus leucas	1	3
			Mesoplodon spp.	1	3
			Subtotal	23	306
TOTAL	1582	4220		1663	43615

*Endangered species

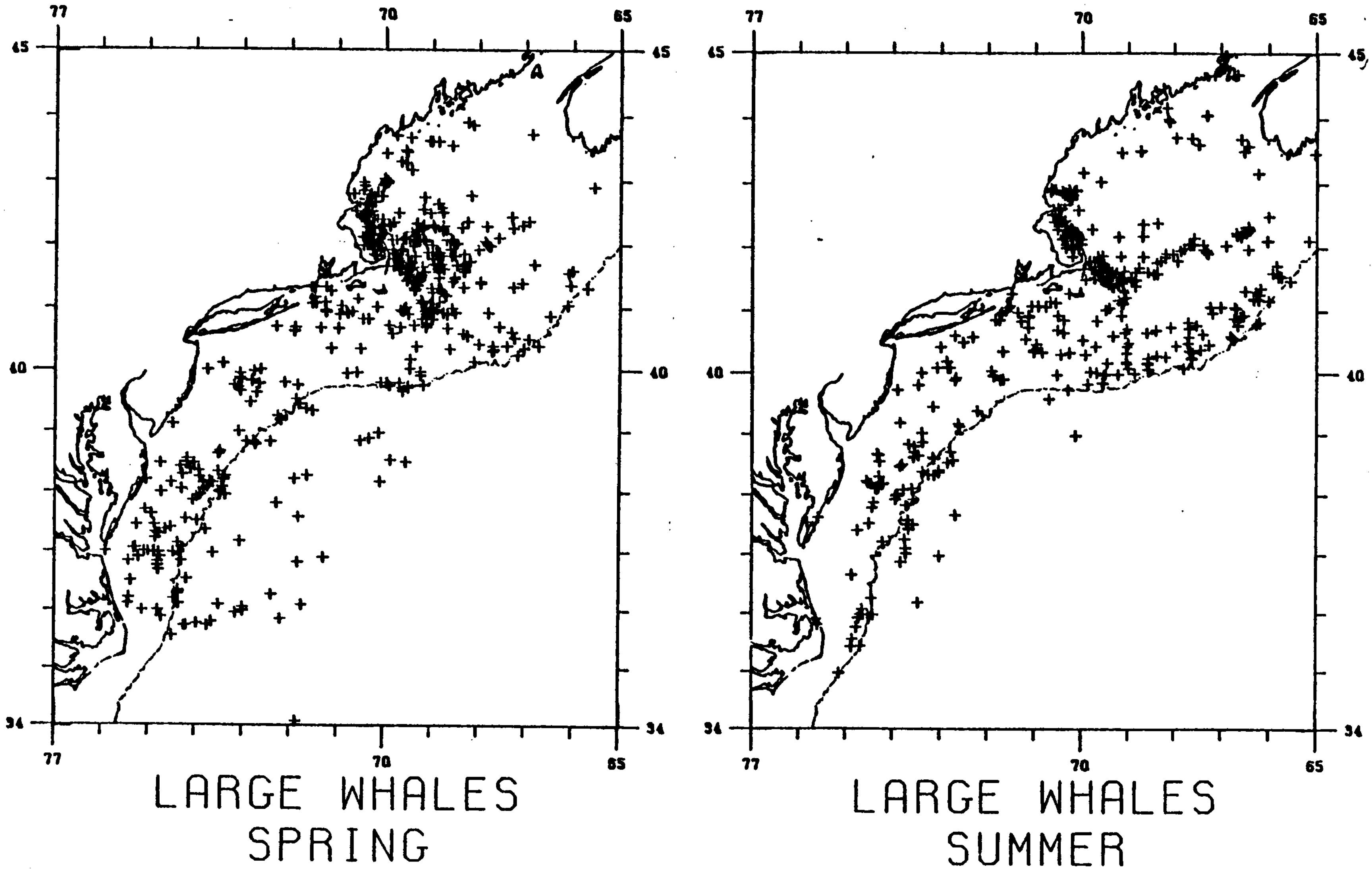


Figure 4. General distribution of large whales--all species with average length > 25 feet (7.6 m)--1 November 1978 to 9 January 1980. Seasonal plots show spring = March, April, May; summer = June, July, August; fall = September, October, November; winter = December, January, February.

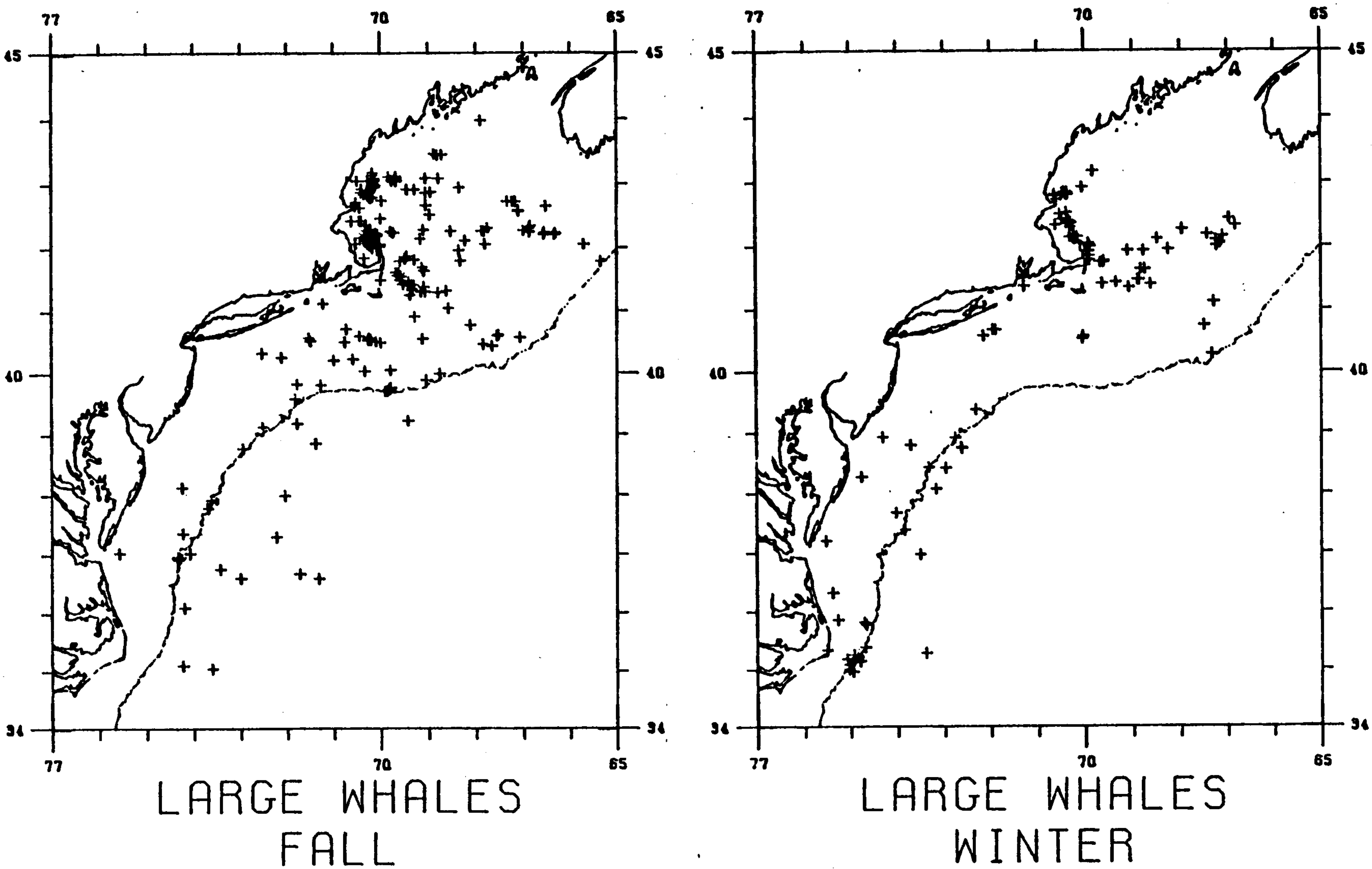


Figure 4. (continued).

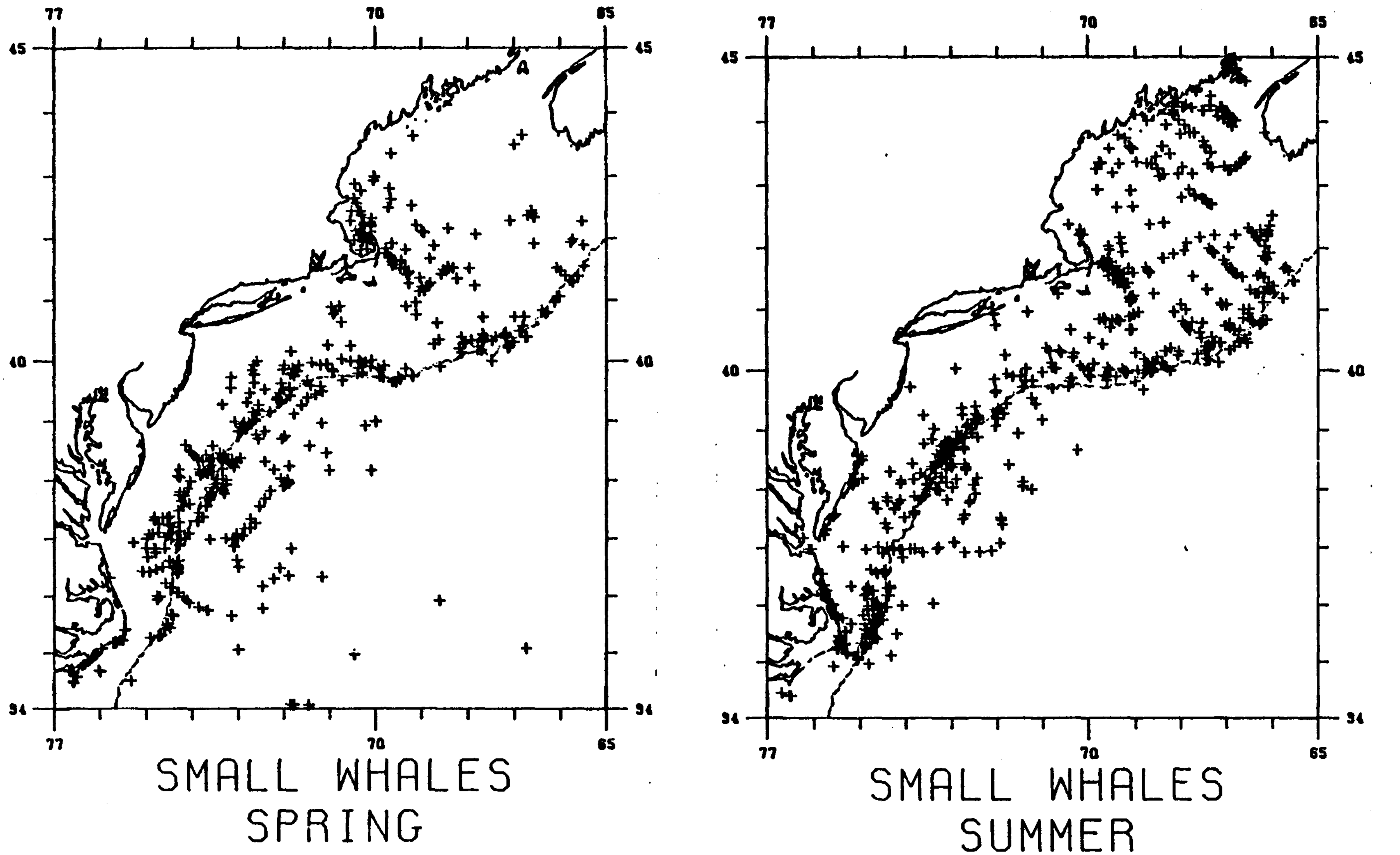


Figure 5. General distribution of small whales--all species with average length < 25 feet (7.6 m)--1 November 1978 to 9 January 1980. Seasonal plots show spring = March, April, May; summer = June, July, August; fall = September, October, November; winter = December, January, February.

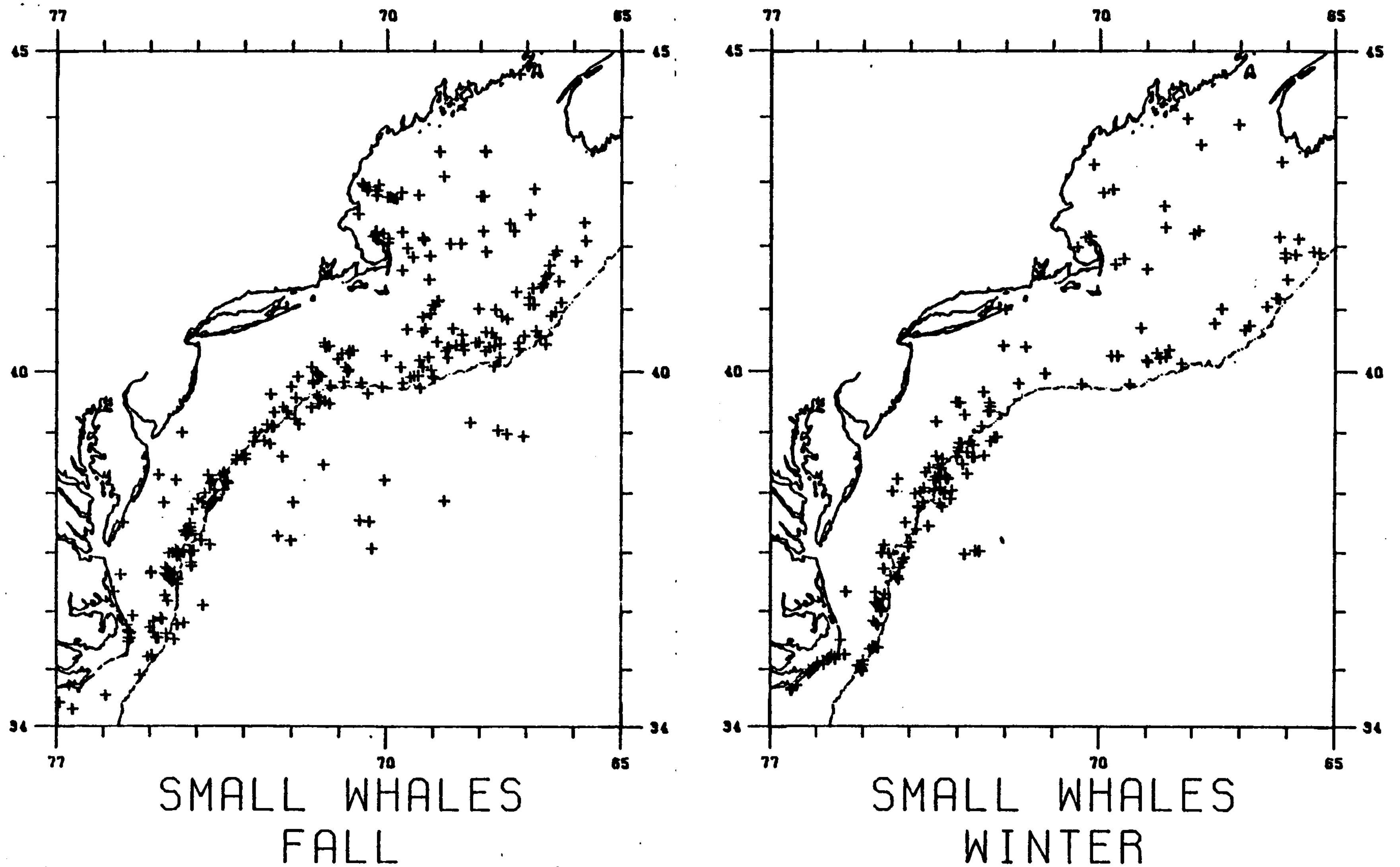


Figure 5. (continued).

"unidentified dolphins" and "unidentified blackfish" have been included in the plots to show the general distribution of animals within this size class in the study area.

The overview presented by this treatment suggests that cetaceans, both large and small, are widely distributed throughout the study area in all four seasons of the year. If the effects of sighting effort were to be subtracted out, the point densities created as the result of non-uniform sampling would be smoothed somewhat, and the actual distribution would appear more uniform. Several additional points are suggested:

a. Small whales or dolphins are common along the shelf edge over large areas of the mid-Atlantic bight during all four seasons of the year.

b. Small whales are seen less frequently over the continental shelf proper, i.e., in shallower water, in the mid-Atlantic bight. Again, this is generally true for all seasons. The exception is those animals found close to shore in the North Carolina and Delmarva areas (this has been found to be largely Tursiops truncatus).

c. There is a suggestion that large whales are absent or scarce in the northeastern Gulf of Maine in winter. A more definitive statement on this requires additional sampling.

d. There is a suggestion of a general scarcity of large whales in continental shelf waters south of Long Island in the fall.

e. It is generally believed that whales are absent or scarce in northern waters in the winter. Our data suggest that this is not the case. In spite of low sampling levels, whales were observed over large areas of the shelf. Additional wintertime sampling will be of interest.

6. To date, five endangered species (as defined by the Endangered Species Act of 1973, 16 U.S.C. 1531-1543) of marine mammals have been sighted in the study area. These five species are Balaenoptera physalus (fin), Megaptera novaeangliae (humpback), Physeter catodon (sperm), Eubalaena glacialis (right), and Balaenoptera borealis (sei). The relative number of sightings can be obtained by referring to Table 1. Since all are large whale species, and all common large

whales but one are endangered, the general seasonal distribution of the endangered species is approximated by the large whale plots given in Figure 4a-b. For more detailed information on the endangered species, refer to the appropriate sections of Chapter II, as well as Chapters VI, VII, and VIII in the CETAP Annual Report for 1979. The other endangered species which might possibly occur in the waters of the northeastern U.S. continental shelf, Balaenoptera musculus, the blue whale, has not been observed by CETAP to date.

7. In the detailed information presented in Chapter II of the CETAP Annual Report for 1979, each species is treated individually in a species account. The distribution of the 13 common species is shown graphically by subdividing the year into eight 45-day periods. The accompanying text gives information on group size, interspecies associations, migration and movements, feeding locations, and presence of calves or juveniles. One area, however, not adequately treated by the individual species accounts is that of multispecies sightings (groups of cetaceans comprised of two or more species). These associations occurred in 12% of the total sightings. Mixed groups of Globicephala spp. and T. Truncatus (pilot whales and bottlenose dolphins), dolphins bowriding large whales, or feeding aggregations of several species of whales and dolphins are typical examples of these multispecies associations. Of the various associations, the most common was that of fin (B. physalus) and humpback (M. novaeangliae) whales.

8. Analysis of the species distributions to date suggests that, in the broadest sense, the 13 most common species in the study area can be considered to be of three basic types. Figures 6a-c show the distribution of these basic types and the relation of the distribution patterns to the BLM Lease Sale Areas. The species and characteristics contained in each are as follows:

Type I - Represented by a single species, Phocoena phocoena, the harbor porpoise. The distribution is widespread throughout the Gulf of Maine, waters in the vicinity of Cape Cod, and over much of Georges Bank. The distribution is almost solely over the shelf proper, and shows no strong tendency for the shelf edge. Based on CETAP data, distribution does not appear to extend southwest beyond

Nantucket. That is, the species is not found over the continental shelf south of 40°N and west of 70°W. Figure 6a shows this pattern.

Type II - Represented by all common species of baleen whales, B. physalus, M. novaeangliae, B. acutorostrata, E. glacialis, and one species of odontocete, L. acutus. This distribution is widespread and common throughout the entire Gulf of Maine, and waters in the vicinity of Cape Cod, and over much of Georges Bank. There is a more scattered and occasional distribution trailing southwest from this area over the remainder of the shelf to Cape Hatteras (fin whales are relatively more common in this area than the other four species). While some whales are sighted along the shelf edge at times, the general tendency of this type is to occupy the shelf proper. This distribution pattern is shown in Figure 6b.

Type III - Seven odontocetes follow this general distribution pattern (Figure 6c) but are best grouped into three subtypes or variations. The overall distribution pattern, however, shows a strong tendency for association with the shelf edge (centered about the 1000 m depth contour), rather than the shelf proper.

A. G. griseus, S. coeruleoalba, and Stenella spp. (spotted) are similar in their distribution patterns. This pattern is characterized by a generally linear distribution along the shelf edge from south of Nantucket southwestward to Cape Hatteras. Extensions of the distribution eastward of Nantucket, along the Georges Bank edge, are seasonal only--primarily in the summer. There is no general tendency for the distribution to extend landward of the shelf edge onto the shelf proper. The general distribution is a more southerly one, centered in the mid-Atlantic bight area.

B. Distribution of this variety is seen in P. catodon, Globicephala spp., and D. delphis. Again the distribution occurs along the shelf edge, and again is centered over the 1000 m depth contour. There are several differences, however, between this subtype and the former. The species of this subtype are more widespread in space and time, and appear to be more nearly four-season occupants all along the shelf edge from the eastern tip of Georges Bank southwestward to Cape Hatteras. A second feature is the general tendency for the distribution to extend up onto the shelf at the northern end of the study area. This takes place in the waters south of Cape Cod, on Georges Bank, in the Northeast Channel (northeast of Georges Bank), and in the Gulf of Maine. Thus, there is a seasonal "bulge" or expansion of the distribution to shallower regions of northern waters. All three species have this in common.

C. This variation on the basic Type III pattern is represented by a single species, T. truncatus. The general pattern is similar to that of subtype A--a linear distribution along the shelf edge, extension to the Georges Bank edge in the warm seasons, and general southerly tendency to the overall distribution. With Tursiops, however, a distinct feature is a "J" shape to the species distribution at the southern end of the study area. That is, there is a "crook" in the distribution at the southern end, and an arm of the distribution extends along the coastline from the area of Cape Hatteras northward to Cape Henlopen, DE.

Based on the present data, there seems to be a strong argument for considering each of the major species as members of one of these three basic distribution types. This hypothesis aims at a preliminary attempt at characterizing where and when the various species, or groups of species, occur. The hypothesis will be tested further as additional data are collected and examined.

9. The above statements about the distribution of the whales in northeastern U.S. continental shelf waters may have application to decision makers dealing with the northeastern U.S. OCS study area.

A. P. phocoena, a Type I species, will come under consideration with regard to almost the entire Lease Sale Area 42 and the northeastern half of Area 52. The species has not been reported present in Lease Areas 40, 49, or 59.

B. The baleen whales (all but one of which are endangered) and L. acutus, the Type II species, are found on a regular and widespread basis throughout most of Lease Sale Areas 42 and 52. They are apparently found on a more occasional and scattered basis in Lease Sale Areas 40, 49, and 59.

C. The odontocetes or toothed whales (only one of which, the sperm whale, _P. catodon_, is endangered) of Type III are apparently widely and regularly distributed in Lease Sale Areas 40, 49, and 59. The distribution of those species in subtype III-A is widespread and year-round in the southern half of Lease Areas 42 and 52, and in the warm-weather seasons expands shoreward into all of Area 42 and most of Area 52. Subtypes III-B and III-C apparently extend their distribution eastward into the southern portions of Lease Sale Areas 42 and 52 in the warm seasons only.

Figures 6a-6c show the BLM Sale Area outlines in relation to the three general cetacean distribution types.

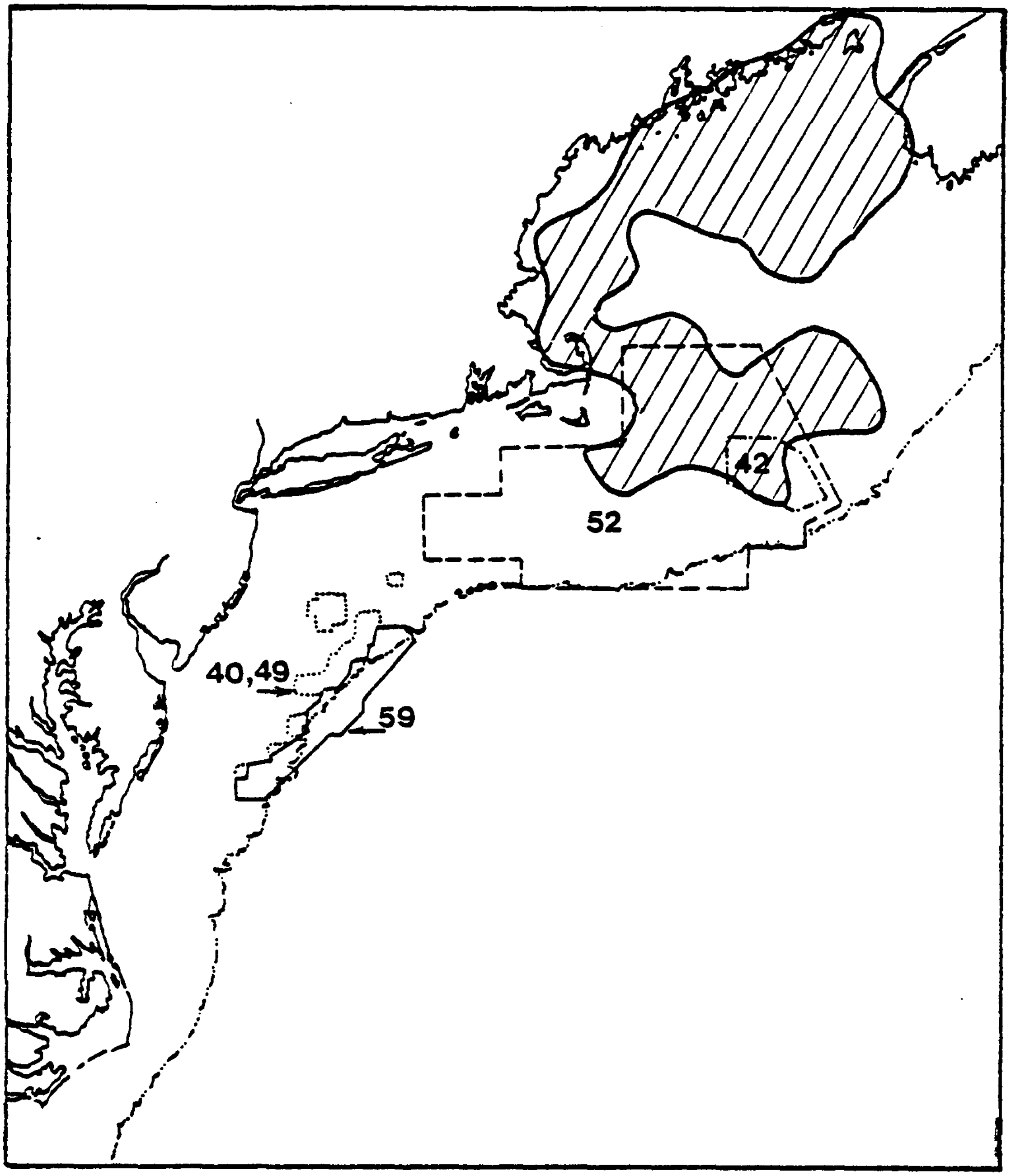


Figure 6a. Cetacean distribution pattern Type I (indicated by lined area) includes a single species, Phocoena phocoena, the harbor porpoise. Distribution is on the shelf proper over large areas of the Gulf of Maine and Georges Bank. The approximate boundaries of BLM Lease Sale Areas 40, 42, 49, 52, and 59 are shown.

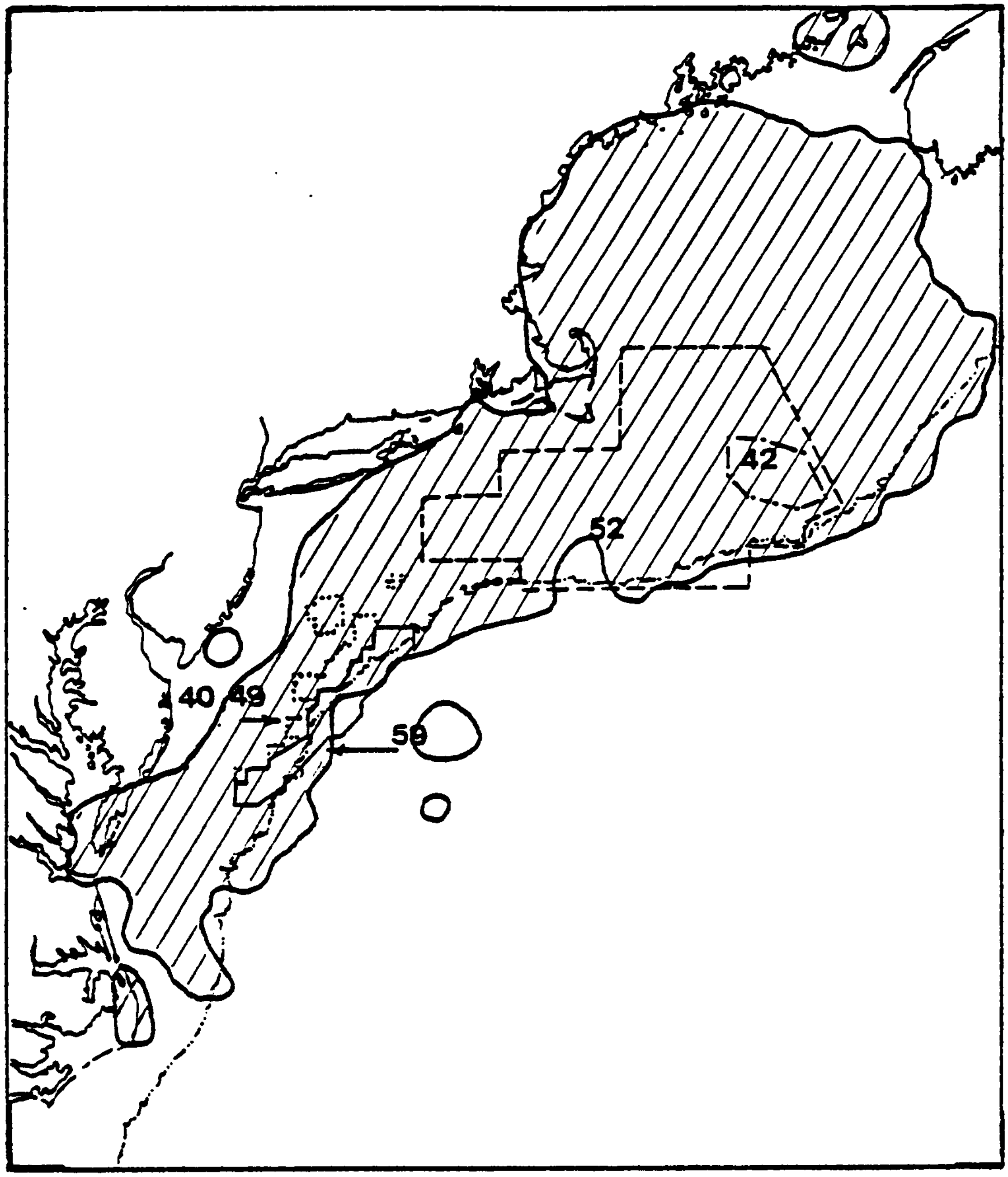


Figure 6b. Cetacean distribution pattern Type II (indicated by lined area) includes all the common baleen whales, B. physalus, M. novaeangliae, B. acutorostrata, E. glacialis, and a single odontocete or toothed whale, L. acutus. Distribution is primarily on the shelf proper with no strong tendency for shelf-edge concentrations. Unlined distribution areas indicate small numbers of outlying sightings not considered to be part of the main pattern. The approximate boundaries of BLM Lease Sale Areas 40, 42, 49, 52, and 59 are shown.

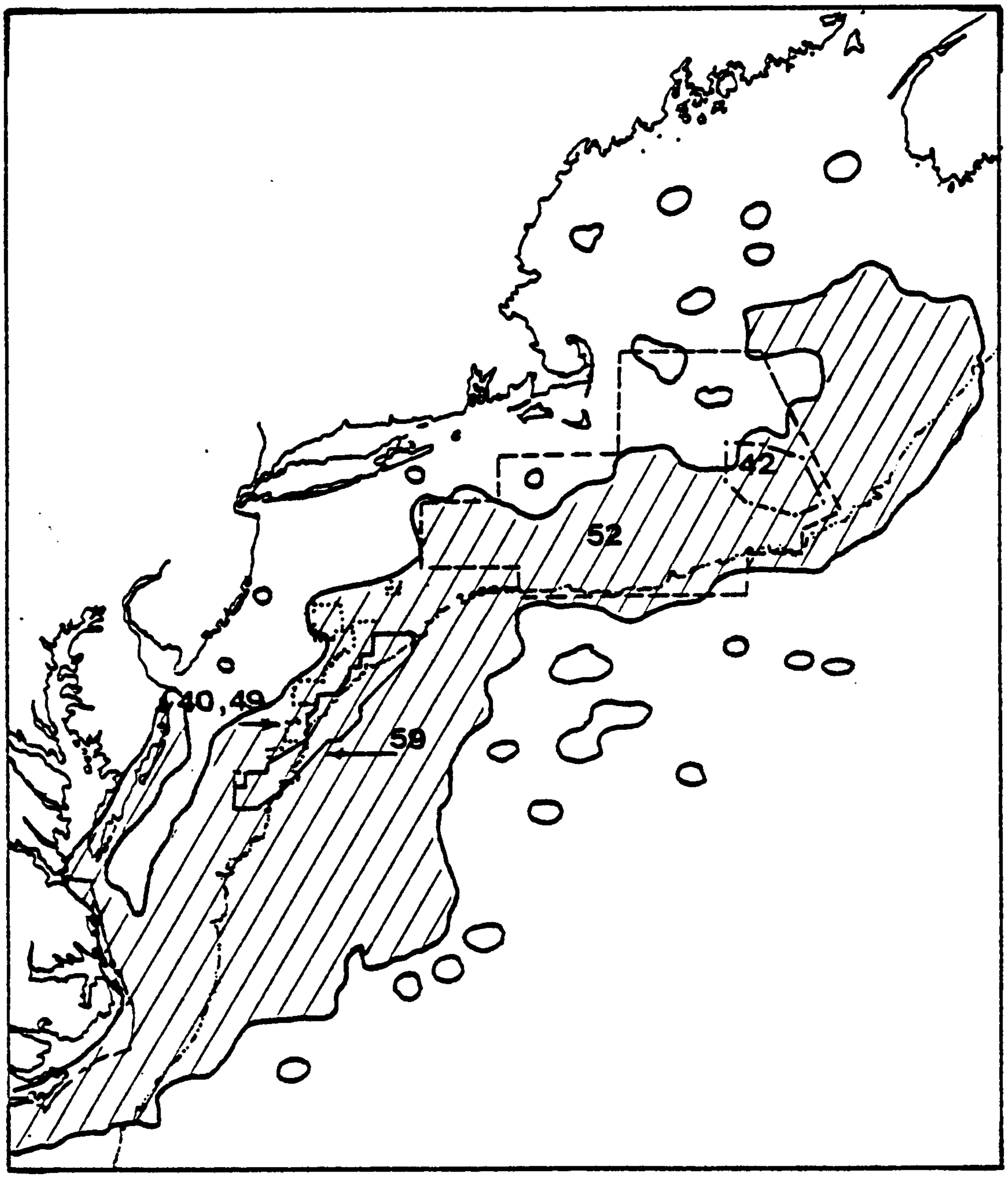


Figure 6c. Cetacean distribution pattern Type III (indicated by lined area) includes a majority of sightings of all the common odontocetes (toothed whales) except for Lagenorhynchus acutus, the white-sided dolphin. This pattern, common to the foregoing species, shows a strong tendency for a shelf-edge distribution, centered about the 1000 m depth contour. The Type III distribution has three variations which are explained in the text. Unlined distribution areas indicate small numbers of outlying sightings not considered to be part of the main pattern. The approximate boundaries of BLM Lease Sale Areas 40, 42, 49, 52, and 59 are shown.

CALIBRATION OF THE BEECHCRAFT AT-11 FORWARD OBSERVATION BUBBLE FOR POPULATION ESTIMATION PURPOSES

Robert D. Kenney and Gerald P. Scott

1. This section describes the methodology used in the calibration and placement of reference marks on the clear panels of the acrylic nose bubble which is part of the aircraft used to survey the CETAP study area for cetaceans and sea turtles. Reference marks are necessary because an estimate of right angle sighting distance from the track line of the aircraft to each cetacean and turtle sighting (Figure 7) is required for species' population estimate calculations.

2. Since the real time measurement of actual distance is a difficult and time-consuming procedure, CETAP decided to classify sightings into distance intervals. Six right angle distance intervals were chosen for each side of the aircraft. These intervals are 0-1/8, 1/8-1/4, 1/4-1/2, 1/2-3/4, 3/4-1, and greater than 1 nautical mile. Observers riding in the aircraft's acrylic nose bubble classify each sighting into one of these intervals through the use of the reference marks. When a sighting is made, the observer moves his head to the standard reference position and determines the right-angle distance interval in which the sighting falls. This information is then called out to the data recorder.

3. The placement of bubble reference marks was performed and calibrated dynamically and statically. Dynamic calibration involved flights at standard altitude and speed (750 feet, 120 knots) at the appropriate known distances from a fixed light tower (Figure 8). At the point where the tower was perpendicular to the flight track, a reference mark (opaque tape) was placed on the appropriate nose window panel. Static calibration involved the use of a calibrated post, known distances, and measured angles (Figure 9). Trigonometric calculations were performed to link the horizontal distance between the observers's eye and the acrylic panel plus the distance between the panel and the post to vertical distances on the calibrated post.

The trigonometric formula, $(d + 100\text{ cm}) \tan \Theta = b$, where d = the average distance between the observers' nose bridge and the bubble (in cm), Θ = the angle of declination from the horizon needed to intercept a known distance b, on the calibrated post, was used to determine Θ and thus to check and correct the locations for the distance interval marks on the bubble "glass".

4. The establishment and calibration of distance intervals and reference marks ensures that cetacean and turtle sightings made by CETAP's observers are classified into distance intervals in a reliable and reproducible manner.

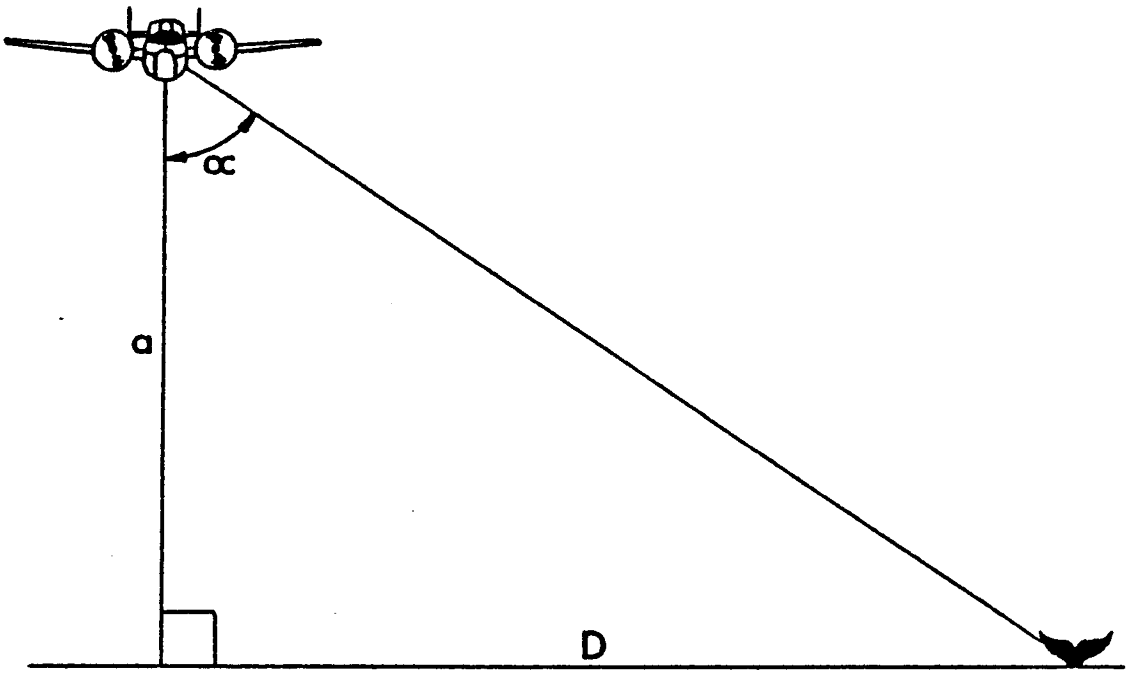


Figure 7. Diagrammatic representation of tangential relationship of aircraft altitude (a), inclination to a sighting (α), and right angle distance to that sighting (D). The right angle distance of the sighting to the survey trackline is a critical measurement for population estimation calculations.

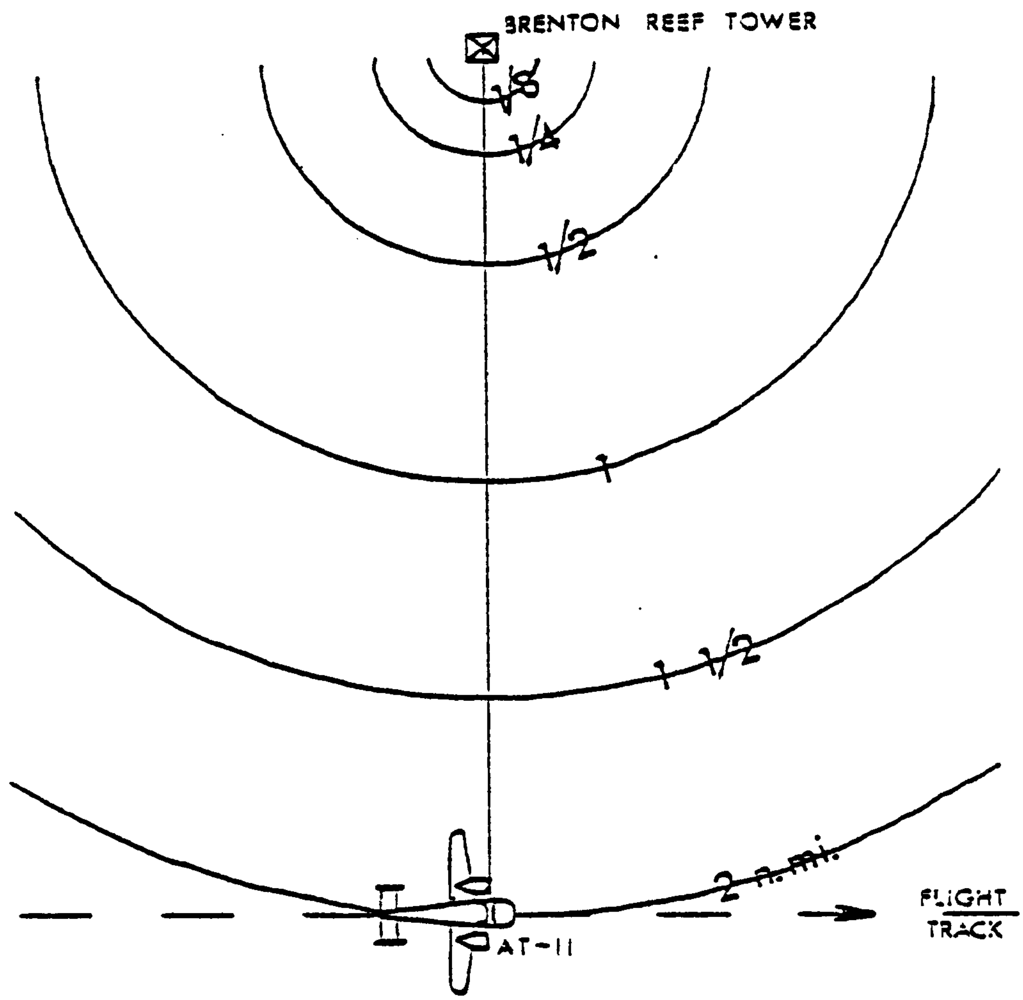


Figure 8. Diagram illustrating the dynamic calibration of AT-11 forward observation bubble with reference to a fixed light tower. Aircraft is flown precisely at pre-determined distance intervals and standardized reference marks are placed on glass of forward observation bubble.

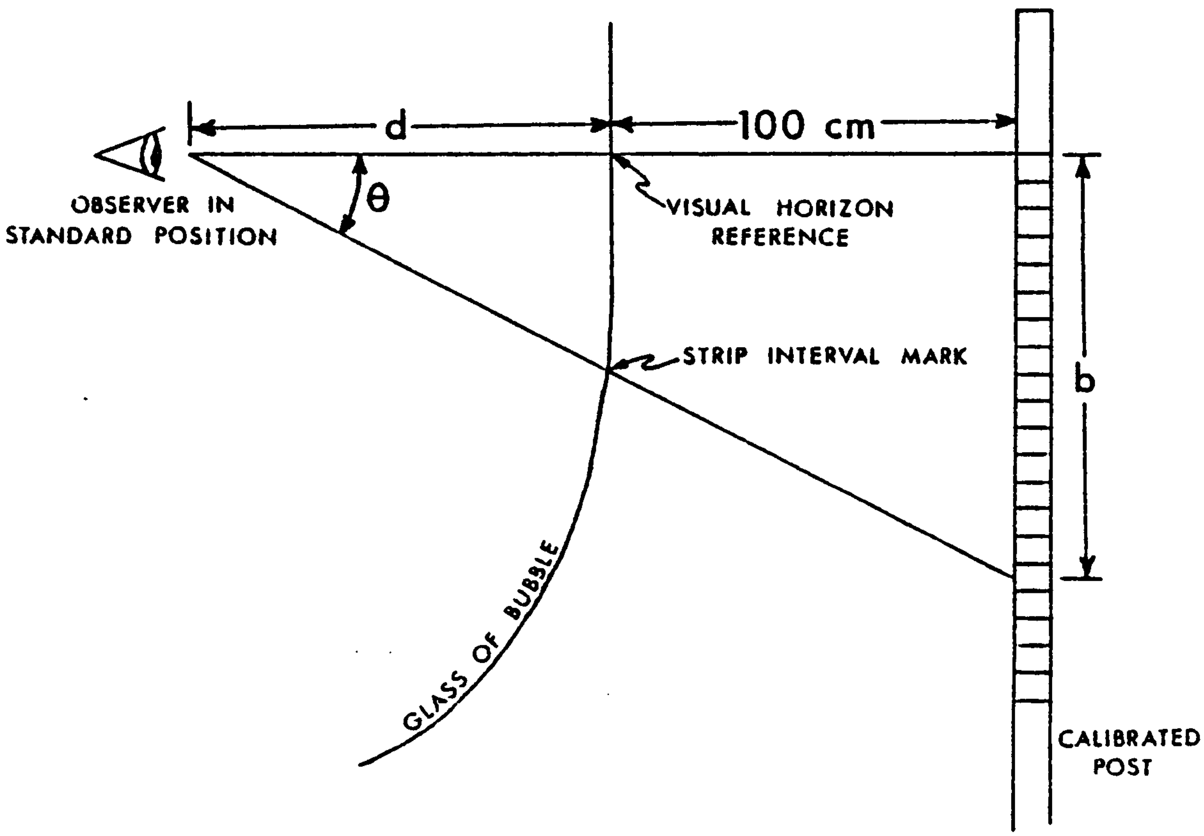


Figure 9. Diagram illustrating the relationships employed in the static calibration of AT-11 forward observation bubble. An observer sights through glass of observation bubble to marks on calibrated post corresponding to calculated declinations for known distances from the trackline.

ESTIMATES OF CETACEAN AND TURTLE ABUNDANCE IN THE CETAP STUDY AREA WITH AN ANALYSIS OF FACTORS AFFECTING THEM

Gerald P. Scott, James R. Gilbert,
Robert D. Kenney, Richard K. Edel

1. CETAP employed aerial sampling surveys to assess the abundance of cetaceans and sea turtles from the outer continental shelf waters within the study area. Abundance estimates calculated from the sighting data are based on the Cox-Eberhardt method. No attempt was made to adjust the estimates for the varying glare and sea state conditions encountered by the sampling survey field crew, or for animal submergence times, i.e., the percentage of each time unit that the animals are under the sea surface and non-visible. For this reason it is stressed that the abundance estimates presented in this report are conservative and should be as indices of relative minimum abundance of a species or species' group in a defined area at a defined time. Although the abundance estimates were not adjusted to account for glare and sea state, the effects of these two variables on the survey observers' ability to sight animals at the surface are presented.

2. The study area is shown in Figure 1. The total sea surface area encompassed within the area is 81,154 n.mi.^{2} (278,350 km^2). Because of its size, the study area was divided into nine sampling areas or "blocks", eight (A-H) with approximately equal areas and one (I) with an area one-half as large (Table 2). This was done to accommodate logistical and safety considerations into the sampling plan.

3. The sampling plan itself was designed with consideration of program and BLM needs, current sampling theory, and the availability of time to adequately survey the area. A semi-seasonal or eight survey period approach, with each survey sampling about 7½ percent of the sea surface within each block, was chosen to provide the most cost effective compromise between analytical requirements for precise data and the costs

Table 2. Areas of the CETAP sampling blocks.

	Sampling Block									
AREA	A	B	C	D	E	F	G	H	I	TOTAL
n.mi.^{2}	10,640	10,373	10,237	9,884	10,383	9,850	8,228	8,202	3,357	81,154
km^2	36,494	35,578	35,112	33,901	35,613	33,785	28,221	28,132	11,514	278,350

incurred by surveying so much area for so many species. As a result, the sampling design called for the simple random selection of transect lines from the pool of all possible northwest-southeast lines spaced at two n.mi. intervals within each block. At least four sampling lines were chosen to ensure that a minimum of 400 n.mi. (741 km) of sampling transects were surveyed (Figure 10 and Table 3). Block I was only about one half the size of the other eight blocks and so needed proportionally less mileage to obtain the same percentage of sea surface coverage as the other eight blocks. Sampling surveys were conducted at 750 foot altitude and 120 knots ground speed in all cases. Weather affects the quality of data collections, so minimum criteria were established early. These criteria require sea states of Beaufort three or less and a visibility of at least 2 n.mi. before a sample is considered acceptable. The absence of transect lines within a block during a given survey (Figure 10) is due to bad weather preventing the survey of the block within the survey "window". With nine blocks each requiring one day to survey, nine days are needed to complete one semiseasonal survey of the study area. Since the northeastern seaboard has weather systems that rarely are stable enough for nine consecutive good weather days, a thirty-day "window" within which the nine sampling days are executed was necessary.

4. Actual sampling observations were conducted by survey teams of six people. The flight crew, consisting of pilot and co-pilot-navigator, were furnished by the aircraft vendor. The remaining four were CETAP staff observers. To maximize efficiency, two observers at a time were on duty in the aircraft's observation bubble. A third observer was designated the data recorder, and the fourth was in a resting and equipment service status. Observers were rotated into the bubble at the end of each transect line or hourly, whichever occurred first.

5. While flying along a transect line, the two duty observers scanned the sea surface from directly ahead of the aircraft to approximately 60^{0} to either side of the transect line, and reported all sightings and environmental data to the recorder. Sightings

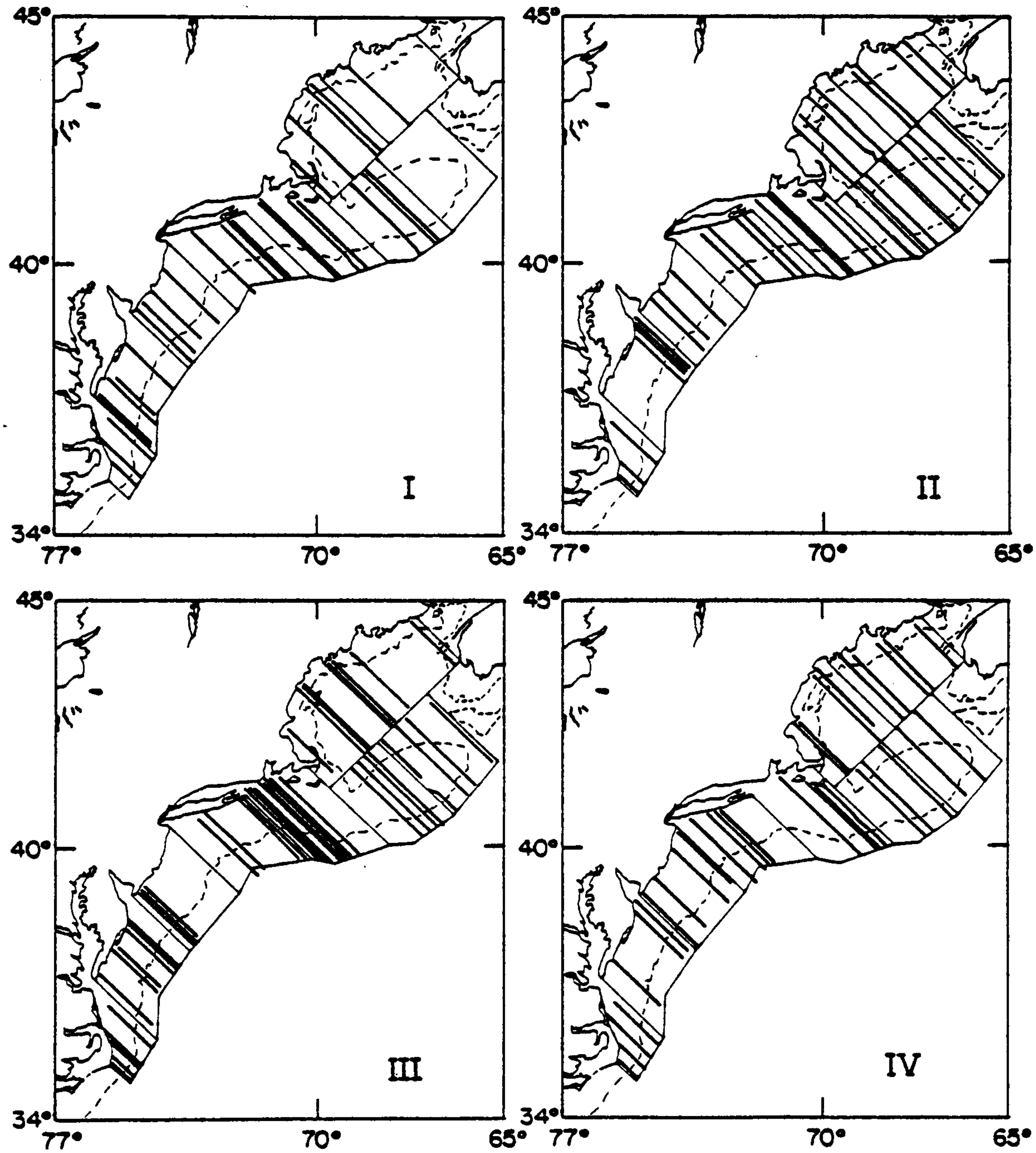


Figure 10. The sampling transects flown during the first year's sampling effort. Thick lines are transects; thin lines are area boundaries. Dashed lines represent the 200 m contour. Roman numerals represent the survey numbers.

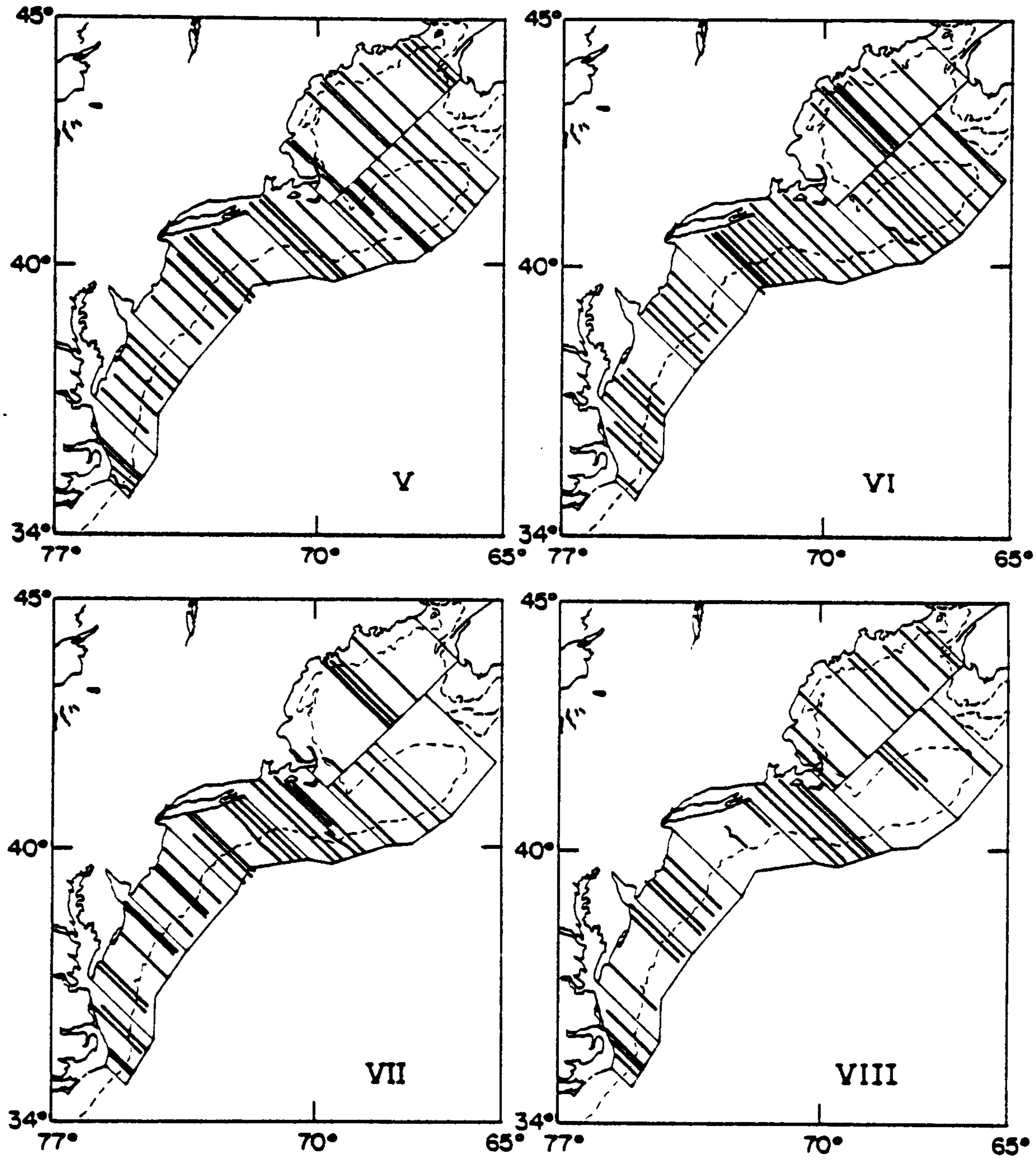


Figure 10 (continued).

Table 3. Sampling transects per area and survey from the first year's field effort.[1]

Sampling Survey	Transects/date sampled per area								
	A	B	C	D	E	F	G	H	I
I	4 4/2/79	0 ---	0 ---	3 12/2/79	4 24/1/79	4 23/1/79	4 19/1/79	2 3 16,17/1/79	3 16/1/79
II	4 3/3/79	4 9/3/79	4 23/2/79	1 5 10,13/3/79	1 2 4 2,3,17/3/79	4 1/3/79	2 2 28/2/79 1/3/79	4 28/2/79	4 27/2/79
III	4 23/4/79	4 24/4/79	4 25/4/79	4 1/5/79	4 3/5/79	4 13/4/79	1 3 11,12/4/79	5 21/4/79	3 4 17,20/4/79
IV	2 4 1,6/6/79	5 7/6/79	4 8/6/79	4 9/6/79	4 14/6/79	4 31/5/79	4 30/5/79	5 16/6/79	4 3/6/79
V	5 9/7/79	5 10/7/79	4 11/7/79	3 4 19/7/79 7/8/79	4 30/7/79	4 18/7/79	4 6/8/79	5 5/8/79	4 4/8/79
VI	4 26/8/79	4 27/8/79	4 10/9/79	4 9/9/79	4 2/9/79	4 12/9/79	5 31/8/79	2 16/9/79	1 16/9/79
VII	0 ---	4 28/10/79	0 ---	4 6/11/79	4 1/11/79	4 19/10/79	5 18/10/79	5 16/10/79	4 17/10/79
VIII	5 15/12/79	5 21/12/79	0 ---	0 ---	4 4/1/80	0 ---	5 12/1/80	5 19/1/79	4 18/12/79

[1]The numbers listed are as follows: a single number (n) placed above a date implies that n transects were sampled on that date. If several integers are listed above dates then those numbers of transects were sampled on the dates listed.

were classified into right angle distance "strips" as discussed in the previous section. Only these transect line sightings collected under environmental conditions which met or exceeded the minimal survey criteria were used for the numerical analyses performed as part of the abundance estimation task.

6. A total of 634 sightings were made from transect line sampling flights under conditions meeting or exceeding CETAP's minimum criteria. This total is comprised of 99 sightings of large whales (four species in the family Balaenopteridae, Eubalaena glacialis, and Physeter catodon), 320 sightings of small whales (seven species in the family Delphinidae), and 215 sightings of marine turtles (Caretta caretta, and Dermochelys coriacea).

7. A minimum population estimate (minimum total abundance) was computed by survey period and block for each of the fifteen species or species' groups commonly sighted. These are summarized over the entire study area in Table 4. It is emphasized that these estimates are average or point estimates believed to be conservative because of the following reasons.

a. During the course of data analysis, it was determined that species' density estimates (estimates of the numbers of each species of whale or turtle per unit sea surface sampled) were significantly affected by the sea state and glare quantity conditions existing during survey, and, by the species category itself (probably due to size and behavioral differences between species).

b. The affect was primarily one of negative bias, i.e., sea state, glare, and species category considerations tend to lower the resultant species density estimates.

c. It is known that cetaceans and sea turtles are diving animals. As a result, all individuals of a species occupying the area sampled may not be at the surface, and therefore sightable, during the brief interval when the aircraft with its observers flies over a given portion of the sampling area.

8. The "population" estimates presented in Table 4 are interpreted in species accounts below. For the purposes of the

Table 4. Minimum population estimates** within the entire study area by species and survey period.

Species	Survey I	II	III	IV	V	VI	VII	VIII
A) Large Whales								
B. acutorostrata	0	0	0	162	63	0	0	28
*B. borealis	0	0	0	109	32	0	0	0
*B. physalus	81	213	175	660	1,102	93	63	28
*E. glacialis	0	0	29	24	0	0	0	0
*M. novaeangliae	0	0	61	684	633	0	0	28
*P. catodon	0	300	174	81	289	135	104	80
B) Dolphins								
D. delphis	263	17,606	13,747	4,447	0	6,724	10,219	1,376
G. griseus	0	9,471	615	2,450	2,093	10,220	9,753	1,024
Globicephala spp.	0	915	4,299	10,996	11,448	2,826	5,814	3,540
L. acutus	0	0	4,713	18,255	20,458	24,287	7,901	1,193
P. phocoena	0	0	271	2,946	658	0	0	307
Stenella spp.	1,153	4,033	6,217	22,376	13,000	7,901	1,756	18,732
T. truncatus	0	1,903	2,713	1,819	3,443	2,194	6,254	1,610
C) Turtles								
C. caretta	0	0	102	3,749	4,017	1,108	3,493	156
*D. coriacea	0	0	0	70	107	636	154	0

*Endangered species as defined by the U.S. Congress

**For an explanation of minimum population estimates or minimum point estimates, see text.

interpretations, the following definitions apply. The study area is the CETAP area of investigation, i.e., the northeastern OCS region shown in Figure 1. Estimated minimum number refers to the average or point estimate obtained by pooling the estimates from the nine blocks. With this estimate, in parentheses, is the 95 percent confidence interval around it, e.g., 162 (± 118, 95% CI). This should be read "within the study area and during at least one survey period, there were 162 plus or minus 118 whales at the 95 percent level of confidence." Relative density is the estimated number of individuals per unit area unadjusted for the survey, environmental, or species-category variables discussed in item 7. Only thirteen species or species' groups of cetaceans presented in Table 4 are discussed. Turtles are discussed in a later section.

a. The large whales.

Balaenoptera acutorostrata - the minke whale

The estimated minimum number of minke whales found in the study area during the survey period of highest abundance was 162 (± 118 95% CI) individuals. The highest relative density of this species was found in sampling Block C during June, 1979. Block C contains a portion of Lease Sale Area 52. Minke whales are not considered to be endangered and while no estimates of the western North Atlantic stock(s) are available, the level of the North Atlantic minke whale population has been estimated to range from 50,000 to 70,000 individuals.

Balaenoptera borealis - the sei whale

The estimated minimum number of sei whales in the study area during the survey period of highest abundance was 109 (± 173, 95% CI). The highest relative density for this species was found in sampling Block C in June, 1979. Block C contains a portion of Lease Sale Area 52. It is believed by some that two stocks of sei whales exist in the western North Atlantic. Individuals of this species found in the CETAP study area belong to the Nova Scotian stock, which is thought to range from southern Newfoundland (the summer and northern limit) to approximately 30° N latitude (the latitude of St. Augustine, Florida; the winter and southern limit). Sei whales are considered to be endangered and investigations have estimated, based on tag and recapture estimates, the Nova Scotian stock to range from 1,398 to 2,248 individuals.

Balaenoptera physalus - the fin whale

The estimated minimum number of fin whales in the study area during the survey period of highest abundance was 1,102 ($\pm$ 1,417, 95% CI). The highest relative density of this species was in sampling Block A during July, 1979. Block A contains a portion of Lease Sale Area 52. Fin whales are considered to be endangered, and there are an estimated 2,000 individuals in the Nova Scotian stock (presumably the stock to which fin whales in the CETAP study area belong). The population level of fin whales in the western North Atlantic is thought to range between 3600 and 6300 individuals.

Eubalaena glacialis - the right whale

The estimated minimum number of right whales in the study area during the survey period of highest abundance was 29 ($\pm$ 44, 95% CI). The highest relative density of this species was found in sampling Block B during April, 1979. Right whales are considered to be endangered.

Megaptera novaeangliae - the humpback whale

The estimated minimum number of humpback whales in the study area during the survey period of highest abundance was 684 ($\pm$ 275, 95% CI). The highest relative density of this species was found in sampling Block A in July, 1979. Block A contains a portion of Lease Sale Area 52. Humpback whales are considered to be endangered. The stocks in the western North Atlantic have been estimated to be in excess of 2050 individuals.

Physeter catodon - the sperm whale

The estimated minimum number of sperm whales in the study area during the survey period of highest abundance was 300 ($\pm$ 373, 95% CI). The highest relative density of this species was in sampling Block I during February, 1979. Sperm whales are considered to be endangered. The stock of sperm whales in the central and western North Atlantic has been estimated to be 22,000 individuals.

b. Dolphins

Delphinus delphis - the common or saddleback dolphin

The estimated minimum number of common (or saddleback) dolphins found in the study area during the period of highest abundance was 17,606 (± 26,749, 95% CI). The highest relative density of this species was in sampling Block G during January and February, 1979. Block G contains a portion of Lease Sale Area 59. This species is not considered to be endangered. More than 30,000 common dolphins are thought to comprise the North Atlantic stock(s) of this species.

Grampus griseus - Risso's dolphin or Grampus

The estimated minimum number of Risso's dolphins (or Gray grampus) found in the study area during the survey period of highest abundance was 10,220 (± 10,194, 95% CI). The highest relative density of this species was in sampling Block G during October, 1979. Block G contains a portion of Lease Sale Area 59. This species is not considered to be endangered. No estimates of the western North Atlantic stock(s) of Risso's dolphins are available.

Globicephala spp. - the pilot whale

The estimated minimum number of pilot whales (both G. melaena and G. macrorhynchus) found in the study area during the survey period of highest abundance was 11,448 (± 18,202, 95% CI). The highest relative density of these species was in sampling Block C during July, 1979. Block C contains a portion of Lease Sale Area 52. This genus is not considered endangered. The 1947 stock of long-finned pilot whales (G. melaena) available to the Newfoundland fishery was estimated to consist of fewer than 60,000 individuals. No estimates of the stock size of short-finned pilot whales (G. macrorhynchus) in the western North Atlantic are available.

Lagenorhynchus acutus - the Atlantic white-sided dolphin

The estimated minimum number of Atlantic white-sided dolphins found in the study area during the survey period of highest abundance is 24,287 (± 15,146, 95% CI). The highest relative density of this species was in sampling Block A during July, 1979. Block A contains a portion of Lease Sale Area 52. This species is not considered endangered. No estimate of the western North Atlantic stock size of Atlantic white-sided dolphins is available.

Phocoena phocoena - the harbor porpoise

The estimated minimum number of harbor porpoise found in the study area during the survey period of highest abundance is 2,946 (± 1,130, 95% CI). The highest relative density of this species was in sampling Block B during June, 1979. Block B contains a portion of Lease Sale Area 52. This species is not considered endangered. A minimum of 4,000 harbor porpoise were estimated to inhabit the waters of the approaches to the Bay of Fundy. No other estimates of the stock(s) of this species are available.

Stenella spp. - spotted dolphins

The estimated minimum number of all species in the genus Stenella found in the study area during the survey period of highest abundance is 22,376 (± 16,988, 95% CI). The highest relative density for this genus was in sampling Block E during June, 1979. This genus is not considered endangered. No estimates of the western North Atlantic stock(s) of this genus are available.

Tursiops truncatus - the Atlantic bottlenosed dolphin

The estimated minimum number of Atlantic bottlenosed dolphins found in the study area during the survey period of highest abundance is 6,254 (± 12,309, 95% CI). The highest relative density for this species was in sampling Block I during October, 1979. This species is not considered endangered. The stock size of Atlantic bottlenosed dolphins available to a shore-based fishery operated from Cape Hatteras in the recent past was estimated to be between 13,748 and 17,000 individuals. No other estimated of the stock(s) of this species in the western North Atlantic are available.

SPATIAL AND TEMPORAL DISTRIBUTION OF HUMPBACK WHALES
IN THE CETAP STUDY AREA

Robert D. Kenney, Donna R. Goodale,
Gerald P. Scott, Howard E. Winn

1. This section reports on data compiled for a single endangered species, the humpback whale (Megaptera novaeangliae). The interpretations presented are based not only on CETAP-collected data but also from the literature and previously unpublished data collected prior to the establishment of CETAP. The sources, year of collection, and number of sightings is as follows:

Source	Yr. of Collection	# of Sightings
Literature & unpublished	Pre-1979	113
Gulf of ME Sighting Network	1974-79	327
CETAP	1979	419

Ninety-four percent of these 859 sightings were positively identified humpback whales; the remaining six percent were tentatively identified as such.

2. The temporal aspects of the humpback whale distribution (Figure 11) indicates the following:

a. Winter sightings (December, January, February, and March) are low in number compared to all other months.

b. The frequency of sightings rapidly increases during April and reaches a maximum in May.

c. The frequency of sightings remains higher during May, June, July, and August than during other months.

d. After the maximum in May, the frequency of sightings diminishes over time except for the month of October when the sighting frequency was slightly higher than in September.

e. Whale-watch boat sightings (the non-shaded portions of the bars in Figure 12 which result from extensive coverage of a limited area north of Cape Cod, MA) complement the pattern described in a through d above.

3. Spatially, the distribution of CETAP's humpback sightings

(Figure 11) indicates a predominance of occurrence in the northern portion of the study area, i.e., north of 40^{o}N latitude. This area includes Georges Bank, the Great South Channel (southeast of Nantucket), and the Gulf of Maine. When all sightings are viewed (Figure 13), three highly localized regions of concentration within the Gulf of Maine become apparent. These three are Jeffreys Ledge (east of Cape Ann, MA), Stellwagen Bank (north of Cape Cod, MA), and the Provincetown Slope (the western slope of the Great South Channel and adjoining the Nantucket Shoals). It is thought that sighting effort bias may affect this interpretation but not negate it.

4. Humpback sightings occurred 70 percent of the time in water depths of 50 fathoms (91.4 m) or less. The mean depth for the 1979 sightings was 45.9 fathoms (84.1 m). No significant difference in sighting distribution with respect to depth occurred over time. Both Figures 11 and 13 show the predominance of humpback sightings over the shelf rather than over the continental slope or mid-Gulf of Maine Basins in spite of the fact that effort occurred over both shelf and off-shelf areas. Furthermore, the occurrence of sightings tends to follow the perimeters of Georges Bank and the Gulf of Maine.

5. No preferences or correlations between humpback occurrence and sea temperature are apparent from the data. Sea temperatures measured at sightings did vary with latitude and season, however.

6. The number of individual humpback whales per sighting, i.e., the group size, varied slightly with time. The lower numbers of individuals per group occurred during winter months. Between February and August, the average number of individuals per group increased month by month from one whale per sighting in February to just over three whales per sighting in August. During the months of September, October, and November, the number of whales per group remained above two and a half. In absolute terms, the number of humpbacks per group varied between one and 25, but eighty-two percent of all groups sighted were comprised of three or fewer whales.

7. The CETAP data indicate, based on a low number of sightings

over the outer continental shelf during spring and fall migratory seasons, that humpbacks, which commonly occur in the study area during late spring and summer, probably migrate offshore and outside of the study area.

8. A possible determining factor for the temporal and spatial distributions observed may be the seasonal occurrence of the American sand lance (*Ammodytes americanus*) a schooling fish thought to be an important prey item and one which is commonly reported during spring and summer from the same area as the humpback whale.

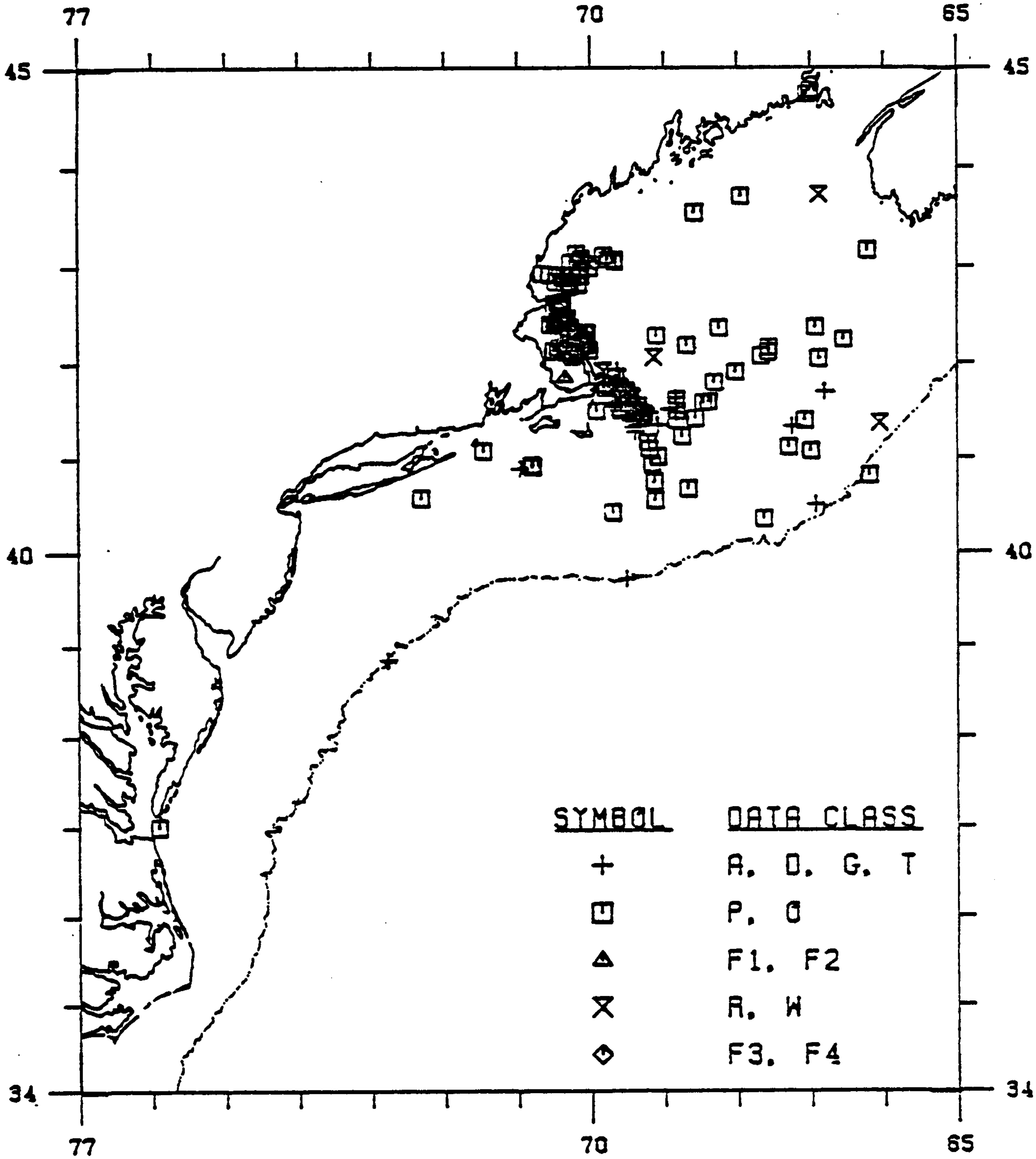


Figure 11. Plot of CETAP humpback whale, Megaptera novaeangliae, sightings, 1 November 1978 to 9 January 1980, differentiated by data class (the various data classes are detailed in Chapter II of the CETAP Annual Report for 1979). The 2000 m depth contour is shown.

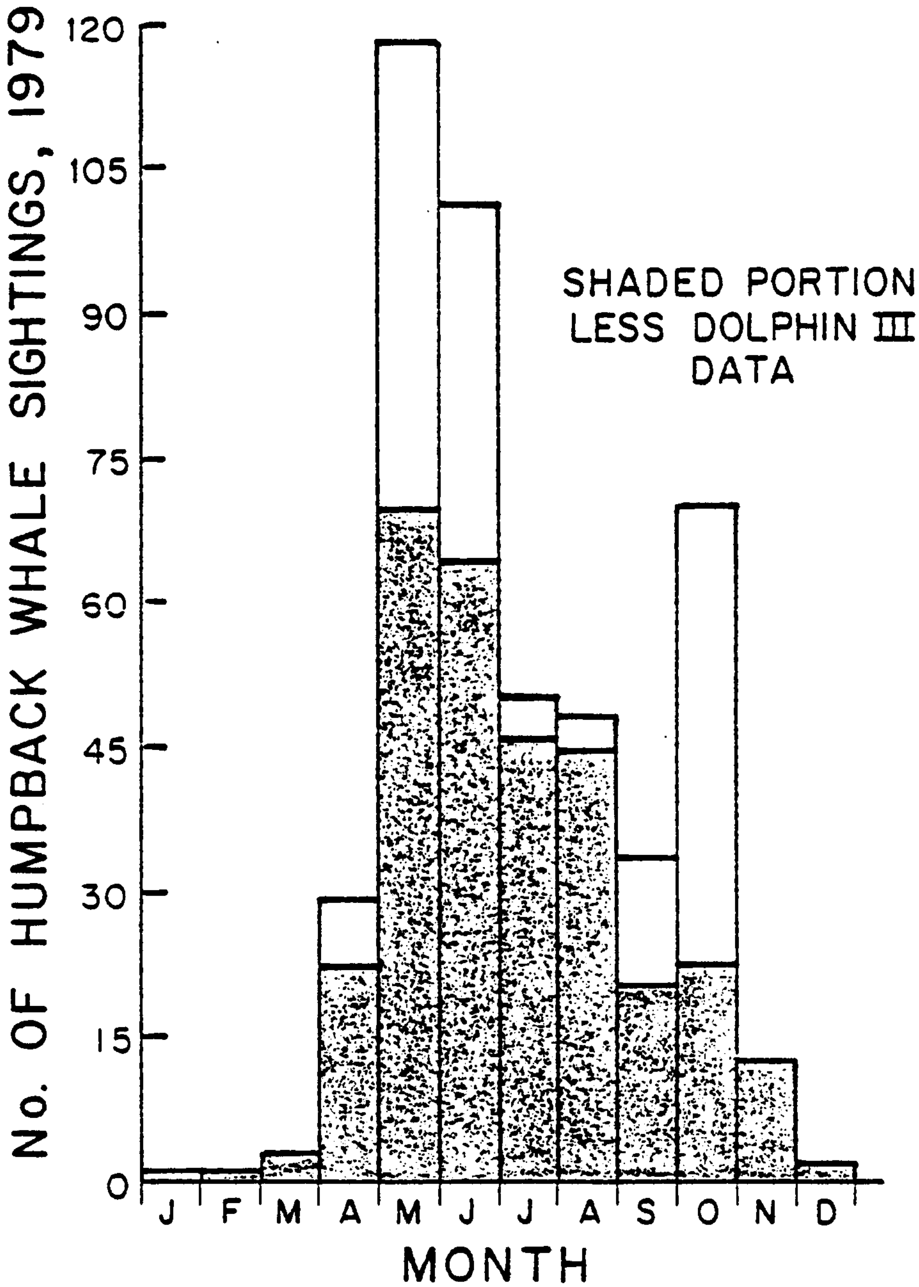


Figure 12. Frequency distribution of 1979 CETAP humpback whale sightings by month with and without sightings from M/V Dolphin III (a commercial whale-watch vessel operating out of Provincetown, MA).

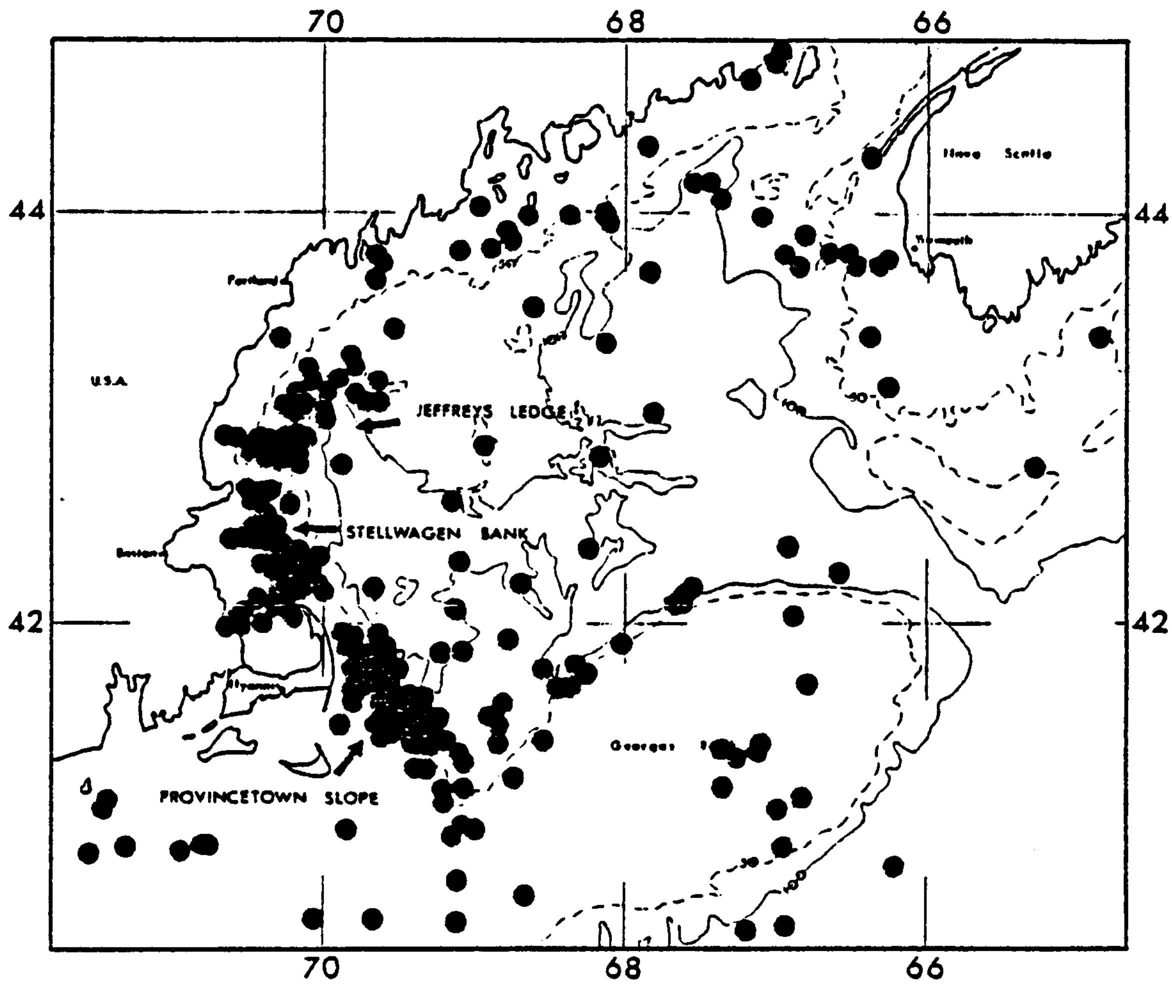


Figure 13. Plot of all CETAP humpback whale sightings in the Gulf of Maine, including Gulf of Maine Whale Sighting Network (a cooperating program at the College of the Atlantic, Bar Harbor, ME) and various historical sightings. The three major concentration areas are designated. Depth contours shown are 50 and 100 fathom lines.

RIGHT WHALE SIGHTINGS AND THE RIGHT WHALE MINIMUM COUNT

Howard E. Winn, Donna R. Goodale, Martin A.M. Hyman,
Robert D. Kenney, Carol A. Price, Gerald P. Scott

1. The right whale, Eubalaena glacialis, is considered by many to be the most endangered cetacean occurring in the study area.

2. In addition to the CETAP field sampling previously described, a number of special spring right whale shipboard and aerial surveys were conducted in 1979 and 1980. These specialized surveys gave additional coverage to most portions of the Gulf of Maine, Georges Bank, and the continental shelf region south of New England and Long Island.

3. The resulting whole-year plot of the 119 sightings of right whales is shown in Figure 14. The sightings generally consisted of 1-3 individuals in relatively isolated groups. In 1979, the aggregations were statistically clustered (possibly due to patchy prey occurrence), with pod sizes of 1-4 individuals tied loosely with larger groups. Some data suggest a general dispersion at daylight and a reconcentration at dusk. A substantial number of sightings were made on the western edge of Georges Bank rather than in the expected nearshore areas. In general, most right whale sightings occurred between depths of 0-200 m.

4. These special surveys were employed to improve upon estimates of the number of right whales in the study area as determined from the dedicated aerial survey data. Thus, on 12 May 1979, an aerial survey designed with abundance estimation as its goal was carried out in a 9218 km^2 trapezoidally shaped area known from previous days to contain a concentration of right whales. This area was centered east of Cape Cod, MA, at latitude 42^{o}N and longitude 69^{o}W. Resultant data were used to compute a point estimate of 66 right whales with a 95% confidence interval of 5 to 173. Considering this estimate of 66 right whales, the minimum count of 19 right whales (19 individuals not reduntantly counted during a single flight), and the estimate of 29 ± 44

(see page 40) based on the dedicated aerial survey, we estimate the population of right whales within the study area to be approximately 100 but not less than 19 nor more than 173. This estimate applies only to the period of highest abundance, lesser numbers occur at other times.

5. An annual cycle of distribution for the right whale is hypothesized, with an early spring northward migration along the 200 m depth contour line or beyond, passage through the Great South Channel, then migration northward to northern Maine and Nova Scotia, and finally culminating with a southwestward return migration during late summer and fall. Three potential migratory routes appear to exist in the Gulf of Maine area.

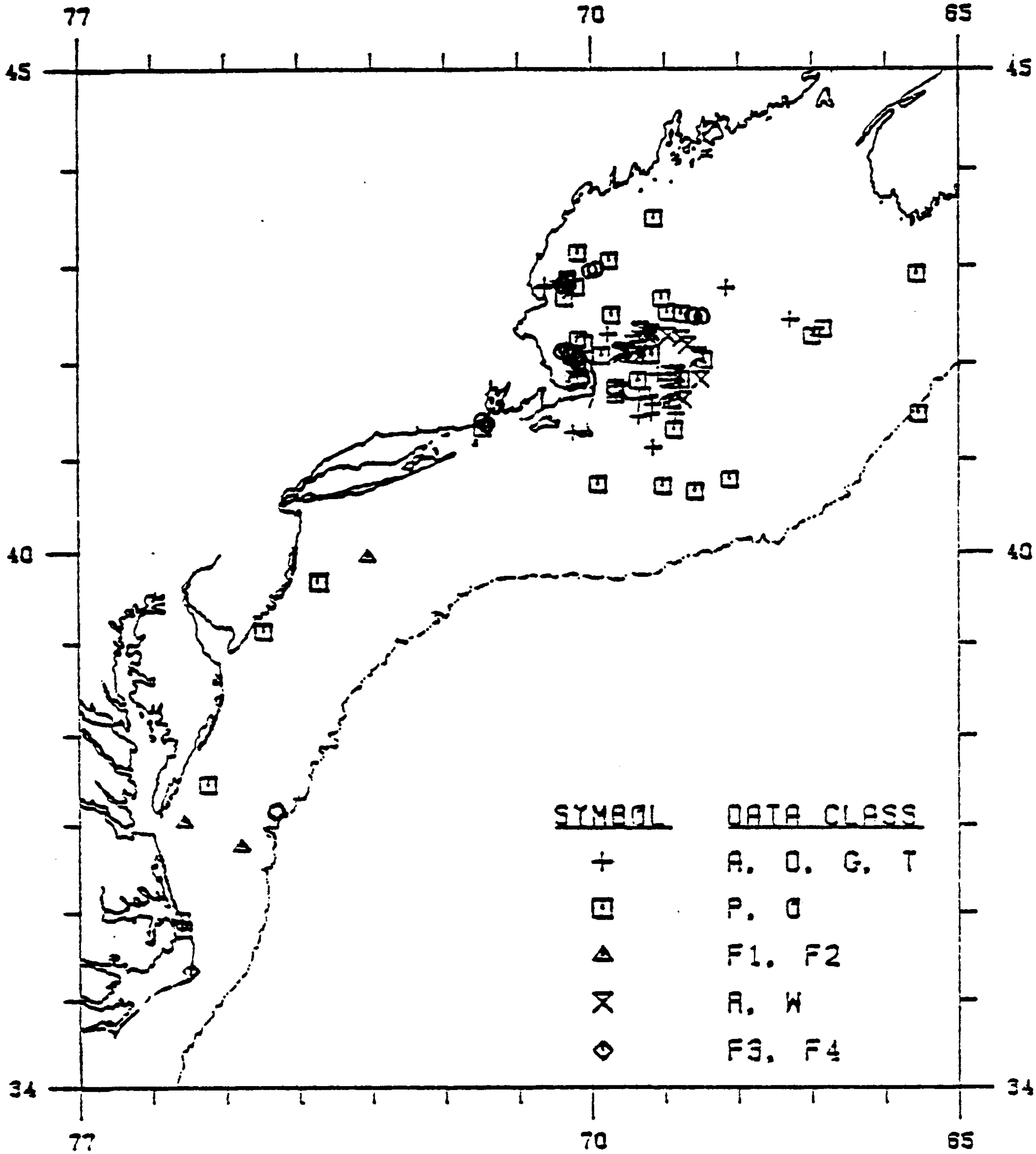


Figure 14. All right whale, Eubalaena glacialis, sightings from 1 October 1978 to 9 January 1980. Sightings are sorted by data class, as described in Chapter II and VI of the CETAP Annual Report for 1979. 2000 m depth contour shown.

CORRELATIONS BETWEEN CETACEAN SIGHTINGS
AND SELECTED ENVIRONMENTAL VARIABLES

Richard K. Edel, Michael Cagan, James H.W. Hain, Peter W. Sorensen

1. Nineteen species or species' groups were commonly sighted during CETAP's 1979 field data collection effort. These species or groups are:

a. Balaenoptera physalus
b. Balaenoptera borealis
c. Balaenoptera acutorostrata
d. Balaenoptera species
e. Megaptera novaeangliae
f. Eubalaena glacialis
g. Unidentified whale
h. Physeter catodon
i. Globicephala spp.
j. Grampus griseus
k. Phocoena phocoena
l. Lagenorhynchus acutus
m. Tursiops truncatus
n. Stenella spp. (spotted)
o. Stenella coeruleoalba
p. Delphinus delphis
q. Unidentified dolphin/porpoise
r. Unidentified beaked dolphin
s. Unidentified Stenella spp.

2. Sightings which occurred within the study area were investigated for spatial patterns of occurrence using two techniques: univariate histograms and bivariate correlations. Two time bases were analyzed: the first used all sightings pooled over the calendar year; the second used survey periods or semiseasons. In this way both whole year spatial distributions and semi-seasonal spatial distributions were available for study.

The histograms are particularly useful for interpretations in that they show the frequency with which a particular species or species' group was sighted at the various latitudes, longitudes, sea temperatures, and depths which characterize the study area. Thus, the histograms demonstrate visually any correlations between the occurrence of cetaceans and the four environmental variables mentioned. For this summary, the whole-year distributions are presented in Figure 15. The figure should be interpreted as follows:

a. For each of the nineteen species or species' groups listed in item 1 above, four histograms and corresponding statistics are given.

b. Each histogram relates the frequency of sightings to one of the four environmental variables, i.e., latitude, longitude, sea temperature, and depth of water under the sighting position.

c. Each environmental variable has a range which is partitioned into intervals.

d. Each sighting is put into the appropriate interval until all sightings for the species or species' group are accounted for. The numbers printed along the y-axis correspond to the mid-points of these intervals. The number of sightings per interval is indicated by a corresponding number of asterisks up to the number when the row of asterisks would run over into the next species field. When this occurs, the total number of sightings for the interval is printed out. A letter "m" or "n" indicates the mean or average interval of all sightings. The table below each histogram gives the standard summary statistics (mean, standard deviation, standard error of the mean, maximum value, minimum value, and sample size) for each variable and species considered.

When inspecting the histograms, one looks for similarities or differences between intervals within the histogram for the species and between intervals across the histograms for the different species. In this way variation of cetacean occurrence with respect to the study area's environmental variables is determinable not only for each species but also between species. This information allows one to make inferences concerning the effects of search effort as well as of preferred habitats or zones of occurrence.

Bivariate correlations were investigated to determine whether or not the site occurrences of a particular species are associated with geophysical factors in a particular way.

3. The results show that there are relationships not only between a species or species' group and its spatial and temporal distributions but also between two or more species or species' groups with regard to their spatial and temporal distributions.

a. All of the baleen whales (B. physalus, B. acutorostrata, Balaenoptera spp., M. novaeangliae, E. glacialis, and Unidentified whale), except for the sei (B. borealis), occupied the OCS between nearshore and the 200 m isobath sometime during the year. Included is the OCS within the Gulf of Maine especially the area just north of the Great South Channel.

M. novaeangliae and E. glacialis either did not, or only temporarily occupied the OCS in the mid-Atlantic region during the cooler months. These species occupied the north-Atlantic region of the OCS during the warmer months but did not or only rarely occupied this region during the cooler months. B. borealis occurred during summer months only over the OCS slope southeast of Georges Bank.

The sea temperatures measured at baleen whale sightings encompassed a large range. Hence, sea temperature, by itself, does not appear to be a limiting factor, i.e., within a given survey period temperatures would be changing to a limited extent, but baleen whales were found in both the cooler and warmer portions of the study area.

b. The medium-sized toothed whales, P. catodon, Globicephala spp. and G. griseus, frequented a narrow zone consisting of the offshore portions of both the mid- and north-Atlantic regions of the OCS and the OCS slope. These areas correspond to depths between 50 and 2000 m. P. catodon and G. griseus rarely entered the Gulf of Maine. Globicephala spp. entered the Gulf of Maine through both the Great South Channel and the Northeast Channel. P. catodon occurred over near-shore portions of the North-Atlantic OCS only during late summer and early fall.

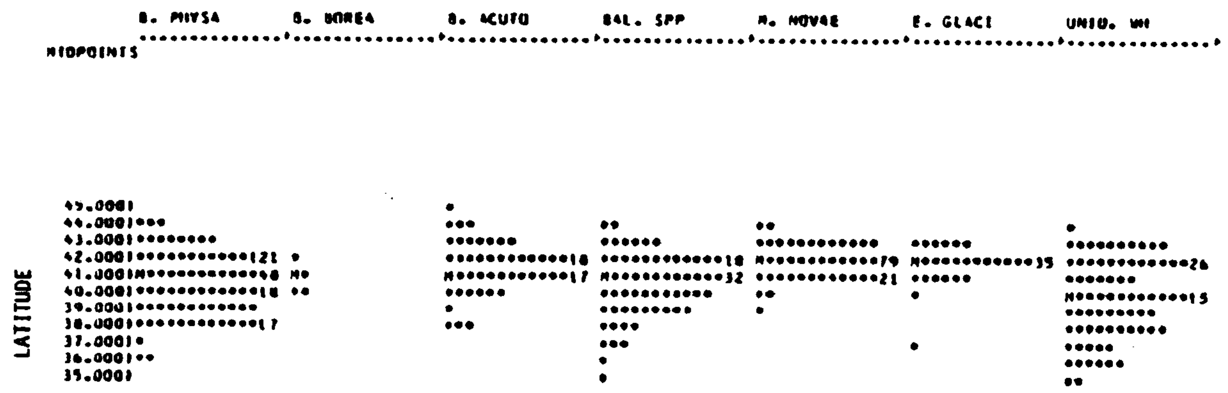
The mid-Atlantic region was occupied more often during the year than the north-Atlantic or Gulf of Maine region. Surmised migration takes place in a narrow band along the mid- and north-Atlantic OCS edge: movement is northward during the warming months and southward during the cooling months.

Sea temperatures measured at sightings corresponded to the offshore areas of occurrence; the temperatures were wide ranging but nonetheless warmer than those measured at sightings of baleen whales.

c. The small whales (dolphins and porpoises) are the remainder of the species or species' groups (k through s in section 1, above). All nine species or species' groups occupied the OCS and/or its outer portions (the OCS edge and slope) between Cape Hatteras and Georges Bank sometime during the year. In the Gulf of Maine the primary small whale occupants are P. phocoena, L. acutus, and D. delphis. South of Georges Bank, T. truncatus, Stenella spp. (spotted), S. coeruleoalba, and D. delphis made up the bulk of the sightings. T. truncatus occurred both nearshore between Cape Hatteras and New Jersey and offshore from Cape Hatteras to eastern Georges Bank. The spotted Stenella's occurred more frequently in the southern part of the study area than the other small whale species except for T. truncatus.

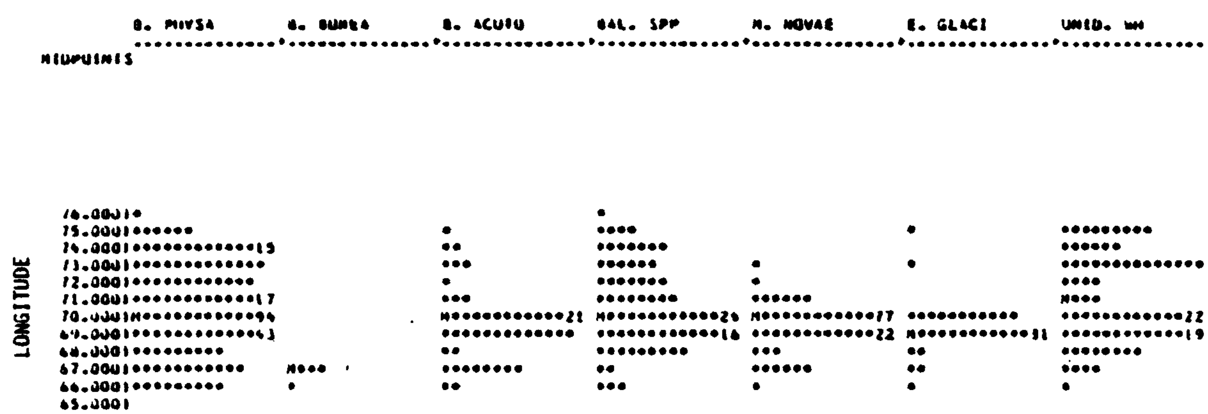
Broad ranges of sighting sea temperatures indicate that sea temperature is not a limiting factor. All species of the genus Stenella, however, occurred in water which was warmer than where the other species occurred.

Semi-seasonal changes in occurrence patterns are probably caused by migration northward and southward along the OCS. It is surmised that many of these species occur just beyond the study area's seaward boundary and may migrate east-west into and out of the study area. In spite of large numbers of sightings, it is difficult to draw conclusions from the two species' groups, unidentified dolphin/porpoise and unidentified beaked dolphins due to the uncertainty of identification and accuracy and variation between species.



GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

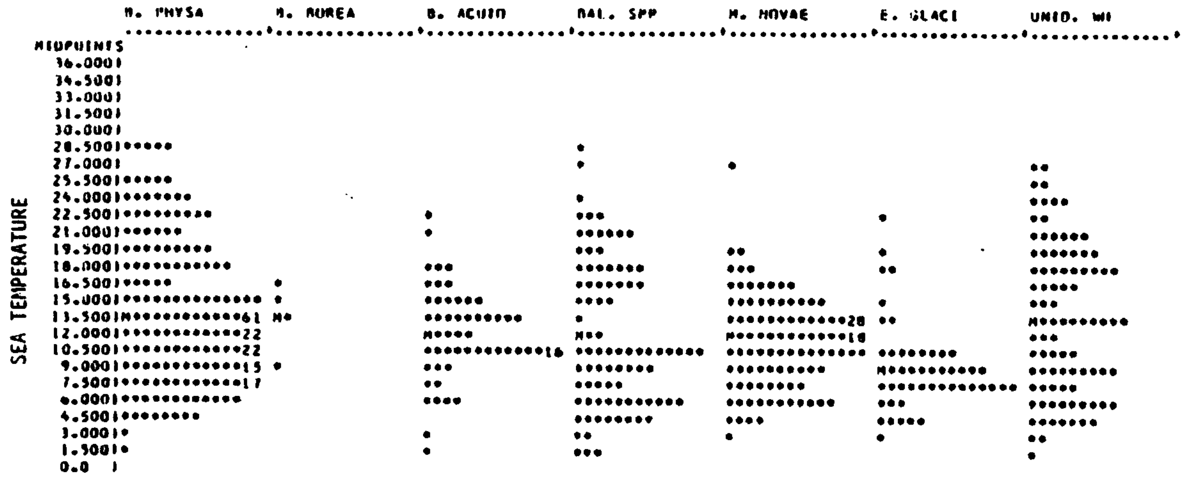
	B. PHYSA	B. BOREA	B. ACUTO	BAL. SPP	M. NOVAE	E. GLACI	UNID. WH
MEAN	41.178	40.706	41.490	40.721	41.875	41.833	40.184
STD.DEV.	1.383	0.489	1.344	1.652	0.677	0.862	2.217
S. E. M.	0.091	0.217	0.180	0.177	0.063	0.123	0.232
MAXIMUM	43.712	41.555	44.583	43.780	43.717	43.062	43.962
MINIMUM	35.925	40.387	38.000	35.417	38.837	37.450	34.957
SAMPLE SIZE	230	5	56	87	117	49	91



GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

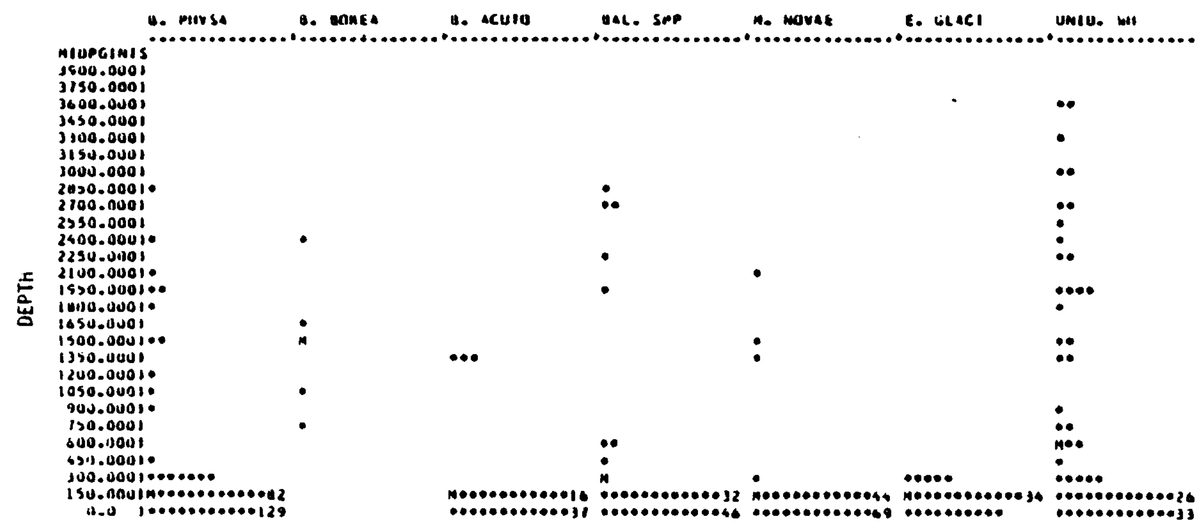
	B. PHYSA	B. BOREA	B. ACUTO	BAL. SPP	M. NOVAE	E. GLACI	UNID. WH
MEAN	70.261	66.700	69.670	70.493	69.707	69.237	70.818
STD.DEV.	1.953	0.563	1.878	2.206	0.990	1.330	2.383
S. E. M.	0.129	0.261	0.251	0.236	0.092	0.190	0.250
MAXIMUM	75.833	67.435	74.733	75.517	72.780	75.250	75.435
MINIMUM	65.827	65.802	66.427	65.567	66.065	65.567	65.700
SAMPLE SIZE	230	5	56	87	117	49	91

Figure 15. Histograms of the frequency of whale sightings at the various latitudes, longitudes, sea temperatures, and depths at the sighting position. The species or species' group names are fully written out in item 1 of the text. Explanations of the histograms and the univariate statistics located below each are given in text item 2.



GROUP MEANS ARE DENOTED BY M*S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

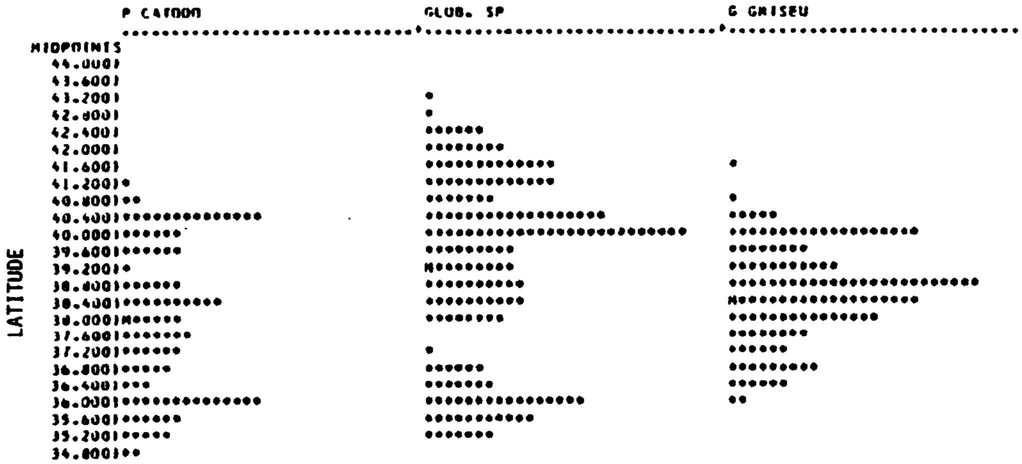
	B. PHYSA	B. BOREA	B. ACUTO	BAL. SPP	M. NOVAE	E. GLACI	UNID. WH
MEAN	13.585	13.400	11.977	11.943	11.721	9.273	13.553
STD.DEV.	5.545	2.729	3.968	6.481	3.867	3.866	6.611
S. E. M.	0.366	1.220	0.530	0.695	0.357	0.552	0.693
MAXIMUM	29.200	16.300	23.000	28.900	27.600	21.800	27.200
MINIMUM	1.300	9.000	1.200	1.700	3.500	3.300	1.700
SAMPLE SIZE	230	5	56	67	117	49	91



GROUP MEANS ARE DENOTED BY M*S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

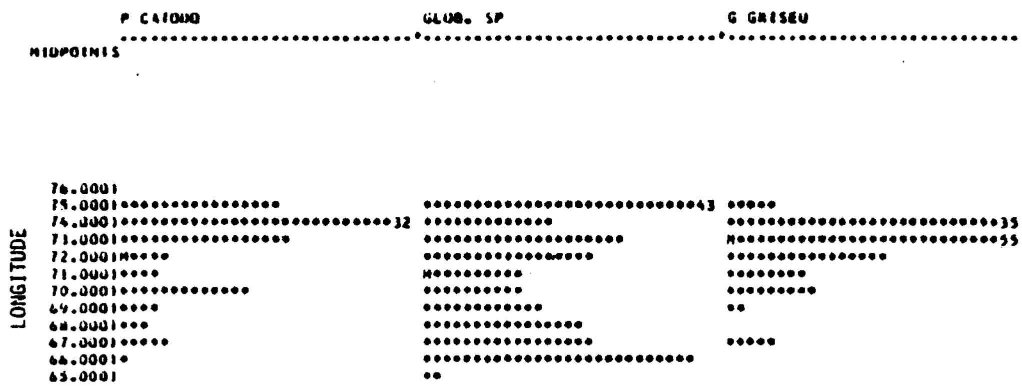
	B. PHYSA	B. BOREA	B. ACUTO	BAL. SPP	M. NOVAE	E. GLACI	UNID. WH
MEAN	168.113	1463.000	134.125	239.186	124.291	150.224	635.077
STD.DEV.	379.354	619.920	299.156	567.817	255.282	73.168	972.851
S. E. M.	25.014	277.236	39.976	60.876	23.601	10.453	101.982
MAXIMUM	2825.000	2377.000	1372.000	2780.000	2045.000	338.000	3660.000
MINIMUM	11.000	732.000	3.000	18.000	5.000	5.000	18.000
SAMPLE SIZE	230	5	56	87	117	49	91

Figure 15 (continued).



GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

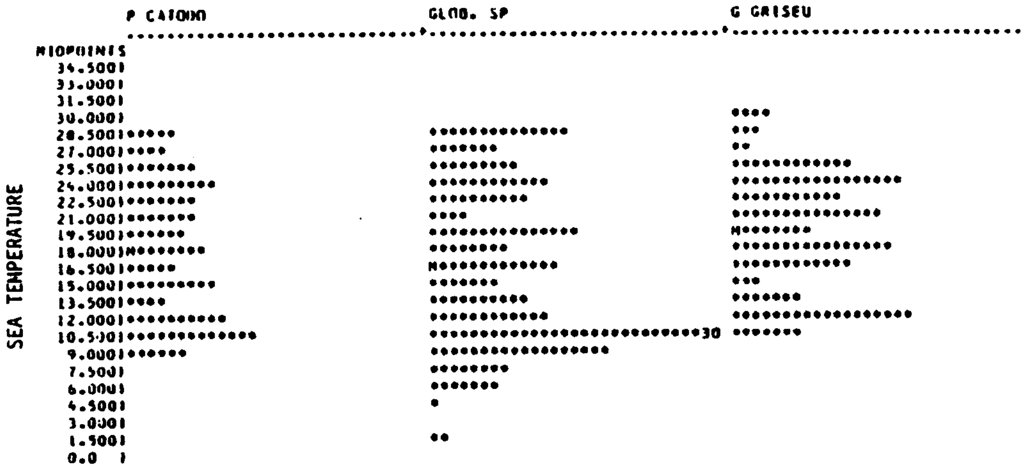
	P CATODO	GLOB. SP	G GRISEU
MEAN	37.947	39.112	38.565
STD.DEV.	1.811	2.151	1.150
S. E. M.	0.181	0.157	0.099
MAXIMUM	41.192	43.173	41.527
MINIMUM	34.980	35.050	35.803
SAMPLE SIZE	100	187	135



GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

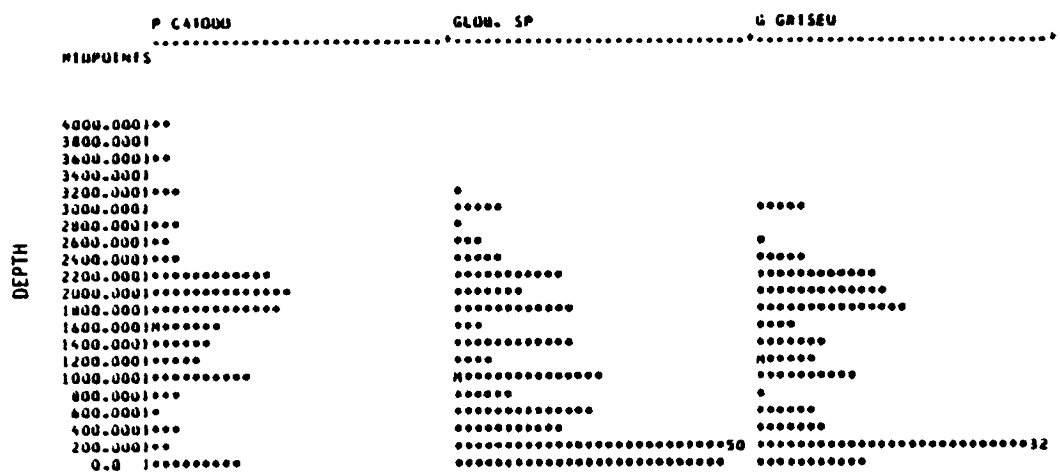
	P CATODO	GLOB. SP	G GRISEU
MEAN	72.410	70.795	72.615
STD.DEV.	2.406	3.281	1.683
S. E. M.	0.241	0.240	0.145
MAXIMUM	75.042	75.133	74.875
MINIMUM	66.208	65.497	66.602
SAMPLE SIZE	100	187	135

Figure 15 (continued).



GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

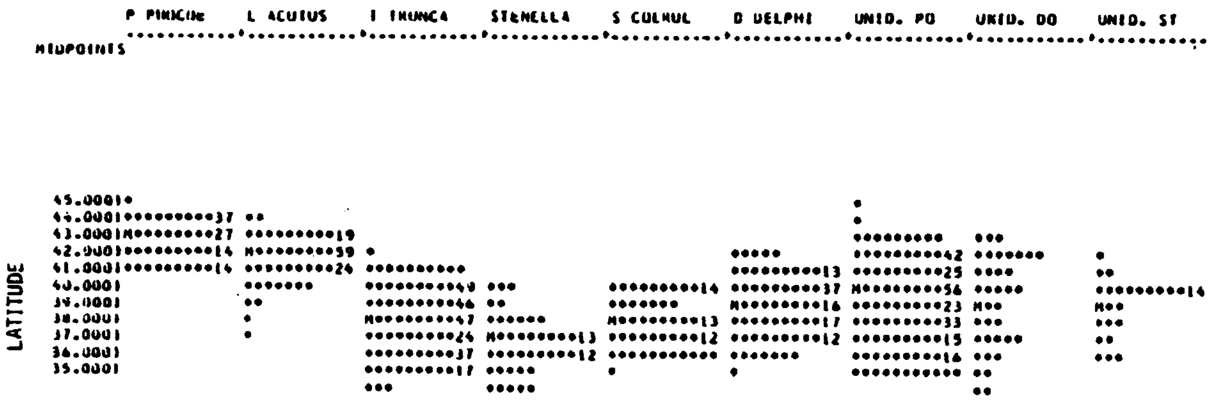
	P CATODO	GLOB. SP	G GRISEU
MEAN	17.917	16.178	19.316
STD.DEV.	6.011	7.006	5.226
S. E. M.	0.601	0.512	0.450
MAXIMUM	29.200	29.100	29.400
MINIMUM	8.300	1.100	10.000
SAMPLE SIZE	100	187	135



GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

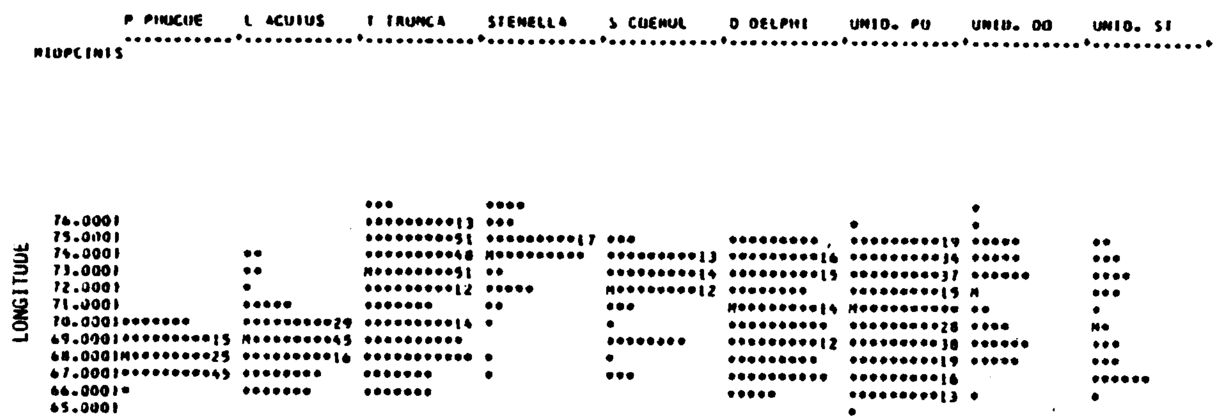
	P CATODO	GLOB. SP	G GRISEU
MEAN	1634.850	908.519	1152.926
STD.DEV.	897.500	869.577	894.986
S. E. M.	89.750	63.590	77.028
MAXIMUM	3950.000	3200.000	2999.000
MINIMUM	57.000	9.000	57.000
SAMPLE SIZE	100	187	135

Figure 15 (continued).



GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

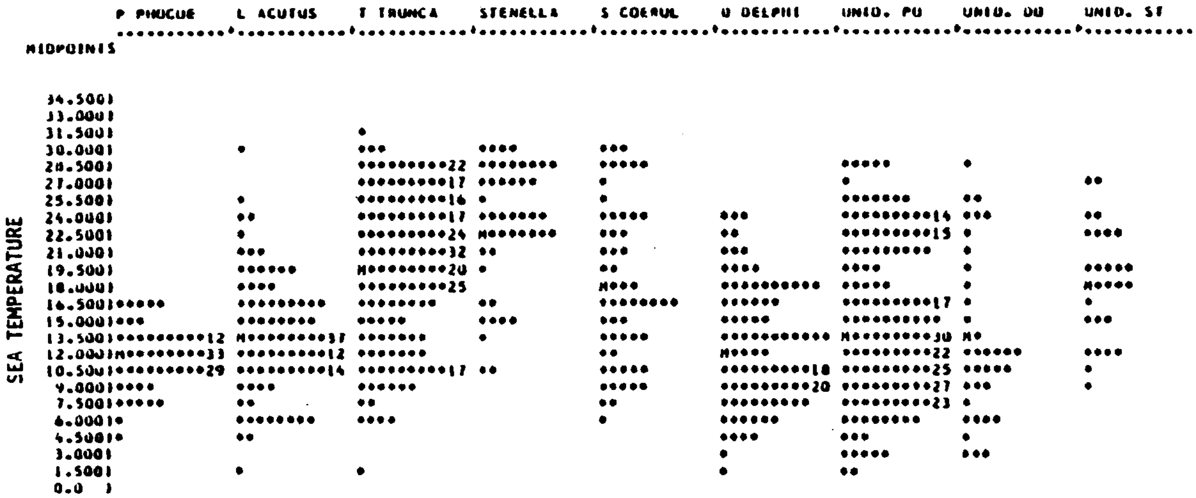
	P PHOCOE	L ACUTUS	T TRUNCA	STENELLA	S COERUL	D DELPHI	UNID. PO	UNID. DO	UNID. ST
MEAN	42.972	41.685	38.083	36.612	38.000	39.172	39.571	39.213	39.206
STD.DEV.	1.136	1.021	1.759	1.609	1.463	1.541	2.152	2.658	1.500
S. E. M.	0.118	0.095	0.115	0.237	0.192	0.153	0.141	0.437	0.283
MAXIMUM	44.633	43.690	42.122	40.417	40.447	42.400	44.750	43.267	41.633
MINIMUM	40.657	36.967	33.617	33.617	35.148	34.988	34.967	34.400	36.147
SAMPLE SIZE	93	115	234	46	58	108	232	37	28



GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

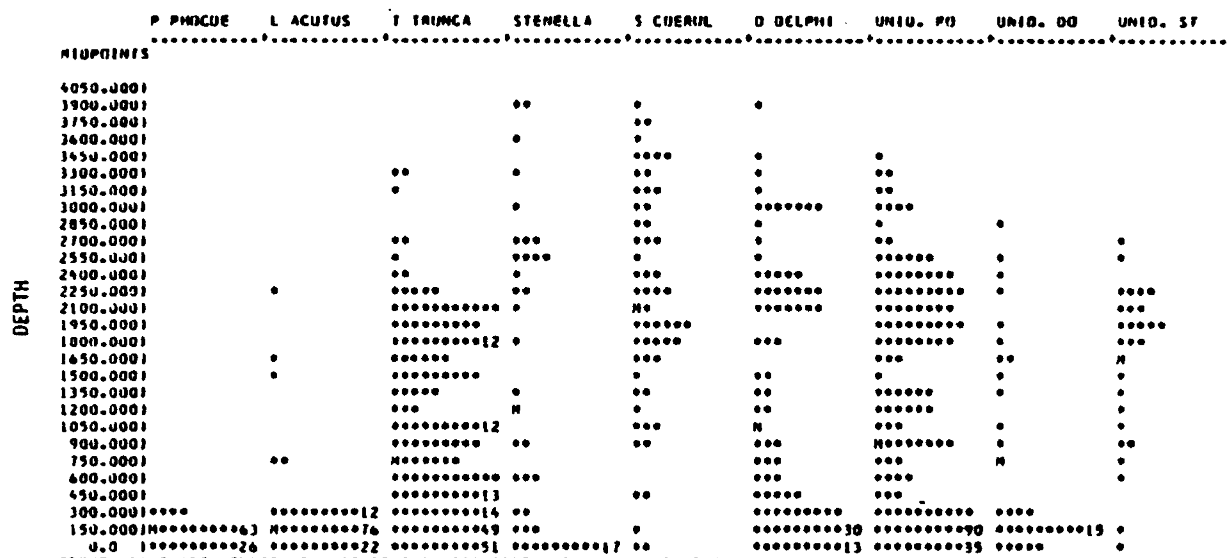
	P PHOCOE	L ACUTUS	T TRUNCA	STENELLA	S COERUL	D DELPHI	UNID. PO	UNID. DO	UNID. ST
MEAN	67.821	69.108	72.808	73.939	72.027	70.910	70.888	71.657	70.360
STD.DEV.	0.944	1.372	2.597	2.057	2.209	2.704	2.772	2.856	2.909
S. E. M.	0.098	0.128	0.170	0.303	0.290	0.260	0.182	0.469	0.550
MAXIMUM	70.468	74.083	76.950	76.950	74.992	75.028	75.760	76.533	74.883
MINIMUM	66.433	66.070	65.618	67.432	66.548	65.815	64.773	65.767	65.652
SAMPLE SIZE	93	115	234	46	59	108	232	37	28

Figure 15 (continued).



GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

	P PHOCOE	L ACUTUS	T TRUNCA	STENELLA	S COERUL	D DELPHI	UNID. PO	UNID. DO	UNID. ST
MEAN	11.544	13.429	20.234	21.243	17.790	12.124	13.919	13.200	18.175
STD.DEV.	2.152	4.512	5.983	5.405	6.709	4.950	6.273	7.183	4.829
S. E. M.	0.223	0.421	0.391	0.797	0.881	0.476	0.412	1.181	0.913
MAXIMUM	16.800	30.000	31.100	30.000	30.000	23.700	28.300	27.800	27.200
MINIMUM	5.000	1.300	1.100	10.300	6.700	2.000	1.000	3.000	9.500
SAMPLE SIZE	93	115	234	46	58	108	232	37	28



GROUP MEANS ARE DENOTED BY M'S IF THEY COINCIDE WITH *'S, N'S OTHERWISE

	P PHOCOE	L ACUTUS	T TRUNCA	STENELLA	S COERUL	D DELPHI	UNID. PO	UNID. DO	UNID. ST
MEAN	123.473	189.330	773.214	1194.587	2159.534	1065.648	838.250	710.297	1642.571
STD.DEV.	61.047	285.909	817.846	1303.989	990.156	1110.914	975.518	870.797	691.357
S. E. M.	6.310	26.661	53.464	192.263	130.014	106.898	64.046	143.151	130.654
MAXIMUM	256.000	2196.000	3292.000	3935.000	3932.000	3932.000	3477.000	2895.000	2672.000
MINIMUM	18.000	18.000	4.000	21.000	49.000	42.000	15.000	16.000	69.000
SAMPLE SIZE	93	115	234	46	58	108	232	37	28

Figure 15 (continued).

FEEDING BEHAVIOR OF THE HUMPBACK WHALE

James H.W. Hain, Gary R. Carter, Scott D. Kraus,
Charles A. Mayo, Howard E. Winn

1. Feeding behavior of the humpback whale, *Megaptera novaeangliae*, was observed on well over 100 occasions from April 1977 to May 1980. Observations were made in the area of West Quoddy Head, ME; Mt. Desert Rock; Stellwagen Bank, north of Cape Cod, MA; the waters east and southeast of Cape Cod; and southeast of Block Island, RI (refer to Figure 16). Feeding, or apparent feeding, was reported for individuals and for groups of up to 20 whales.

2. These observations indicate that the humpback whale possesses a diverse repertoire of multifaceted feeding behaviors. The resulting catalog of behaviors includes two principal categories: (1) swimming/lunging behaviors, and (2) bubbling behaviors. A behavior from a given category may be used independently or in association with others, and by individual or groups of humpbacks.

3. The swimming/lunging behavior category includes (a) lunge feeding, and (b) circular swimming/thrashing behavior. The lunge feeding is an upward rush at the sea surface with the longitudinal axis of the body intersecting the plane of the surface at an angle of 30-90^{o}. As the whale breaks the surface, the mouth is agape, and quite often an enormously distended throat region is seen. Up to one third of the body length clears the surface before the whale falls or settles back into the water. Lunge feeding was recorded in 21% of all feeding observations. The speed of the lunge varies from a vigorous and rapid lunge to an almost slow-motion rise. Both single animals and groups employ this behavior. In several instances, humpbacks were observed lunge feeding in formation. Five or six humpbacks arranged side by side and slightly staggered of one another performed the movements described above in unison. Because of the appearance of the whales' spatial arrangement, this coördinated feeding mode has been termed "echeloned" lunge feeding.

In the circular/thrashing behavior, the humpback swims in a broad circle on a horizontal plane at or near the surface, roiling the surface with flippers and flukes as it swims. This was followed in many, but not all, cases by a feeding rush through the circle.

4. In the second major category, underwater exhalations are employed in a heterogeneous assembly of feeding behaviors, all using underwater "bubbling" in some way. This bubbling behavior was relatively common, and occurred in 52% of all feeding observations. In spite of the apparent diversity, some classification is possible. The structures formed by the underwater exhalations are of two types: (1) bubble column--a smaller (1-1.5 m diameter) structure composed of larger, randomly sized bubbles, used in series or multiples; (2) bubble cloud--a single, relatively large (4-7 m diameter), dome-shaped cloud formed of small, uniformly sized bubbles. Both of these basic structures are employed in a variety of ways, as shown in Figure 17.

Bubble columns are formed by the underwater exhalations of a whale swimming from 3-5 m (estimated) below the surface. As the bubble bursts are released, they rise vertically to the surface in the form of a somewhat ragged column. These bubble columns are used in sequences of from 4-15 in number to form rows, semi-circles, and the complete circles which have been termed bubble nets.

Bubble clouds show marked differences to the bubble columns described above. In this case a single large underwater exhalation forms a dome-shaped "cloud". The cloud is quite narrow initially, but expands as it rises toward the surface. The activity of the whale following creation of the cloud shows a good degree of variation, as illustrated in Figure 18. Although most often bubble clouds are used singly, they were also observed used in series or multiples. These clouds possess the same characteristics as those already described, but are used in groups, often in threes, by one or more humpbacks.

5. The most common prey species observed in association with these behaviors (50-75% of total feeding observations) was the American sand lance, *Ammodytes americanus*. However, at least one other species is a target for humpback feeding behaviors. Humpbacks

in the West Quoddy Head, ME, area took herring, Clupea harengus, from inshore waters or within coves using the bubble cloud and lunge feeding techniques on a number of occasions. While the prey are often observed in or around the various structures created by the whale, the exact effect of the whale's feeding behavior on the prey species, and the advantage conferred to the whale, remains poorly understood at this time. For example, one hypothesis has it that prey are concentrated by the bubble net structures, while our present view is rather that the bubble net, as well as similar structures, serves only to maintain or corral naturally occurring patches or schools of prey. It is also presently unknown whether environmental factors, some characteristic of the prey species, or perhaps prey density, influences the choice of feeding method.

6. While the bubbling behavior appears to be common in association with feeding, underwater bubbling, even in the presence of feeding activity, may not always be directly related to feeding. Also, a number of examples are known where underwater exhalations occur in distinctly non-feeding situations (e.g., the apparent use of bubble screens as camouflage to protect a calf or mother-calf pair.

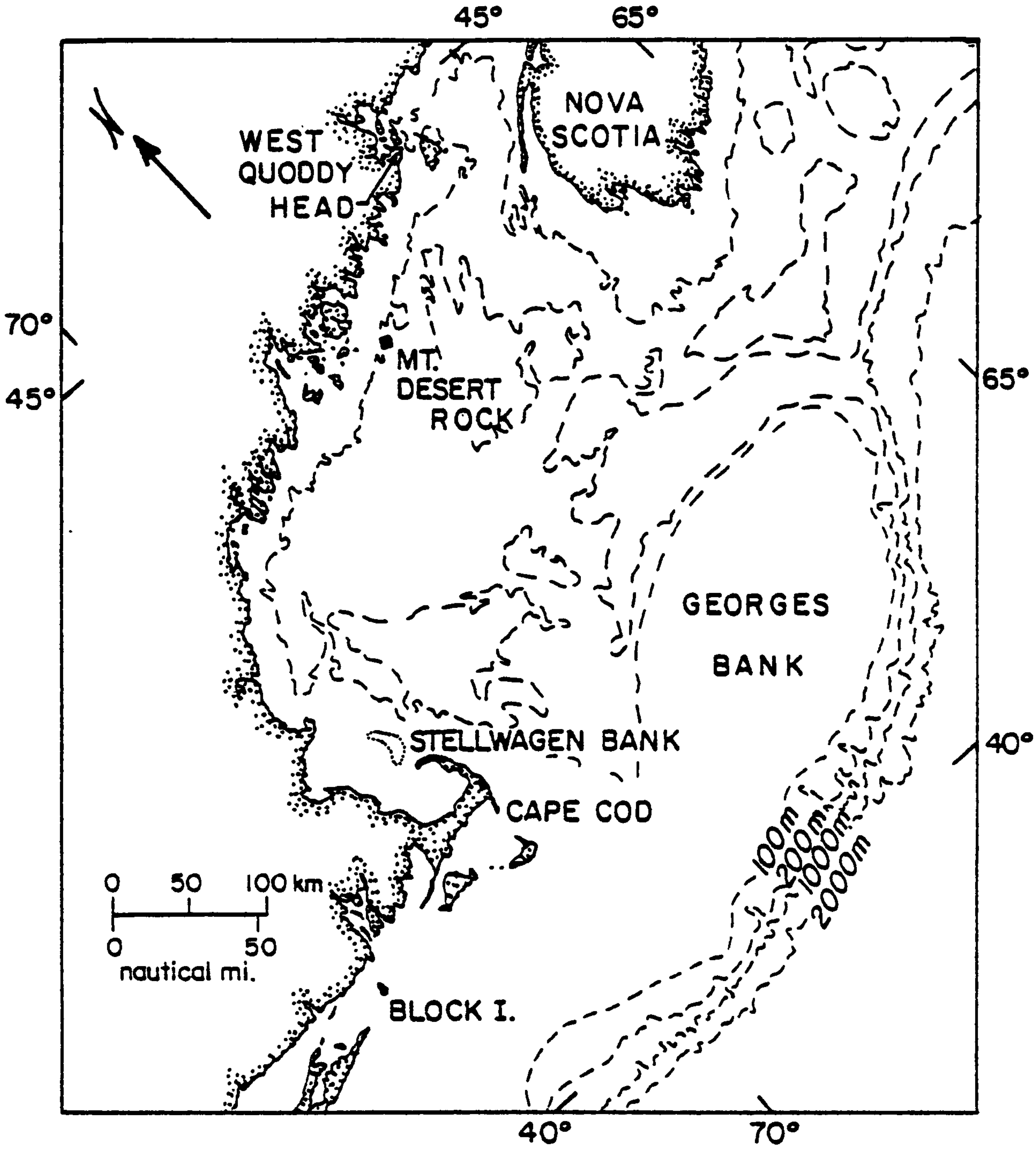


Figure 16. Study area where observations of feeding behaviors were made. Place names on chart are those referred to in text.

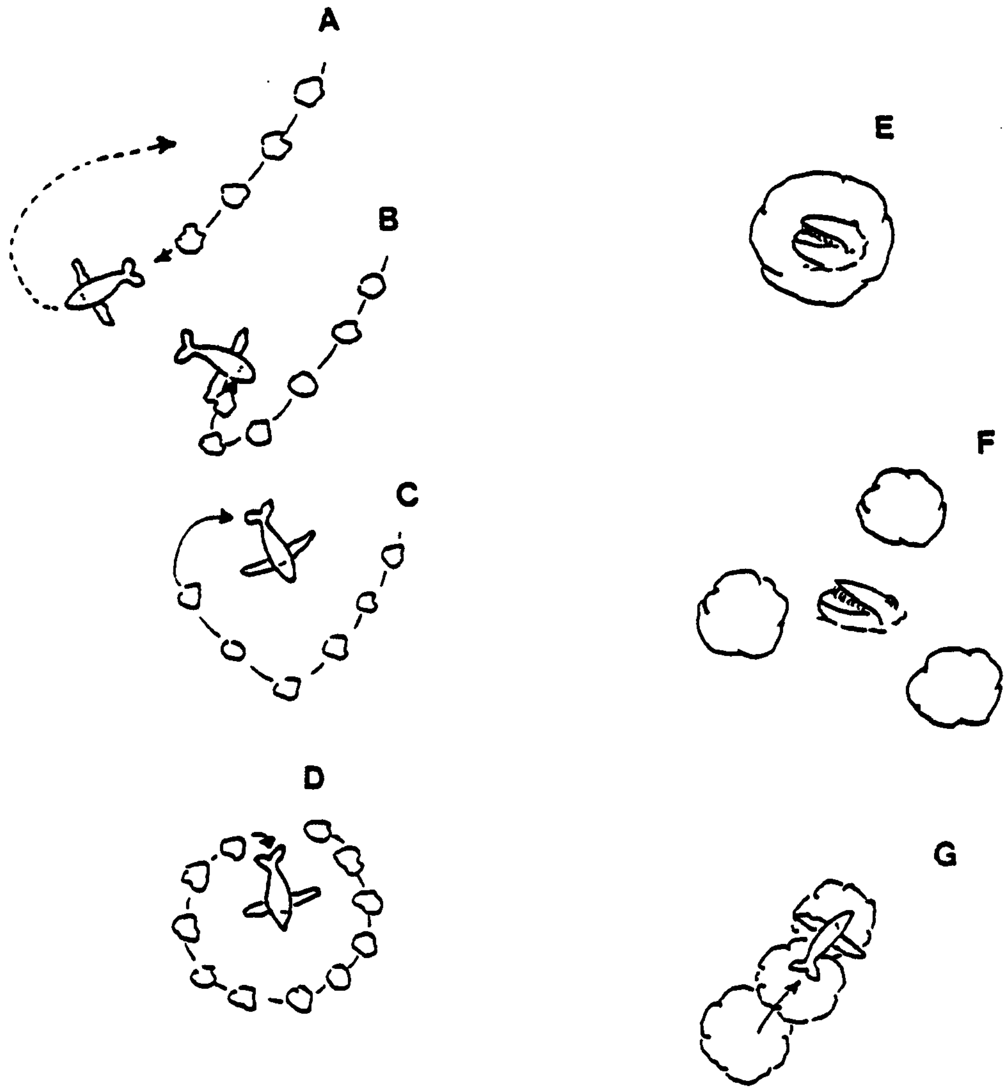


Figure 17. A diagrammatic representation of the seven types of bubbling behaviors associated with feeding in humpbacks. A through D are structures using bubble columns, which are 1-1½ m in diameter and composed of non-uniform sized bubbles (estimated at > 2 cm). E through G are bubble cloud structures, 4-7 m in diameter and composed of uniformly sized bubbles (estimated at < 2 cm). A. Bubble row. B. Bubble row with "crook", whale feeding location shown. C. V or semicircle shaped bubble curtain. Whale feeds in and through open side of the semicircle. D. Complete circular formation, or bubble net. E. Single bubble cloud. In this example, one of several variations, whale lunge feeds through center. F. Triangular formation of multiple bubble clouds. G. Linear formation of multiple bubble clouds.

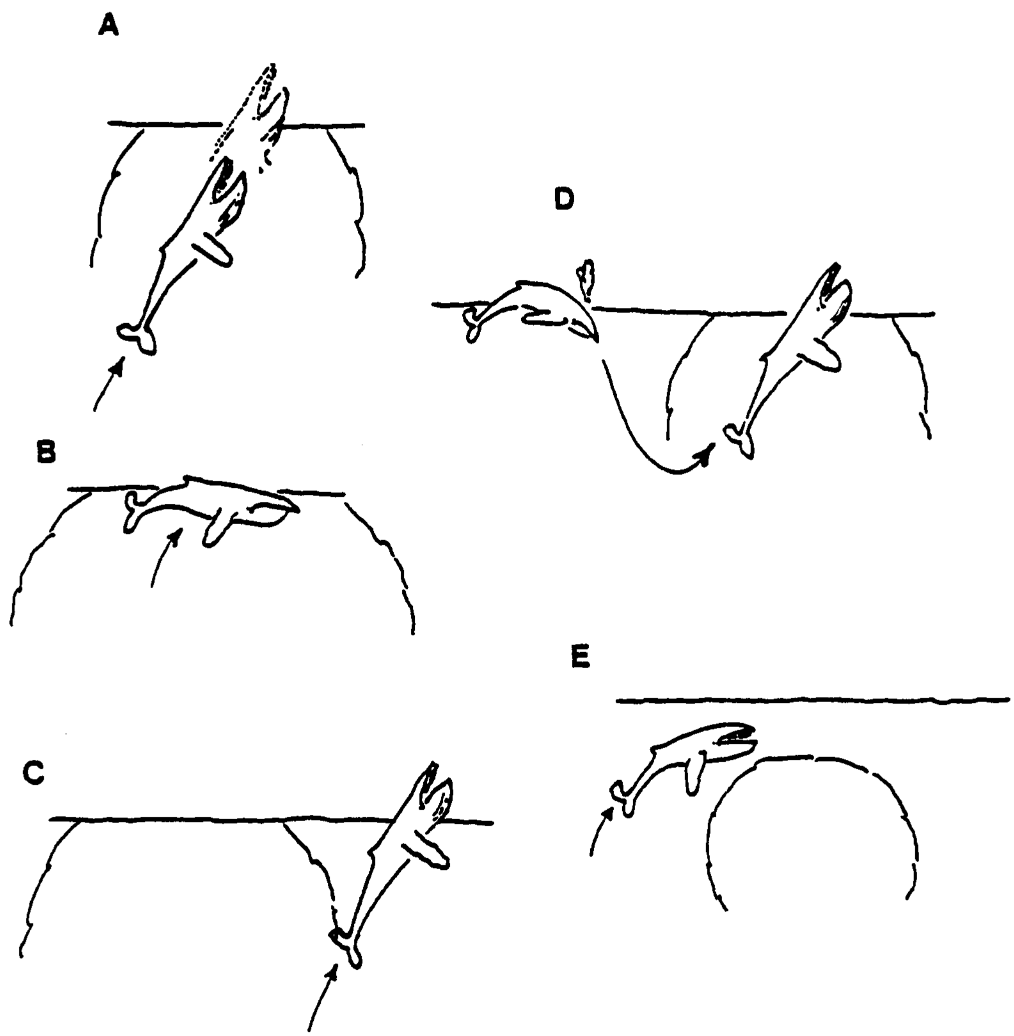


Figure 18. Diagrams illustrating the five feeding variations observed associated with bubble clouds. A. Whale lunge feeds vertically through middle of cloud. B. Whale apparently feeds underwater and upon completion is seen to rise slowly in midst of spent bubble cloud. C. Whale lunge feeds to one side of cloud. D. Whale surfaces alongside cloud, emits a weak blow, dives down, and reappears lunge feeding through the center. E. Whale is seen to rise up alongside of still rising cloud, and feed, mouth open, between the cloud and the water's surface.

SEA TURTLES IN THE REGION BETWEEN CAPE HATTERAS AND NOVA SCOTIA IN 1979

C. Robert Shoop, Thomas L. Doty, Nancy E. Bray

1. Four species of sea turtles were reported in the study area. The loggerhead sea turtle (Caretta caretta) holds threatened status; Kemp's ridley turtle (Lepidochelys kempi), leatherback turtle (Dermochelys coriacea), and the Florida sub-population of the green sea turtle (Chelonia mydas) are classified as endangered. Prior to this study, occurrences of these animals in the area were known primarily from reports of dead animals found on shore and from incidental reports by individuals encountering the animals offshore. Nesting loggerheads have long been known from Virginia southward.

2. Our primary source of data acquisition was by aerial surveys conducted from a Beechcraft AT-11 flown at an altitude of 750 feet. This platform provided information on relative densities and distributions of sea turtles throughout the year. Additional observations from U.S. Coast Guard HU-16E (Grumman Albatross) aircraft flown at an altitude of 500 feet supplemented the primary data. Observations from a single engine aircraft provided data on near-shore occurrences and nesting areas. Sightings by observers on ships of opportunity and U.S. Coast Guard vessels were also used for distributional analysis. Governmental agencies provided information on sea turtle nesting in several areas.

3. The information presented is based on aerial observations of 842 loggerhead sea turtles (Figure 19), and 56 leatherback turtles (Figure 20), in addition to stranding and individual reports. Sea turtles were observed from April through November in the study area. Although both leatherbacks and loggerheads were found in lease sale areas (Lease Sale Areas 40, 42, 49, 52, and 59), loggerheads were most common in areas 40, 49, and 59 off the mid-Atlantic coast. Leatherbacks were most likely to be seen in the Gulf of Maine and Lease Sale Areas 42 and 52 near New England.

4. The occurrences and relative abundances of sea turtles in the study area changed throughout the year in relation to sea surface

temperature. Surface sea water temperatures were closely correlated with the spatial distribution of all turtle species. Ninety-seven percent of all turtles sighted from the AT-11 were in water from 16° to greater than $26^{\circ}C$. Leatherback turtles were observed more frequently in colder waters at higher latitudes during the summer than the other species. Most turtles observed were in water less than 60 m in depth. Loggerhead sea turtles were by far the commonest sea turtles. Minimum abundance during late summer is estimated at the low thousands of animals. These occurred over the Outer Continental Shelf mainly south of Cape Cod, MA. Leatherbacks were observed throughout the study area. Peak estimates of relative abundances during summer were in the hundreds. Kemp's ridley turtles were not observed but were reported as the strandings of juveniles on the shore of Cape Cod, MA. A single stranding of a green sea turtle on the Outer Banks of North Carolina was also reported. Insufficient data exist at this time for a better assessment of Kemp's ridley and green sea turtle status in the study area.

5. Sun glare greatly affected the observers' ability to make turtle sightings from the survey aircraft. However, no correlation between observed Beaufort sea state and number of turtles sighted was demonstrated. An important variable which may have affected the observations is the time of day that the observations were made. Definitive studies related to the activity of sea turtles at the sea surface are lacking.

6. In the study area loggerhead sea turtles regularly nest on Virginia and North Carolina beaches although the number of nests is very small compared to the major nesting areas father south in North Carolina through Florida. One nest was reported from New Jersey.

7. Although few sea turtles nest in the study area based on the large number of turtles present there, it is probably an area for feeding, or migration to and from feeding areas. The stranding on Cape Cod of 22 Kemp's ridley turtles over several years indicates that the Cape Cod area may be near a feeding ground for juveniles of this most endangered of sea turtle species.

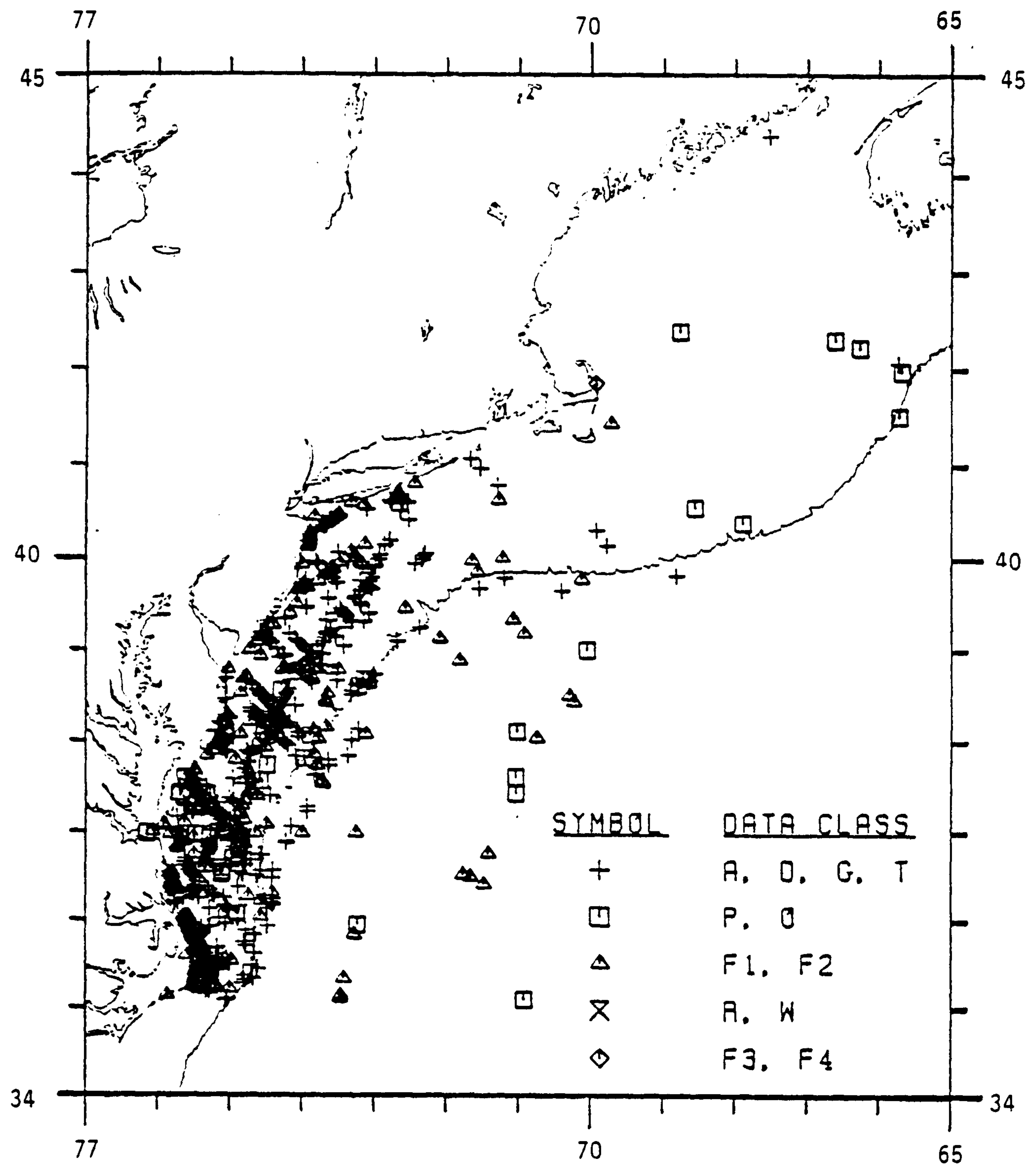


Figure 19. Plot of all sightings of loggerhead sea turtles, <u>Caretta caretta</u> from 1 October 1978 to 9 January 1980, sorted by data class (data classes and their symbols are explained in Chapter IX of the CETAP Annual Report for 1979). The 2000 m depth contour is shown to delineate the approximate boundary of the OCS.

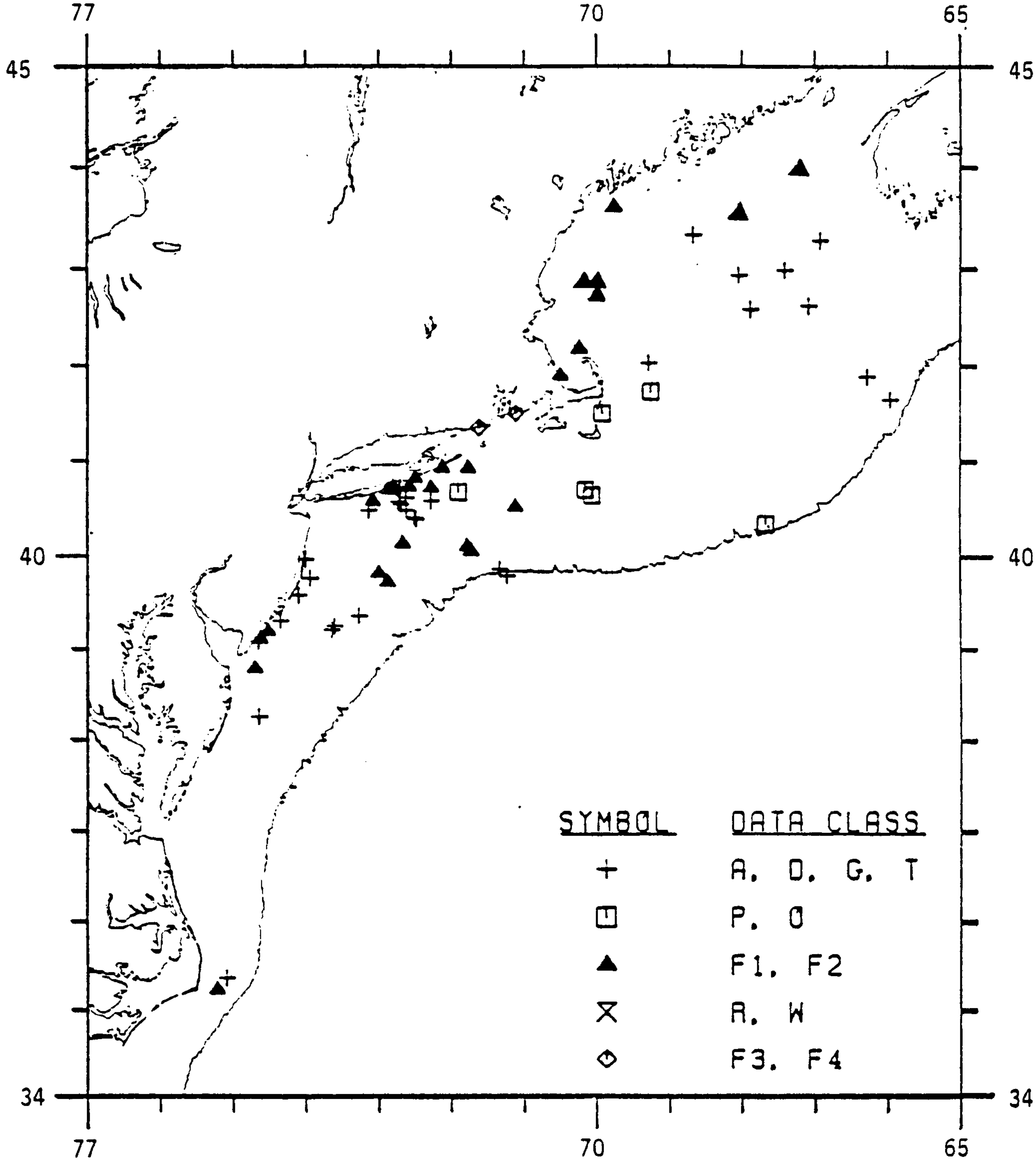


Figure 20. Plot of all sightings of leatherback sea turtles, Dermochelys coriacea, from 1 October 1978 to 9 January 1980, sorted by data class (data classes and their symbols are explained in Chapter IX of the CETAP Annual Report for 1979). The 2000 m depth contour is shown to delineate the approximate boundary of the OCS.

PHOTOGRAMMETRIC INVESTIGATION OF CETACEAN MORPHOMETRY

Gerald P. Scott, Mary Ratnaswamy, Howard E. Winn

1. When CETAP conducts its rigorous aerial surveys, vertical photographs of large-whale species are taken whenever possible. Vertical photographs, taken with a calibrated system, enable an investigator to measure various animal lengths (direct measures of total length and measures of the lengths of certain body parts). When only body part lengths are obtainable, methods exist to extrapolate total whale length as well. All measured and extrapolated lengths can be used to characterize the relative age distribution of a species, and to estimate vital population parameters such as recruitment.

2. CETAP's chartered survey aircraft carry dual Hasselblad MK-70, 70 mm electrically driven cameras mounted through the belly of the aircraft. A third Hasselblad, aimed at an instrument panel, simultaneously photographs the flight data necessary for photogrammetric calculations, and the time, which is needed to discriminate the data and photographs for an individual whale.

3. This CETAP photogrammetry system was calibrated by aerially photographing a stranded, dead humpback whale which was concurrently measured by a ground truthing crew. The photo scale found to be optimal in terms of minimum photogrammetric error is between 1:2500 and 1:5000. These scales correspond to flight altitudes of 500 to 1000 feet. Photogrammetric error at these altitudes and scales lies between 3.0 and 15.0 percent, i.e., $\pm$ 0.3 to $\pm$ 1.5 m for a 10 m actual length. This precision should be sufficient to permit the assignment of photogrammetrically measured cetaceans into generalized age classes such as calf, subadult, and adult.

4. Preliminary results on the right whale (*Eubalaena glacialis*) indicate that calculations of total length from six measured snout-to-blowhole lengths appear consistent with lengths found in the literature.

CETACEAN RESPONSES IN ASSOCIATION WITH THE REGAL SWORD OIL SPILL

Donna R. Goodale, Martin A.M. Hyman, Howard E. Winn

1. On 18 June 1979 the Liberian freighter REGAL SWORD collided with the tanker EXXON CHESTER southeast of Cape Cod. As a result of the collision, the REGAL SWORD sank and began to leak fuel oil from its tanks. The vessel was reported to have 307.2 kiloliters of bunker C and 24 kiloliters of number 2 fuel oil on board.

2. On 20 June, the U.S. Coast Guard informed the Cetacean and Turtle Assessment Program (CETAP) that 22 to 25 cetaceans were observed within 5 nautical miles of the oil source. CETAP proceeded to develop and initiate a systematic aerial survey of the wreck area (Figure 21) at this time.

3. The oil leakage occurred at a location determined by CETAP to be part of a major cetacean feeding area. CETAP was thus afforded a unique opportunity to observe cetaceans in and near an oil "spill".

4. The spill area was aerially surveyed multiple times by CETAP and BLM scientists on 20 and 21 June. A later flight was made by a CETAP observer on board a USCG plane on 26 June.

5. All survey flights of the spill area resulted in the sighting of cetaceans (Fig. 22). Also sighted in the area were a sea turtle (only tentatively identified) and several sharks. Three of six cetacean species sighted were large baleen whales considered to be endangered species. These were the finback whale (*Balaenoptera physalus*), the humpback whale (*Megaptera novaeangliae*), and the northern right whale (*Eubalaena glacialis*). The remaining three species sighted were the pilot whale (*Globicephala* spp.), the harbor porpoise (*Phocoena phocoena*), and the white-sided dolphin (*Lagenorhynchus acutus*). Other cetaceans which were sighted could not be identified with certainty.

6. Calves were seen accompanying adults of three species: *Globicephala* spp., *B. physalus*, and *M. novaeangliae*, observed in the spill area.

7. Behavior inferred to be feeding was observed in *B. physalus*,

M. novaeangliae, and *L. acutus* both within and outside of the oil spill.

8. No attraction or repulsion effect was observed between cetaceans and the oil spill. Furthermore, no effect of the oil on the cetaceans which were feeding was apparent during the short time period the cetaceans were observed.

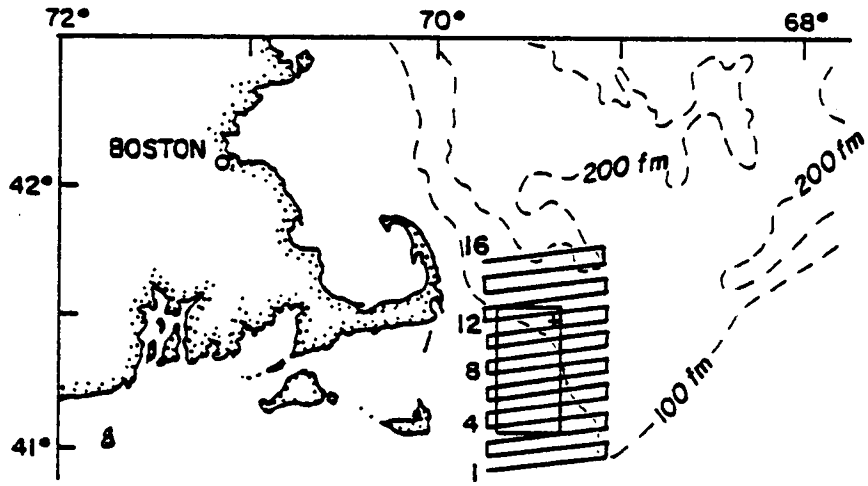


Figure 21. The study area involved with the sinking of the Regal Sword. The small, inner rectangle is the USCG-defined oil spill area. The cross indicates the wreck position. Numbered lines are CETAP-designated flight tracks used in the CETAP surveys.

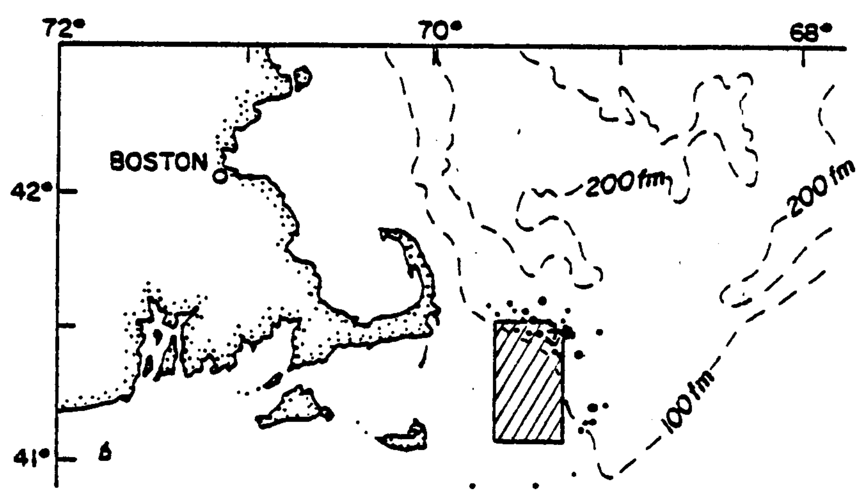


Figure 22. The plotted positions of all cetacean sightings relative to the oil spill area (cross-hatched rectangle).