A Distributional Assessment of Cetaceans in Shelf/Shelf-Edge and Adjacent Slope Waters of the Northeastern United States Based on Aerial and Shipboard Surveys, 1978-1988

By

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INTRODUCTION

The shelf/shelf-edge and adjacent slope waters of the northeastern United States contain several important habitats for feeding aggregations of marine mammals (CeTAP 1982; Payne et al. 1984; Kenney and Winn 1986; Hain et al. 1985; MBO 1988). Recent National Marine Fisheries Service/Northeast Fisheries Center (NMFS/NEFC) research has emphasized an integrated, multispecies approach to management of fisheries resources (Sherman 1980; Sissenwine et al. 1982). The NMFS/NEFC also acts as legal custodian for all endangered and protected species of marine mammals in the shelf/shelf-edge waters of the northeastern United States. Given their ecological approach to fisheries management and legal responsibilities, NMFS/NEFC requires data on the distribution of cetaceans compatible with existing NMFS/NEFC databases in order to examine trophic interactions between these consumers and potential prey species.

Since 1978 there have been two large-scale surveys of cetaceans throughout shelf/shelf-edge and adjacent slope waters of the northeastern United States; the Department of the Interior, Bureau of Land Management sponsored Cetacean and Turtle Assessment Program (CeTAP), and the NMFS/NEFC sponsored Cetacean and Seabird Assessment Program (hereafter these latter surveys are referred to as NMFS/NEFC surveys). Cetacean sighting data collected during these two surveys provided the most comprehensive sighting effort throughout the study area.

The major objectives of CeTAP were to provide a spatial overview of cetacean distribution (Hain et al. 1981; CETAP 1982; Kenney and Winn 1986), and to estimate the absolute abundance of cetaceans in the study area (Scott et al. 1981; CETAP 1982; Kenney et al. 1985). These data were to be used by federal agencies making decisions about potential development of oil- and gas-lease sale tracts (Edel et al. 1981a); therefore special attention was
paid to these areas (Sorensen et al. 1984). The CeTAP aerial surveys also provided the first absolute estimates of cetacean abundance in the shelf waters of the northeastern United States from line-transect surveys.

The collection of the NMFS/NEFC shipboard sighting data also followed line-transect procedures (as described by Seber 1973; Burnham et al. 1980) but have been used, thus far, only to describe relative densities or abundance of cetaceans rather than absolute densities as were generated by CeTAP. These data have been used to monitor small-scale temporal changes in the distribution and relative abundance of these taxa (Powers 1983; Powers and Payne 1983; Powers and Brown 1986; Payne et al. 1984, 1989, 1990a, 1991a, 1990b); to determine physical oceanographic factors influencing cetacean distributions (Selzer and Payne 1988); and to describe trophic interactions between cetaceans and/or seabirds and potential prey (Payne et al. 1986; Powers and Backus 1986; Smith et al. 1988, 1990; Overholtz et al. 1991).

Despite differences in platform and objectives, both programs provided parallel information on the distribution of cetaceans in shelf waters of the northeastern United States (Payne et al. 1984; Hain et al. 1985; Kenney and Winn 1986, 1987; Selzer and Payne 1988; MBO 1988). In this paper we examine the spatial distribution of cetacean sightings in shelf/shelf-edge and adjacent slope waters of the northeastern United States for the period 1978-1988 which were collected during the CeTAP surveys (November 1978-January 1982) and the NMFS/NEFC surveys (May 1980-January 1988).

Study Area
The study area consisted of shelf/shelf-edge <200f (183m) in depth and adjacent slope waters 183-1830m (200-2000f) off the northeastern United States between Cape Hatteras, North Carolina and Nova Scotia, Canada (Fig. 1a). Four major oceanographic regions (Gulf of Maine, Georges Bank, southern New England and mid-Atlantic) occur within the shelf boundary of the study area. Slope water occurs over the entire length of the study area seaward of the shelf.
edge.

The Gulf of Maine is bounded on the northwest by the USA coastline, and on the northeast by the Bay of Fundy and Nova Scotia (Fig. 1a). The oceanographic character of the Gulf of Maine is influenced by relatively cold, low-salinity surface water from the Scotian Shelf (Sutcliffe et al. 1976; Hopkins and Garfield 1979; Smith 1983; Flagg 1986) and deep basins. The maximum depth is 377m in Georges Basin located inside the Northeast Channel north of Georges Bank. The Gulf of Maine is insulated from the warmer waters of the offshore Atlantic on the east and south by two relatively shallow banks, Browns Bank (Scotian Shelf) and Georges Bank respectively, essentially making the Gulf a closed basin. The Northeast Channel (depths to 270m) divides Browns Bank and Georges Bank, and is the largest passage for warm, Atlantic waters entering into the Gulf of Maine from offshore.

Georges Bank is a broad, relatively shallow area noted for high primary productivity (Cohen and Grosslein 1986; O'Reilly et al. 1986). The northern half of the bank has numerous, shallow shoals (minimum depth about 4m). Water on the central part of the Bank (<60m in depth) is nearly homogeneous due to strong tidal mixing (Bumpus 1976; Hopkins and Garfield 1981; Sherman et al. 1988). The northern edge of the Bank has a very steep slope into the Gulf of Maine, and the southern edge deepens to the continental shelf-edge which is cut by several submarine canyons (Fig. 1a). Offshore of Georges Bank lie waters of the continental slope (Wright 1976. The Great South Channel separates the western boundary of Georges Bank from broad, gently sloping Southern New England and Mid-Atlantic shelf regions (Fig. 1a).

The combined southern New England and mid-Atlantic regions form a broad shelf at the Great South Channel (northern end) but becomes quite narrow toward the southwest to Cape Hatteras (Fig. 1). The southern New England and mid-Atlantic regions are characterized by a broad, gently sloping shelf from
the coast to the shelf-edge. Two principal water masses are found in these regions: relatively cool, low-salinity shelf water, which extends 50-70km seaward of the continental shelf-edge; and slope water which is found seaward of shelf water throughout the region (Sherman et al. 1988). The Hudson Canyon, an important submarine feature, cuts across the southern New England shelf. The mid-Atlantic also includes the mouths of the Delaware and Chesapeake Bays (Fig. 1a).

Several submarine canyons cut the seaward edge of the entire study area at the continental shelf-edge (Fig. 1a). Shelf and slope waters meet in a narrow region of sharp temperature and salinity gradients at the shelf-edge/slope front (Wright 1976). The front generally intersects the bottom near the 50m contour (Sherman et al. 1988).

Partitioning of the Survey Area
The NMFS/NEFC study area (212,686 km$^2$) consisted of all shelf/shelf-edge and adjacent slope waters between Cape Hatteras and Nova Scotia <910m (<500f), although most of the NMFS/NEFC surveys were conducted in shelf waters <183m (<100f). The CeTAP surveys (from CeTAP 1982) also encompassed the entire U.S. outer continental shelf seaward to the 1820m (2000f) isobath (278,350 km$^2$). Therefore the NMFS/NEFC study area was comparable in scope (but functionally smaller in area due largely to a decrease in slope area being surveyed) to the CeTAP study area (described in Scott and Gilbert 1982).

The NMFS/NEFC stratified the study area into individual stratum (Grosslein 1969) based principally on depth and latitude. These strata have been combined into ecological subregions (Fig. 1b) in a manner consistent with Payne et al. (1984, 1986, 1989, 1990a). The combined subregions comprise each of the four major shelf regions used by NMFS/NEFC. We refer to these subregions, the four shelf regions defined by NMFS/NEFC, to coastal waters (water depth <15f) and to slope waters which extend seaward of the continental shelf.
(water depth >100f).

METHODS

Collection of Whale Sighting Data
Aerial Surveys-CeTAP
The CeTAP aerial surveys were conducted from November 1978 to January 1982. Throughout the three-year CeTAP study, a number of sampling schemes and time intervals for data collection and analyses were employed, and each year a number of refinements and changes were incorporated into the database management (Edel et al. 1981a; Scott et al. 1981; Scott and Gilbert 1982; CETAP 1982). During 1979, dedicated, random-transect aerial surveys were conducted during each of 8 time periods throughout the year (Edel et al. 1981a). During 1980 and 1981, four dedicated surveys were flown each year, usually one per season (CeTAP 1982). The observer crew consisted of either two sets of two observers which alternated observation periods, or two observers who sat and observed out side windows, depending upon aircraft used (CeTAP 1982).

The CeTAP dedicated aerial surveys provided the first absolute estimates of cetacean abundance in the shelf waters of the northeastern United States. Only the data collected during the dedicated aerial surveys were used by CeTAP in estimating absolute abundance. CeTAP sighting data which could not be corrected for level of effort comparable to that obtained during the dedicated aerial surveys (therefore were not used by CeTAP to estimate abundance, but which were incorporated into the combined database and used in this study to describe distributions of cetaceans) were also collected during the following surveys.

Also during each year of the CeTAP study, special aerial surveys were conducted emphasizing endangered species not adequately sampled by the dedicated surveys (Winn et al. 1981), or to characterize species occurrence and abundance in specified lease sale areas. During May 1979, a special right whale (*Eubalaena glacialis*) survey was conducted over the entire Gulf of Maine.
and OCS regions immediately south of the Gulf of Maine (Winn et al. 1981). Also, during 1980 and 1981, several surveys were conducted during spring and late-summer of each year to Lease Sale 52 Nomination Area (east of Cape Cod south through the Great South Channel and eastward over Georges Bank, and to the northern Gulf of Maine and southwestern Scotian Shelf (CeTAP 1982). Sighting data from these surveys were used in this paper.

Special Shipboard Surveys-CeTAP
During May 1980 and 1981, behavioral data on dive duration and frequency by baleen whales were collected during two cruises to waters adjacent to Cape Cod (CeTAP 1982). Sighting data from these surveys were also used in this paper.

Surveys of Opportunity-CeTAP
During 1979 and 1980, CeTAP placed observers on aircraft and vessels-of-opportunity operating within the study area (CeTAP 1982). The U.S. Coast Guard and NMFS/NEFC provided the majority of vessel platforms. These platforms were supplemented by several institutional research vessels. The aerial portion of this effort was generally provided by the U.S. Coast Guard, Cape Cod, Massachusetts, and continued through 1981. The shipboard component of this effort was discontinued in 1980.

NMFS/NEFC Shipboard Surveys
A long-term series of bottom trawl surveys were begun by NMFS/NEFC in 1963 (see Grosslein 1969; Azarovitz 1981). Between 1976 and 1987 plankton surveys were conducted and NMFS/NEFC initiated the Marine Monitoring Assessment and Prediction Program (MARMAP) to provide annual and seasonal monitoring of the distribution, biomass, and population structure of principal biota, and the physical environment on a broad geographical scale (Sherman 1980). In May 1980 NMFS/NEFC extended the MARMAP strategy by placing a dedicated observer on each NMFS/NEFC survey to monitor the distribution and abundance of cetaceans and seabirds, and to a lesser extent, turtles. These standardized shipboard surveys were conducted by the Manomet Bird Observatory from May 1980 through
December 1988.

The NMFS/NEFC shipboard surveys were designed to provide a near-continuous assessment of cetacean/seabird populations in shelf/shelf-edge waters (generally <200m) of the northeastern United States. Data collection procedures have been described previously (Powers et al. 1980; Payne et al. 1984; 1986; Selzer and Payne 1988; Smith et al. 1990). Generally, observers were placed on NMFS/NEFC research vessels, principally the R/V ALBATROSS IV and R/V DELAWARE II, on a non-interference basis and did not alter the trackline of the vessel during the survey. Cetacean observations were recorded continuously by the observer along the predetermined trackline between randomly placed NMFS/NEFC sampling stations as long as the vessel moved on a straight course and at a uniform speed. The NMFS/NEFC sampling stations were randomly placed within each stratum (roughly in proportion to the size of each stratum, Grosslein, 1969); therefore the extent of cetacean sighting effort (the spatial and temporal coverage) and the stratified random component of the NMFS/NEFC cetacean surveys were dependent entirely on the design of the NMFS/NEFC fisheries/oceanographic surveys.

Observer effort was quantified in 15-minute periods (where each period was considered a transect). Initially, the amount of time spent obtaining cetacean and seabird sighting data within NMFS/NEFC strata was considered proportional to the size of each stratum. However, Payne et al. (1990a) found that the observer effort per NMFS/NEFC strata was inversely related to the size of the stratum, the larger strata being undersampled in these surveys. Although data collection of NMFS/NEFC shipboard sighting data followed line-transect procedures (as described by Seber 1973; Burnham et al. 1980) they are biased by uneven effort allocation relative to strata size; therefore do not, at present, provide a basis for the estimation of absolute cetacean abundance.

Non-NMFS/NEFC Shipboard Surveys
During each year cetacean/seabird sightings were also conducted from research vessels for government agencies other than NMFS/NEFC. The Environmental Protection Agency (EPA) provided the vessel for most of these additional surveys. The EPA surveys focused on the distribution and assessment of endangered or threatened species in waters which included, or adjacent to, designated deepwater dumpsites or proposed incineration-at-sea locations. Although these surveys did not follow the stratified-random survey design prescribed by NMFS/NEFC, the sighting data were collected in a manner comparable to that collected on standardized NMFS/NEFC surveys. Therefore these sightings data were also incorporated into the combined database and used in this paper.

Treatment of the Sighting Data

All cetacean sightings collected during the CeTAP aerial surveys (Nov 1978-Jan 1982) and by MBO onboard shipboard surveys (May 1980-Dec 1988) were combined and treated as one dataset. The distribution of each cetacean species was examined, generally, by initially grouping the sighting data into six, 2-month time-periods (i.e. January-February, March-April, May-June, July-August, September-October, and November-December). Each sighting in the database was then weighted by group-size per sighting (i.e. 1-10, 11-30, 31-300 or 301->1000 individuals per sighting) and overlayed onto a basemap of the study area (following Payne et al. 1989, 1990a, 1990b).

Relative densities (sighting data corrected to some measure of standardized effort) could not be used to describe species distributions with the combined database because of differences in survey types and platforms, within and between programs, and because of uneven effort allocation within the study area between, and within, surveys. Therefore, these sighting data do not provide a basis for quantitative, cetacean abundance estimates for the study area. Despite this bias, the number of individuals per sighting approach (unweighted by effort) provided the most detailed, qualitative account of the
spatial and temporal distribution of cetaceans throughout shelf/shelf-edge and adjacent slope waters of the northeastern United States.

All base maps were digitized and sighting data overlayed onto the base maps using the PC based mapping-program CAMRIS (Computer Aided Mapping and Resource Inventory System) (Ford 1989).

Exceptions to the above 2-month data groupings include the presentation of sighting data for species which predictably occur throughout the study area in low numbers (therefore we have very few sightings over the 10-year study period). For these few species sighting data were either combined into one figure (i.e. not partitioned into 2-month intervals) or sighting locations were given and a discussion followed without presentation of a distribution map. Also, for several species movement patterns (generally within a season, not for the entire year) could be explained in more detail by presenting the sighting data by month (rather than in 2-month periods). Any further changes in the temporal presentation of the data are explained throughout the text.

SPECIES ACCOUNTS—RESULTS AND DISCUSSION

Bottlenose Dolphin (*Tursiops truncatus*)

The sighting distribution of coastal and offshore bottlenose dolphins combine to form a distinctive J-shaped distribution (described by Hain et al. 1981; CeTAP 1982) in shelf/shelf-edge and slope waters of the northeastern United States. Coastal and offshore *Tursiops* can be hematologically differentiated by the type and concentration of hemoglobin present, the packed cell volume and red blood cell count (Duffield et al. 1983; Hersh and Duffield 1990) and indirectly distinguished by parasite load (Mead and Potter 1990). The coastal form (ecotype, from Hersh and Duffield 1990) has a seasonal distribution north of Cape Hatteras to Delaware Bay and southern New Jersey (Fig. 2). The sighting distribution of offshore *Tursiops* occurred in shelf-edge and adjacent slope waters generally seaward of the 50f contour between Cape Hat-
teras and the Northeast Channel, Georges Bank (Fig. 2). All bottlenose dolphin sightings which occurred in slope waters \( n = 543/1,073 \) or approximately 50% of all *Tursiops* sightings, Table 1) were considered the offshore ecotype.

Generally, the number of sightings were low during winter. Only four percent \( n = 48/1073 \) of all bottlenose dolphin sightings occurred during January-February (Table 1). Seventy-seven percent \( n = 822/1073 \), Table 1) of bottlenose dolphin sightings throughout the year occurred May-August. Also, the number of *Tursiops* sightings in May-June and July-August were very comparable (Table 1) indicating similar levels of abundance (Scott et al. 1981; CeTAP 1982). Approximately 73% of all shelf sightings occurred in mid-Atlantic waters \( n = 389/530 \), Table 1).

Small groups of *Tursiops* occasionally follow warmwater intrusions through the Great South Channel or the Northeast Channel into coastal and nearshore Gulf of Maine waters. However this species is considered uncommon in Gulf of Maine waters \( n = 6 \) sightings, Table 1). Strandings also occur periodically within the Gulf of Maine north to eastern Canada (Miller and Kellogg 1955; Sergeant and Fisher 1957; Hairs and Scattergood 1958, 1959).

**Seasonal Distribution and Movements**

*Shelf Sightings of Bottlenose Dolphin*

During January-February all but one shelf sighting occurred in mid-Atlantic waters \( n = 31/32 \), Table 1, Fig. 2a). The number of sightings increased north of Cape Hatteras during March-April (Fig. 2b) primarily along the mid-Atlantic shelf-edge/slope interface \( n = 62/120 \), Table 1). During the 4-month period, January-April all known sightings of the inshore bottlenose dolphin ecotype occurred below Cape Hatteras, their sighting distribution remaining spatially disjunct (from the offshore ecotype) even over the narrow shelf southeast of Cape Hatteras (Figs. 2a-2b).

Inshore sightings of *Tursiops* increased significantly north of Cape Hatteras during May-June, primarily in mid-Atlantic shelf waters \( n = 116/160 \),
Table 1). The sighting distribution extended in a patchy continuum from Cape Hatteras north to the mouth of Delaware Bay (Fig. 2c). The number of shelf sightings in the mid-Atlantic during May-June and in July-August were comparable (Table 1), indicating similar levels of abundance (CeTAP 1982) and little change in distribution. During summer, bottlenose dolphins also entered lower Chesapeake and Delaware Bays (Fig. 2d) where, historically, a bottlenose dolphin fishery existed (Mead 1975a).

The number of sightings in mid-Atlantic shelf waters decreased during September-October (Table 1) and the coastal distribution of Tursiops sightings again occurred south of the Chesapeake Bay (Fig. 2e). An even greater decrease in the number of bottlenose dolphin sightings occurred throughout the study area during November-December (Table 1). Approximately seventy-seven percent (n = 64/83, Table 1) of all Tursiops sightings in November-December again occurred in mid-Atlantic waters. Inshore sightings were clustered only at Cape Hatteras (Fig. 2f) indicating a southward shift in the distribution of bottlenose dolphin during late-autumn. Numerous sightings of coastal Tursiops also occur below Hatteras during winter (Caldwell and Golly 1965; Caldwell et al. 1971a; CeTAP 1982; Burn et al. 1987).

Most nearshore or coastal populations of Tursiops have seasonal range expansions similar to those which occur along the eastern United States north of Cape Hatteras (Shane 1980, 1990; Irvine et al. 1981, 1982; Leatherwood 1982; Wells et al. 1980, 1981; Shane et al. 1986). The seasonal movements of coastal Tursiops may result from changes in water temperatures (Gaskin 1968; Mead and Potter 1990), changes in prey density or composition affecting prey availability (Leatherwood et al. 1978; Barros and Odell 1990; Shane 1990; Scott et al. 1990) or may be related to their minimum seasonal reproductive requirements (as suggested by Scott et al. 1990; Wells et al. 1980; Irvine et al. 1981) which may occur only below Cape Hatteras.
Offshore sightings of Bottlenose Dolphin

The offshore *Tursiops* occurred in shelf-edge and adjacent slope waters from Cape Hatteras to Georges Bank throughout the year with seasonal shifts in abundance. Sightings in slope waters during mid-winter were reduced in number (Table 1) but occurred from Cape Hatteras north to, and including, Georges Bank (Fig. 2a). The largest shelf-edge/slope concentration of bottlenose dolphin sightings during January-February occurred east of Cape Hatteras (Fig. 2a).

The number of slope sightings from Cape Hatteras north to the Northeast Channel increased during March-April (Fig. 2b). Fifty-three percent of all March-April sightings (*n* = 64/120) occurred in slope waters (Table 1). During May-June and July-August the number of slope sightings were very comparable (approximately 45%-47% of the bottlenose dolphin sightings occurred in slope waters during these months, Table 1), also indicating similar levels of abundance (CeTAP 1982). The number of bottlenose dolphin sightings from the Great South Channel north to the Northeast Channel (Georges Bank shelf/shelf-edge and slope waters) peaked during May-August (Table 1). By September-October the number of Georges Bank shelf-edge/slope water sightings decreased (Table 1) and the sighting distribution extended north on Georges Bank only to Lydonia Canyon (Fig. 2e).

Fifty-four percent (45/83) of all sightings during November-December occurred in slope waters of the mid-Atlantic (Table 1) and the largest concentrations of shelf-edge/slope bottlenose dolphin sightings generally occurred south of Hudson Canyon seaward of the 50f contour (Fig. 2f).

Ecological and Management Considerations

From June 1987 through June 1988, over 700 *Tursiops* stranded from New Jersey south to Florida (Scott et al. 1988), apparently due to a disease epidemic. Scott et al. (1988) suggested that the mortality affected mid-Atlantic coastal *Tursiops* (rather than the offshore ecotype) and that the
coastal population was reduced by as much as 53%. Further, assuming a constant rate of mortality equal to pre-epidemic estimates, Scott et al. (1988) estimated recovery time to range from 18 to >100 years (median value = 50.5 years).

The offshore bottlenose dolphin also occurs in slope waters seaward of the 500f contour. Kenney (1990) reported sightings in slope waters considerably away from the shelf-edge and bottlenose dolphins were a dominant member of the cetacean fauna observed along the northern edge of the Gulf Stream on a recent (August 1990) NMFS/NEFC survey into slope waters (NMFS/NEFC, unpublished sighting data).

Between 1977-1988 nine offshore *Tursiops* were reported taken incidental to foreign fishing efforts for squid (long-finned *Loligo pealei* or short-finned squid *Illex illecebrosus*) and Atlantic mackerel (*Scomber scombrus*) (Waring et al. 1990). The offshore *Tursiops* are also taken during the drift-gillnet fishery for swordfish *Xiphias xiphius* (Earle 1990). This fishery occurs in slope waters between Cape Hatteras and Corsair Canyon, Georges Bank primarily from May–November. The extent of the incidental take relative to the offshore *Tursiops* population is not yet known.

**Rough-Toothed Dolphin *Steno bredanensis***

Rough-toothed dolphins are associated with water temperatures >25°C (Leatherwood et al. 1976, 1983), likely preferring tropical–Gulf Stream influenced waters south of (and possibly seaward of) the study area. They have been reported from Virginia south to Florida, the Gulf of Mexico and the Caribbean (Layne 1965; Caldwell and Caldwell 1974; Leatherwood et al. 1976; Schmidly 1981; Perkins and Miller 1983).

Strandings of this species in cold temperate waters are considered vagrant. Therefore, sightings of the rough-toothed dolphin north of Cape Hatteras are considered rare. One sighting (coded as "sure" by CeTAP 1982) was
recorded on 21 September 1979 in slope water (depth >1500 f) seaward of the study area (CeTAP'1982).

Atlantic Spotted Dolphin *Stenella frontalis*

Two species of spotted dolphin are recognized in the North Atlantic, the pantropical *Stenella frontalis* and the endemic *S. attenuata* (Caldwell et al. 1971b; Perrin 1975; Perrin et al. 1987). In the western North Atlantic the distribution of *S. frontalis* extends farther north than *S. attenuata* (Gunter 1954; Caldwell 1955; Caldwell and Caldwell 1966, 1974; Fritts and Reynolds 1981; Perrin et al. 1987). The range of each species overlaps in the western North Atlantic south of Cape Hatteras (Katona et al. 1978; Schmidly 1981; Perrin et al. 1987), then *S. frontalis* is replaced by *S. attenuata* in the Caribbean (Caldwell et al. 1971b; Caldwell and Caldwell 1973). Although *S. attenuata* occasionally strand in the study area, *S. frontalis* is considered to be the spotted dolphin species which commonly occurs in shelf-edge/slope waters north of Cape Hatteras. The now-established vernacular name for *S. frontalis* is the Atlantic spotted dolphin (Perrin et al. 1987).

The preference by this species for mid-Atlantic shelf/shelf-edge and slope waters was apparent throughout the year. Eighty-three percent (n = 148/179 of all spotted dolphin sightings) occurred in the mid-Atlantic region (Table 2) and, although the spotted dolphin has stranded north of 40°00'N lat, there were no spotted dolphin sightings recorded in the Gulf of Maine during these surveys (Table 2, Fig. 3).

**Seasonal Distribution and Movements**

There were no sightings of spotted dolphin north of 35°00'N during January-February (Table 2) although one spotted dolphin sighting was reported off Cape Fear, North Carolina (below 35°00'N lat). This species is generally considered absent in the study area from December-February. Furthermore, during March-April only nine sightings were reported from the study area...
(Table 2). Most of these sightings occurred during April and all but one were reported from mid-Atlantic shelf-edge or slope waters (Table 2, Figs. 3a-3b). The number of spotted dolphin sightings increased between 35°00'N-39°30'N lats (mid-Atlantic waters) during May-June (Fig. 3c). Ninety-one percent \( (n = 32/35) \) of the sightings during this two-month period occurred in the mid-Atlantic region. The number of spotted dolphin sightings peaked during July-August \( (n = 72, \text{Table } 2) \) although the distribution did not vary markedly from the previous 2-month period, still being centered in the mid-Atlantic (Fig. 3d).

The sighting distribution of spotted dolphin was the most widespread during September-October (Table 2, Fig. 3c), extending north of the mid-Atlantic in slope waters to Georges Bank. Only thirty-one sightings (approximately 17% of the total) occurred north of the mid-Atlantic throughout the year. Thirty percent of these sightings \( (n = 13/43) \) occurred in southern New England/Georges Bank shelf-edge \( (n = 3) \) and slope \( (n = 10) \) waters during September-October (Table 2).

All but one November-December sighting occurred in southern New England or mid-Atlantic slope waters (south of 39°00'N lat) (Table 2, Fig. 3f) indicating a distributional shift southward to warmer, Gulf-stream influenced waters during winter.

**Ecological and Management Considerations**

The spotted dolphin was taken in slope waters of the southern New England and mid-Atlantic regions during the drift-gillnet fishery for swordfish *Xiphias xiphias* during 1989-1990 (IWC 1990). The full extent of the incidental take is not yet known.

**Striped Dolphin *Stenella coeruleoalba***

In the western North Atlantic striped dolphin are known mainly from warm-temperate and tropical waters (Leatherwood et al. 1976, 1983).

North of Cape Hatteras \( (35°00'N \text{ lat}) \) striped dolphin were distributed in
slope (rather than shelf/shelf-edge) waters from Cape Hatteras to Georges Bank (Fig. 4). Eighty-three percent (n = 90/115) of all striped dolphin sightings occurred in slope waters (Table 3). In southern New England-Georges Bank slope waters (between the Great South Channel and Hydrographers Canyon) striped dolphin sightings occurred during all seasons and during each 2-month period (Figs. 4a-4f) except January-February (Table 3). Between 37°00′N-39°00′N lats. striped dolphin were observed during all seasons (generally seaward of the 500f depth contour, Figs. 4a-4f). CeTAP (1982) suggested that striped dolphin occupied this area throughout the year, with shifts in their sighting distribution to the southwest in winter and spring, and eastward in summer and autumn.

The preference of these dolphins for offshore, slope and Gulf Stream-influenced waters throughout the year was reflected in the average depth-at-sighting (>1000f, Edel et al. 1981b; CeTAP 1982), the deepest of any regularly occurring delphinid species in the study area.

**Seasonal Distribution and Movements**

Only 11 striped dolphin sightings occurred during January-February, all in mid-Atlantic shelf-edge/slope waters (Table 3) north to approximately 38°30′N lat (Fig. 4a). The number of striped dolphin sightings increased during March-April (Table 3). Eighty-eight percent of all March-April sightings (n = 31/35) also occurred in mid-Atlantic waters. The remainder occurred in slope waters north to Lydonia Canyon, Georges Bank (Fig. 4b).

From May through August (Figs. 4c-4f) sixty-four percent of all sightings (n = 28/44) were in mid-Atlantic slope waters (Table 3). All but three of the remaining sightings occurred in a slope water-patchy continuum from the Great South Channel northeast through Hydrographers Canyon to 41°00′N lat (approximately Corsair Canyon). During late-summer and autumn Mansfield (1967) and Sergeant et al. (1970) also reported striped dolphin from Nova Scotia suggest-
ing a continued movement north and northeast of Georges Bank at this time.

From September-December the number of striped dolphin sightings decreased steadily throughout the study area to January-February levels (Table 3). Eighty-four percent of all September-December sightings (n = 21/25) occurred south of the Hudson Canyon in southern New England/mid-Atlantic slope waters (Table 3).

Striped dolphin are considered stragglers within the Gulf of Maine during any season (n = 2 sightings, Table 3). They are most often recorded in this region from late-autumn through winter as a stranding event. Mid-winter strandings have also been reported from Sable Island, Nova Scotia (Sergeant et al. 1970):

Ecological and Management Considerations
Striped dolphin have been taken in slope waters from the mid-Atlantic north to Corsair Canyon during the pelagic drift-gillnet fishery for swordfish (Xiphias gladius) (Earle 1990). The full extent of the incidental take is not yet known.

Spinner Dolphin Stenella Longirostris
Spinner dolphins have been reported from tropical Atlantic waters south of Cape Hatteras (Taruski and Winn 1976; Caldwell et al. 1971b) into the Gulf of Mexico (Fritts and Reynold 1981; Schmidly 1981; Loehfener et al. 1989; Fritts et al. 1983). They were recorded rarely during these surveys (Fig. 9).

Seasonal Distribution and Movements
Hain et al. (1981) reported 2 sightings of spinner dolphin (19 April 1979 and 30 August 1979) in slope water (>1000f) considerably beyond the seaward limits of the study area. Two other sightings (suggested by Cetap as possibly the same group of dolphins) were reported in slope waters below Nantucket (39°70'N-69°95'W and 39°67'N-69°83'W respectively) during August 1979 (Fig. 5). Another sighting was reported south of Cape Hatteras.

Several sightings of spinner dolphins were also observed seaward of the
shelf-edge along the northern edge of the Gulf Stream in August, 1990 during the NMFS/NEFC Gulf Stream/slope water survey (NMFS/NEFC, unpubl. data, not plotted here). Two of these dolphins (one sighting) were seen with a small group of sperm whales *Physeter macrocephalus* in waters >2000 f in depth and surface water temperatures exceeding 28°C.

Spinner dolphins are generally considered absent in shelf waters of the study area.

**Common or Saddleback Dolphin Delphinus delphis**
Common dolphin were widespread in mid-shelf/shelf-edge and adjacent slope waters (Fig. 6) from 36°00'N lat northeastward to the Northeast Channel (42°00'N lat) during all seasons. They are strictly an outer-shelf/slope species west of 72°00'W long (Fig. 6). Their distribution east of 70°00'W long followed the perimeter of Georges Bank, although they were not as abundant on the northern edge (Fig. 6). They were the most frequently sighted dolphin in southern New England/Georges Bank shelf waters throughout the year. The only near-shelf incursions occurred in the southern New England region (Fig. 6).

Common dolphin regularly occur, but are not considered abundant, in Gulf of Maine waters.

**Seasonal Distribution and Movements**
During January-February common dolphin occurred from Cape Hatteras to the eastern edge of Georges Bank, with a conspicuous gap in the southern New England region between 71°00'W and 72°00'W long (Fig. 6a). Scattered sightings occurred along the shelf-edge; however the largest concentrations occurred between Norfolk and Baltimore Canyons, and below the Great South Channel (Fig. 6a). CeTAP (1982) found the abundance of this species greatest during winter.

Sightings were concentrated along the shelf-edge and adjacent slope waters south of 39°00'N lat during March-April (Fig. 6b). Eighty-three per-
cent of all sightings during this two month period (n = 122/147) occurred in southern New England/mid-Atlantic waters (Table 4). The large cluster of sightings which occurred below the Great South Channel in January-February (Fig. 6a) no longer occurred during March-April. Rather, another sighting concentration formed below Georges Bank from Oceanographer to Lydonia Canyons (Fig. 6b). This sighting distribution indicates that common dolphin move northeast along the outer edge of Georges Bank during March-April with little movement onto mid- or near-shelf waters at this time.

The sighting distribution continued to shift northeastward along the shelf-edge during May-June (Fig. 6c). The large concentrations along the 50-100 f contours in the mid-Atlantic decreased significantly, shifting northeast along the shelf-edge and into slope waters (Fig. 6c). The number of sightings also increased in near- to mid-shelf waters of the southern New England region (common dolphin moved up the Hudson Canyon to form a distinct "spike", Fig.) and on Georges Bank from the Great South Channel to the Northeast Peak (Table 4, Fig. 6c).

The southern limit of sightings in July-August was approximately 38°00'N lat indicating a continued movement northeast throughout the study area during summer. Hain et al. (1981) also suggested that summer and autumn sightings are greatest north of 37°30'N lat. Approximately fifty percent (n = 54/109) of all sightings during July-August occurred on Georges Bank (Table 4). The northeast progression of sightings is more apparent when July sightings north of 39°00'N lat (Fig. 6d) are examined separately from those which occurred in August (Fig. 6e). The sighting distribution shifted from southern New England waters in July (Hudson Canyon to the Great South Channel) onto northeastern Georges Bank in August. In contrast, <10% of all common dolphin sightings, July-October, occurred in mid-Atlantic waters, a regional minimum.

Sixty-seven percent (n = 89/132) of all common dolphin sightings during...
September-October occurred on Georges Bank, a regional maximum (Table 4). However most of these sightings occurred during October, rather than September. During September (Fig. 6f) common dolphin sightings (and abundance, from CeTAP 1982) decreased throughout the study area as this species moves over the Northeast Channel and become abundant on the Scotian Shelf (east of Nova Scotia) (Sergeant and Fisher 1957; Sergeant et al. 1970; Leatherwood et al. 1976). Also, Whitehead and Glass (1985) reported sightings of common dolphin on the southeast shoals of the Grand Banks (approximately 44°00'N lat) during late summer-autumn. The combined sightings suggest a widespread movement, inshore and northward throughout the North Atlantic by common dolphin at this time.

During October (Fig. 6g) common dolphin again move southward across the Northeast Channel onto central Georges Bank, and along the shelf-edge of Georges Bank to the Great South Channel. The number of sightings on Georges Bank increased significantly over the previous month. Payne et al. (1984) found that the greatest densities of this species on Georges Bank occurred in autumn. Selzer and Payne (1988) suggested that the widespread movement of this species onto Georges Bank at this time was due, possibly, to increased water temperatures and increased densities of squid, a known prey species-group of common dolphin in this region (Major 1986; Waring et al. 1990). Sightings of common dolphin west of 70°00'W long during September-October (Figs. 6f-6g) are nearly absent.

Eighty percent of all sightings during November-December (n = 139/174) occurred in Georges Bank/southern New England waters which suggests a continued movement southwest from the Scotian Shelf into southern New England shelf waters. The center of the sighting distribution at this time extended from the Northeast Peak of Georges Bank to the Hudson Canyon (Fig. 6h).

Hain et al. (1981) indicated that common dolphin are most abundant on
Georges Bank May–June, then again from October–December. Also, the lack of sightings in Georges Bank/southern New England slope waters at this time (n = 13) further indicate a common dolphin movement onto Georges Bank/southern New England shelf waters from the Canadian shelf (rather than an onshelf movement from slope waters below Georges Bank). Common dolphin remain abundant on Georges Bank throughout the winter. In contrast only three percent (n = 6 sightings) occurred in mid-Atlantic waters during November–December (Table 4). These sightings were scattered south to 37°00′N lat (Fig. 6h). However, by January the distribution of common dolphin again becomes widespread in a mid-shelf-to-shelf-edge band from Georges Bank south to Cape Hatteras.

The Gulf of Maine is not considered preferred habitat for this species. Occasional sightings did occur from the Scotian shelf (over the Northeast Channel) southwest along the northern edge of Georges Bank from October–December (Figs. 6g–6h). At this time local water temperatures exceeded 10°C due to warm-water intrusions through the Northeast Channel into the Gulf.

Ecological and Management Considerations

Between March 1977 and December 1988, 203 common dolphin were reported taken incidental to foreign fishing activities off the northeastern United States (Waring et al. 1990). Most of these (68%) were taken along the southern New England/mid-Atlantic shelf-edge primarily during December–February (Waring et al. 1990). From 1977–1986 most were captured in the Loligo squid fishery. This fishery was discontinued following the 1986 season (Waring et al. 1990). During 1987 and 1988, fifty common dolphin were taken in the expanded fishery for Atlantic mackerel (Waring et al. 1990).

During 1989–1990 common dolphin were also taken in slope waters during the pelagic drift-gillnet fishery for swordfish (Earle 1990). The full extent of the incidental take is not yet known.

Atlantic White-Sided Dolphin (Lagenorhynchus acutus)
The white-sided dolphin is the most abundant dolphin in the Gulf of Maine. Seventy-seven percent of all sightings throughout the study area \( n = 826/1067 \) occurred in Gulf of Maine waters (Table 5). This species was present throughout the year north of \( 40^\circ30'\text{N} \) lat from the Great South Channel/western Georges Bank region, northwest along the 50f contour outside of Cape Cod throughout the western half of the Gulf of Maine (Fig. 7). Several areas north of \( 40^\circ00'\text{N} \) lat where white-sided dolphin sightings were noticeably absent at all times included the mid-shelf region from the Hudson Canyon north to Long Island, and the shallow-water shoals below Nantucket and on Georges Bank.

South of \( 40^\circ00'\text{N} \) lat, their sighting distribution was restricted, generally, to southern New England waters with Hudson Canyon being their only known area of concentration (Fig. 7). Only 4 white-sided dolphin sightings (<1.0% of the total number) occurred in mid-Atlantic shelf waters (Table 5).

**Seasonal Distribution and Movements**

The white-sided dolphin has been characterized as a shelf-species with no tendencies for shelf-edge concentrations (Hain et al. 1981). However, the number of sightings during January-February does not support the hypothesis that white-sided dolphin necessarily remain on the shelf throughout the year. Only 20 white-sided dolphin sightings were reported throughout the study area during January-February (Table 5), significantly fewer than at other periods of the year. These sightings were reported from the southwest Gulf of Maine and waters adjacent to the Hudson Canyon (Fig. 7a).

During March-April the number of white-sided dolphin sightings increased significantly in the Gulf of Maine (Table 5). The distribution of these sightings was concentrated in the southwest Gulf of Maine along the 50f contour from the Great South Channel to the northern edge of Stellwagen Bank (Fig. 7b). The observed increase in the number of March-April white-sided dolphin sightings (from the scattered number of sightings observed in
January-February) is not understood, but it is not considered an artifact of sampling. The differences between the number and concentration of sightings during these two time periods suggest rapid movement into the study area during late-February/early-March.

The number of sightings continued to increase during May-June (Table 5) but the distribution still remained centered from the Great South Channel northwest along the 50f contour (Fig. 7c). A few shifts in the sighting distribution suggest a movement pattern toward the Great South Channel/southern Gulf of Maine from southern New England waters. The dolphin sightings which occurred in southern New England shelf-edge waters during March-April are reduced in number by May. Another sighting concentration was observed from Montauk Point east to below Martha's Vineyard, Massachusetts (Fig. 7c). Also, white-sided dolphin sightings extended north from Stellwagen Bank to Jeffreys Ledge in May-June further indicating a northward shift in their distribution into the Gulf of Maine (Fig. 7c).

A significant concentration of white-sided dolphin sightings occurred on the Northeast Peak of Georges Bank during May-June (Fig. 7c). White-sided dolphins occurred on Georges Bank throughout the year in low numbers (n = 145 sightings, from Table 5), however most of these sightings occurred on southwest Georges Bank (near the Great South Channel where sightings occurred throughout much of the year). The white-sided dolphin sightings on the Northeast Peak of Georges Bank during mid-summer (Figs. 7c-7d) occurred primarily during 1986-1987 in response, we suggest, to a shift in the distribution and density of prey during those years.

A noticeable shift in the sighting distribution occurred during July-August (Fig. 7d). White-sided dolphins occurred in a patchy continuum from the southwestern Gulf of Maine-Great South Channel region north into the western and north-central areas of the Gulf of Maine (Fig. 7d). Sightings
were concentrated from northern Stellwagen Bank/Jeffreys Ledge northeast, and 
from Cashes Ledge/ Basin north to the central Gulf of Maine below Mt. Desert 
Island (Fig. 7d). White-sided dolphin sightings also occurred in Northeast 
Channel/Browns Bank (Scotian Shelf) waters during July-August (Fig. ) indi-
cating movement from Georges Bank northeast out of the study area. Although 
sightings of white-sided dolphin were widespread during mid-summer, their 
greatest densities extended from the Great South Channel north along the 50f 
contour around the western rim of the Gulf (as opposed to the central basins). 

White-sided dolphins have been reported in group sizes >2000 individuals 
on Jeffreys Ledge during mid-summer (Mercer 1985). Group sizes >1000 individ-
uals are not uncommon throughout the southwest Gulf of Maine. White-sided 
dolphin sightings have also been reported from the Bay of Fundy (north of the 
present survey effort) from mid-summer through autumn (Kraus and Prescott 
1981, 1982).

Summer sightings below 39°00'N lat are considered south of the present 
seasonal range for this species. Rowlett (1980) did not observe any white-
sided dolphin between 37°00'N-39°00'N lats from 1971 to 1977 during his summer 
surveys.

Between September-December the white-sided dolphin sighting distribution 
changed little (Figs. 7e-7f). Sightings were concentrated, generally, in the 
southwestern Gulf of Maine from Jeffreys Ledge to east of Nantucket. There 
were more sightings at the base of the Great South Channel during November-
December (Fig. 7f), however there was little indication that white-sided 
dolphin continued to move below the Great South Channel during this period. 
Despite the large number of November-December sightings (n = 98, Table 5) and 
no indication of a significant or rapid change in their distribution, white-
sided dolphin sightings were absent (or significantly reduced in number) from 
the study area by January. A possible interpretation of these sighting data
is that white-sided dolphin move off-shelf mid-December to early-January.

**Ecological and Management Considerations**

The abundance and distribution of white-sided dolphin in shelf waters of the northeastern United States have changed considerably during the past several decades. A lack of sightings during the 1950's and 1960's suggest that it was not a particularly abundant species at that time (Schevill 1956; Sergeant and Fisher 1957). The first confirmed report of white-sided dolphin from Cape Cod occurred in 1954 (Schevill 1958). However, sighting-effort has increased significantly in the study area since the mid-1970's; therefore a lack of white-sided dolphin sightings prior to then does not suggest that they were completely absent. Available data does indicate, however, that they were not as abundant in coastal and near-shelf waters during that period as they are at present. Also, the increased number of sightings, combined with a rapid and concurrent increase in the number of strandings from the Gulf of St. Lawrence to the Gulf of Maine (Katona et al. 1976; Sergeant et al. 1980; Mitchell 1981; Sergeant 1982) strongly suggest that the absolute abundance of white-sided dolphin has increased in shelf waters north of Cape Cod in recent decades.

During the mid-1970's several white-sided dolphin sightings were reported from Georges Bank slope waters (Katona 1976; Ramsdell 1978; Testaverde and Mead 1980). The white-sided dolphin has also been reported from Newfoundland over deep waters (Mercer 1973), from slope waters (>500f)'south of Iceland' (Sigurjonsson et al. 1989) and from the shelf-edge of southwest Norway and northwest Europe (Jonsgaard and Nordli 1952). Since they were considered uncommon during the 1960's and so little is known regarding the distribution of white-sided dolphin prior to the mid-1970's, it is not unreasonable to consider that their distribution was different, possibly mid-shelf to shelf-edge/slope, rather than strictly a shelf-based distribution as recent sighting
data indicate. Generally, it is difficult to explain deep-water sightings and a concurrent increase in shelf sightings and strandings from the Chesapeake Bay to Newfoundland without considering that white-sided dolphin have recently entered near-shelf waters in the study area from offshore. The near complete lack of sightings during January-February, 1978-1988 also suggest that at least a part of the white-sided dolphin population of the northeastern United States may move beyond the seaward boundary of the study area at that time.

One possible explanation for a shift in the distribution of white-sided dolphin sightings during recent decades might be a response to a change in the distribution and abundance of prey. Since the mid-1970's sand lance *Ammodytes spp.* abundance increased significantly in the study area (Meyer et al. 1979; Sherman et al. 1981; Morse 1982). In Gulf of Maine-Georges Bank waters white-sided dolphin have been frequently observed in close association with humpback *Megaptera novaeangliae* and fin *Balaenoptera physalus* whales (Hain et al. 1981; Mayo 1982) which were observed feeding on sand lance. White-sided dolphin might also have been feeding on sand lance in these mixed-species associations.

The shelf-wide increased sand lance abundance followed the depletion of offshore stocks of Atlantic herring (Sherman et al. 1981). The decreased biomass of offshore herring coupled with increased sand lance abundance near-shelf could have precipitated the suggested offshore-to-nearshore shift in the distribution of white-sided dolphin during recent decades. Such a recent distribution shift into the Gulf of Maine (in response to increased prey densities) would also explain the lack of confirmed white-sided dolphin sightings near Cape Cod during the 1950's and 1960's, and a subsequent increase in sightings since the 1970's.

The close predator-prey relationship between sand lance and white-sided dolphin in the southwest Gulf of Maine can be demonstrated further by examin-
ing the sighting distribution (data from NMFS/NEFC survey vessels only) in the southwestern Gulf of Maine in 1984-1985 (Fig. 7g) to comparable data collected during 1986-1987 (Fig. 7h). The sighting distribution in 1986-1987 shifted southeastward from Stellwagen Bank into the Great South Channel and onto Georges Bank (Fig. 7h). This shift occurred concurrently with a decreased abundance of sand lance on Stellwagen Bank during 1986 (sand lance data from Nelson and Ross 1991). The concentrations of white-sided dolphin on Georges Bank during 1986 were the largest reported since 1978-1979 (those reported by CeTAP 1982). A similar shift in distribution away from Stellwagen Bank (in response to decreased prey densities at that location) was observed for humpback, and to a lesser extent, fin whales during 1986 (Payne et al. 1990c).

Strandings of white-sided dolphin and mortality due to gillnet entanglement have been reported from the Gulf of Maine (Katona et al. 1976; Mead 1979; Sergeant et al. 1980; Sergeant 1982; Gilbert and Wynne 1988). Waring et al. (1990) also reported the incidental capture of white-sided dolphin in the southern New England mid-shelf/shelf-edge (Hudson Canyon region) fisheries for squid and Atlantic mackerel between March and early-May. Neither form of incidental take seem to have a significant impact on the population.

**White-Beaked Dolphin** *Lagenorhynchus albirostris*

The distribution of white-beaked dolphin sightings in the northwest Atlantic presently extends in temperate and sub-arctic waters from at least 41°00'N lat (below Cape Cod) north to Greenland, the Davis Straits and Iceland (Sergeant 1958; Sergeant and Fisher 1957; Leatherwood et al. 1976, 1983; Katona et al. 1983; Whitehead and Glass 1985; Alling and Whitehead 1987; Sigurjonsson et al. 1989). However, they are far more numerous in shelf waters between Canada and Iceland than off the northeastern United States.

White-beaked dolphin are considered regular, but uncommon, throughout the study area. Thirty-five sightings were recorded 1978-1988 (Table 6).
Seasonal Distribution and Movements

Only one white-beaked dolphin sighting was recorded in the study area between September-February (Table 6). White-beaked dolphin are presently considered to be rare in the study area during that period. Most white-beaked dolphin sightings have occurred between March and August (Table 6) in southwest Gulf of Maine shelf-waters from the western boundary of the Great South Channel northwest over Stellwagen Bank to Jeffreys Ledge and Basin (Fig. 8). The largest recorded sighting of this species (@200 individuals) in the study area occurred on 8 July 1979 near Jeffreys Ledge (Stone et al. 1983). Several sightings have also occurred below Cape Cod, and CeTAP (1982) reported three shelf-edge sightings (Fig. 8). Only one sighting has been reported south of 39°30′N latitude.

CeTAP (1982) considered southern New England waters to be the southern range limit for this species in the northwest Atlantic.

Ecological and Management Considerations

The white-beaked dolphin was the *Lagenorhynchus* species most often reported in the Gulf of Maine as recently as the early 1970's (Katona 1976). It is generally accepted that white-beaked dolphin were more abundant around Cape Cod in the 1950's-1960's than at present (Katona et al. 1983).

Sigurjonsson et al. (1989) suggested that white-beaked dolphins displace the smaller white-sided dolphin in cooler, nearshore Icelandic waters. Katona et al. (1983) also suggested that the two *Lagenorhynchus* species segregate spatially by water temperature, and ecologically by diet. However, this warm water/cool water distinction between the two *Lagenorhynchus* species does not adequately explain the recent decline in white-beaked dolphin sightings throughout the Gulf of Maine. Although available data do not provide for a causal explanation, a qualitative examination does indicate several ecological changes in the Gulf of Maine food-web which may be relevant to the decline of white-beaked dolphin.
The preferred prey of white-beaked dolphin in Canada and Iceland are schooling fish, respectively Atlantic herring and capelin Mallotus villosus, or squid (Sergeant and Fisher 1957). Between the mid-1960's and mid-1970's a >50% reduction in herring and mackerel biomass occurred in the Gulf of Maine-Georges Bank regions (Clark and Brown 1977; Anthony and Waring 1980; Grosslein et al. 1980). White-beaked dolphin abundance may have declined following the removal of their preferred prey despite the subsequent appearance of a super-abundant, ecologically similar prey in sand lance. The white-sided dolphin (a species which preys extensively on sand lance in the southwest Gulf of Maine) may have then replaced the white-beaked dolphin in this region.

Incidental catches of white-beaked dolphin in the northeastern United States have not been reported.

Grampus or Risso's Dolphin Grampus griseus

Grampus are widespread in slope waters throughout the western North Atlantic. It has been reported from the Lesser Antilles (Caldwell et al. 1971b), the southeastern United States/Gulf of Mexico (Gunter 1954; Paul 1968; Fritts and Reynolds 1981; Schmidly 1981; Dorf 1982; Jennings 1982; Fritts et al. 1983; Loehofner et al. 1989) north to eastern Newfoundland (Leatherwood et al. 1976, 1983).

Grampus have a three season distribution in the study area centered from 36°00'N to 41°00'N lats (Fig. 9). Eighty-three percent of all sightings (n = 460/552, Table ) occurred in southern New England/mid-Atlantic shelf-edge and adjacent slope waters (Table 7). Typically, grampus were not observed inshore of the 50ft contour.

Jennings (1982) recorded grampus throughout the year in slope waters off eastern Florida. Sixty-three percent of all the grampus sightings (n = 349/552, Table 7) occurred in slope waters, approximately one-half of these (n = 170) in the mid-Atlantic (Table 7). It is possible, therefore, that grampus
also occur north of Cape Hatteras during mid-winter, but in slope waters
seaward of the study area and nearer Gulf-stream influenced water.

Seasonal Distribution and Movements
Only 16 sightings of grampus were reported during January-February (Table
7). Approximately eighty percent of the grampus sightings during this 2-month
period (n = 13/16, Table 7) occurred in mid-Atlantic slope waters below the
Baltimore-Wilmington Canyons (Fig. 9a). During March-April 70% of the grampus
sightings (n = 32/46, Table 7) were still observed in mid-Atlantic slope
waters between 36°30'N-39°00'N lats, Fig. 9b). Scattered sightings also
occurred in shelf-edge waters northeast of the Hudson Canyon (Fig. 9b).

The sighting distribution extended north into southern New England slope
waters to the base of the Great South Channel by May-June (Fig. 9c). Grampus
also extended their distribution into shelf-edge waters. One-third of all
sightings during May-June occurred in shelf-edge waters (n = 33/103, from
Table 7) from 36°30'N to the Great South Channel.

The peak abundance for this species in shelf-waters occurred during
summer (CeTAP 1982). Fifty-four percent of all shelf sightings (n = 104/193,
Table 7) occurred during July-August and the sighting distribution shifted
northeast (Fig. 9d). Also, the number of grampus sightings more than doubled
over May-June levels (Table 7) and were near-equally divided between shelf-
edge and adjacent slope waters during this period (Table 7). Seventy-eight
percent (n = 22/28, Table 7) of all Georges Bank sightings throughout the year
occurred during this 2-month period. The largest concentrations of grampus
sightings at this time extended along the shelf-edge/slope interface from
38°00'N lat to the Hudson Canyon, and west of 71°00'W to Lydonia Canyon,
Georges Bank (Fig. 9d). Occasional slope sightings also occurred along the
Northeast Peak of Georges Bank.

The number of sightings decreased dramatically during September-October
(Table 7) and their distribution shifted northeast (Fig. 9e), becoming cen-
tered in southern New England waters. During this 2-month period approximately seventy percent of all shelf sightings (n = 34/45), and sixty percent of the total number of sightings throughout the study area (n = 66/113) occurred in southern New England waters (Table 7) generally along the shelf-edge/slope interface. Throughout September-October grampus continued to move along the shelf-edge/slope interface northeast and offshore out of the study area.

By November (Fig. 9f) there were few grampus sightings north of 40°00'N lat. All but two November-December sightings in the study area (n = 34/36, Table 7) occurred in slope waters, generally from Hudson Canyon south into the mid-Atlantic region. Therefore, the distribution of grampus shifted back into slope waters seaward of the study area (based on the absence of sightings) during late-autumn.

This species is generally considered absent from the Gulf of Maine (n = 8/552 sightings, Table 7). However sightings near Cape Cod or inside the Northeast Channel do occur, generally, during late-summer and autumn following warm water intrusions into the Gulf of Maine from offshore. Mercer (1985) reported grampus on Fippennes Ledge (42°45'N, 69°18'W) and in Ipswich Bay, Massachusetts during August 1985. Surface water-temperatures at these sighting exceeded 27°C (from Mercer 1985). Several shore-based sightings have been reported and Gulf of Maine strandings occur but they are considered uncommon.

Ecological and Management Considerations
The incidental capture of grampus in foreign-fishing activities were reported on 4 occasions between 1977 and 1988 (Waring et al. 1990). They have also been taken incidental to the drift-gillnet fishery for swordfish (Earle 1990).

Killer Whale Orcinus orca
Killer whale sightings are widespread (and sporadic) throughout the western North Atlantic from pack-ice to the Lesser Antilles, and into the Gulf
of Mexico (see Sigurjonsson and Leatherwood 1988 for a complete discussion of killer whale sightings in the North Atlantic).

**Seasonal Distribution and Movements**

Killer whale sightings in the study area occurred April through September (Table 8) primarily in mid-shelf to shelf-edge waters (Fig. 10). Katona et al. (1983, 1988) suggested that killer whale sightings increased in the Gulf of Maine during late-summer following the appearance of bluefin tuna *Thunnus thynnus*, a preferred prey of killer whales in this region.

Killer whale sightings (from sources other than the NMFS/CeTAP surveys) have been reported most frequently from Cape Cod Bay–Stellwagen Bank throughout the western Gulf of Maine (regions of considerable whalewatch and vessel effort). A summary of known sightings in the study area are provided by Katona et al. (1988) and Mitchell and Reeves (1988).

**False Killer Whale *Pseudorca crassidens***

False killer whale sightings and strandings are widely distributed in warm temperate and tropical waters (Brimley 1937; Caldwell et al. 1970, 1971a, 1971b; Mitchell 1975a, 1975b; Leatherwood et al. 1976, 1983; O'dell et al. 1980; Schmidly 1981; Loehoefner et al. 1989), but rarely reported from shelf waters north of Cape Hatteras.

**Seasonal Distribution and Movements**

One "possible" sighting (reliability code from CeTAP 1982) of 7 individuals was reported in slope waters southeast of Cape Hatteras (>500m depth) on 30 August 1980. Generally, they are considered absent from the study area.

**Pygmy Killer Whale *Feresa attenuata***

The pygmy killer whale is distributed widely in deeper, warm-temperate to tropical waters (Caldwell and Caldwell 1971c; Nishiwaki 1966; Ross and Leatherwood 1988) but no where has been described as abundant (Leatherwood et al. 1983).

**Seasonal Distribution and Movements**

A single pygmy killer whale sightings was reported by CeTAP (1982) on 1
August 1981 in slope water (depth >1000f) south of Georges Bank. Because of
the unsure identification of this species (sighting reliability reported by
CeTAP), the occurrence of this species in the study area is questionable
(CeTAP 1982).

Pilot Whale Globicephala melaena and G. macrorhynchus
The Atlantic or long-finned pilot whale (G. melaena) is commonly observed
in the northwest Atlantic from at least Cape Hatteras, North Carolina (Leath-
erwood et al. 1976; Hain et al. 1981; CeTAP 1982; Payne et al. 1984) north to
the Scotian Shelf, eastern Canada and Newfoundland (Sergeant 1962, 1968;
Sergeant and Fisher 1957; Sergeant et al. 1970; Geraci and St. Aubin 1977;
Mercer 1975; Mitchell 1975a, 1975b; Hay 1982); Greenland (Kapel 1975), Iceland
and the Faeroe Islands (Sigurjonsson et al. 1989; Bloch et al. 1989a, 1989b,
1990).

The short-finned pilot whale (G. macrorhynchus) is sympatric with G.
melaena in the northern portion of its western North Atlantic range. The
short-finned pilot whale is considered a more tropical species, common south
of Cape Hatteras into Caribbean waters (Caldwell and Erdman 1963; Caldwell and
Golley 1965; Caldwell et al. 1971b; Caldwell and Caldwell 1975; Erdman 1970;
Erdman et al. 1973; Leatherwood et al. 1976) into the Gulf of Mexico (Gunter
1954; Schmidly 1981; Fritts and Reynolds 1981; Dörf 1982; Fritts et al. 1983;
Loehofner et al. 1989) and south to Venezuela (Leatherwood et al. 1976,
1983).

There are few confirmed records of G. macrorhynchus in the study area.
Rowlett (1980) reported a sighting of G. macrorhynchus seaward of the Balti-
more Canyon (38°6'N, 73°45'W) during September 1977, and strandings have been
reported as far north as New Jersey (Mead 1975b; Katona et al. 1978). Leath-
erwood et al. (1976) suggested that they probably range as far north as Vir-
ginia during late-summer and autumn. CeTAP (1982) also proposed the occur-
rence of two Globicephala species in the study area during fall based on the occurrence of calves in both spatially separated northern and southern pilot whale concentrations.

In the waters of the northeastern United States, pilot whales constitute a significant percentage of the entire cetacean biomass for the shelf-edge/slope community (Hain et al. 1985; Kenney and Winn 1987). Because the range of each species potentially overlaps in southern New England/mid-Atlantic shelf/shelf-edge and slope waters between 35°00′N (Cape Hatteras) and 38°00′N-39°00′N, and because of difficulties in separating these two species in the field, both have been considered together in recent distributional and abundance analyses (CeTAP 1982; Powers and Payne 1983; Payne et al. 1984; Hain et al. 1985; Kenney and Winn 1987). However, Payne et al. (1989) considered their distributions to be seasonally disjunct in the shelf waters of the northeastern United States. This paper provides separate discussions of the two species whenever possible.

**Seasonal Distribution and Movements**

The distribution of pilot whale Globicephala spp. sightings off the northeastern coast of the United States generally followed the shelf-edge/slope region from Cape Hatteras (35°00′N lat) to the northeastern portion of Georges Bank and onto the Scotian shelf (Fig. 11). Sightings of pilot whales also extended from the V-shaped basin of the Great South Channel along the northern edge of Georges Bank to the Northeast Channel (Fig. 11).

Pilot whale sightings were observed frequently during every 2-month period except January-February (Table 9) when they were infrequent (n = 26) and loosely distributed along the shelf-edge/slope region of the study area (Fig. 11a). Only 3 sightings occurred on Georges Bank and throughout the Gulf of Maine during this 2-month period (Table 9). Based on the sighting distribution, all near- and mid-shelf areas were sparsely occupied by pilot whales
at this time.

The number of sightings increased along the shelf-edge/slope interface from Norfolk Canyon to the Northeast Channel during March (Fig. 11b) and April (Fig. 11c). Ninety-three percent of all shelf sightings (n = 52/56, Table 9) occurred in southern New England/mid-Atlantic waters during March-April. Only 2 sightings occurred on Georges Bank during this period. However, most sightings at this time occurred in slope waters (n = 82 sightings, 63% of total number of sightings). The sighting distribution in slope waters extended from the mid-Atlantic to the Northeast Channel, Georges Bank.

A significant increase in the number of pilot whale sightings in the Gulf of Maine occurred during May and June (Table 9). During May pilot whale sightings north of 40°00'N lat increased from the Great South Channel northeast around the outer edge of Georges Bank and onto the Scotian Shelf (Fig. 11d). During June (Fig. 11e) the sighting distribution extended into the deeper, central Gulf of Maine.

The number of pilot whale sightings in mid-Atlantic slope waters also increased dramatically during May-June over the previous four months (Table 9). Although the May-June sighting distribution extended from 35°00'N (Cape Hatteras) north along the entire shelf-edge/slope interface of the study area, there was an obvious gap in the distribution of sightings located west of the Great South Channel between 40°00'N-38°40'N lat (centered on the Hudson Canyon, Fig. 11e). This resulted in two separate groups of pilot whale sightings—a northern group occurred from the Great South Channel northeast to the Scotian Shelf, and into the Gulf of Maine (predominantly north of 40°00'N lat) and a second group of pilot whale sightings which occurred in mid-Atlantic slope waters (not shelf waters, see Table 9) from 39°00'N lat (Wilmington Canyon) south to the southern edge of the study area (Fig. 11e).

The number of pilot whale sightings on Georges Bank during July-August
more than doubled from the previous 2-month period (Table 9). Also, these sightings were concentrated nearer the Northeast Channel (Fig. 11f) than were Georges Bank sightings in May-June. Another large concentration of sightings occurred in the mid- to upper reaches of the Great South Channel (Fig. 11f).

Seventy percent (n = 55) of all pilot whale sightings in slope waters during July-August occurred in the mid-Atlantic (Table 9). This large number of mid-Atlantic-slope sightings first occurred during May-June, peaked in July-August, then remained high throughout the remainder of the year.

Eighty-seven percent of all mid-Atlantic sightings from May through December (n = 183/211, from Table 9) occurred in slope waters. The northernmost range of these sightings extended to 39°00'N lat (east of Delaware Bay), and more importantly, remained spatially segregated from those north of 40°00'N lat. throughout the year.

During September-October eighty-three percent (n = 92/111) of all pilot whale sightings on the shelf occurred in the Georges Bank/Gulf of Maine regions (Table 9). Shelf waters west of 70°00'W long were unoccupied by pilot whales, generally, from September through December (Figs. 11g-11i). There was also a decrease in the number of pilot whale sightings on the central-northeast areas of Georges Bank, concurrent with an increase in the number of pilot whale sightings concentrated in the lower Gulf of Maine (western Georges Bank to the Great South Channel). Most pilot whales observed in the Great South Channel at this time were moving southwestward out of the Gulf of Maine (from observers notes and personal observations).

By November-December, the only noticeable concentration of pilot whale sightings on the shelf (<200m) was at the Great South Channel (Fig. 11i). However, the distribution of pilot whale sightings in slope waters again extended throughout the study area (Table 9) with a noticeable gap in southern New England waters. A major concentration of slope sightings at this time (n
=50/67, Table 9) occurred in Mid-Atlantic waters east of Cape Hatteras (Fig. 111). These sightings were not present in January.

**Distribution and Movements of the Long-finned Pilot Whale Based on the Distribution of Sighting Data.**

From January throughout April there was little evidence of a disjunct distribution of pilot whale sightings north of 37°00'N lat suggesting that only one species *G. melaena* (the northernmost and most commonly observed) was present in the study area during that period. By March-April most shelf/shelf-edge sightings occurred in southern New England waters, while slope sightings extended from the northern mid-Atlantic northeastward along the outer perimeter of Georges Bank.

The distribution of *G. melaena* was most widespread during May-June. During this period sightings occurred on Georges Bank and in the deeper basins of the Gulf of Maine. The sighting data indicate movement onto shelf and nearshore waters from late-spring through early-summer, a movement pattern also described for *G. melaena* throughout Canada (Sergeant and Fisher 1957; Sergeant et al. 1970; Mercer 1975). These movements may be related to an inshore movement of the short-finned squid (*Illex illecebrosus*) during the warmer months (Sergeant 1961, 1962; Mercer 1975).

The distribution of those *G. melaena* remaining on the shelf (Georges Bank/Gulf of Maine regions) during September-December shifted southward. By the end of December *G. melaena* were not abundant north of 40°00'N lat, and were infrequent in southern New England/mid-Atlantic waters indicating a large-scale movement out of the study area into slope waters during late-autumn/winter. Pilot whales moving into slope waters complete a clockwise gyre to the mid-Atlantic/southern New England regions by the following spring when they again move northward along the shelf-edge/slope interface.

**Distribution and Movements of the Short-finned Pilot Whale Based on the Distribution of Sighting Data.**

By May-June two distinct groups of pilot whale sightings occurred in the
study area—one whose distribution occurred throughout shelf and shelf-edge/slope waters north of 40°00'N lat (G. melaena) and another which remained in mid-Atlantic slope waters below 38°30'N lat. We believe the increased number of pilot whale sightings in mid-Atlantic slope waters between May-December (from Table 9) followed an incursion of G. macrorhynchus into the study area during a northward, seasonal extension of their more tropical range south of Cape Hatteras.

Sightings of G. macrorhynchus occurred in Mid-Atlantic/southern New England slope waters at three locations during July-August (Fig. 11f)—one east of Cape Hatteras, another east of the mouth of Chesapeake Bay, and the northernmost at approximately 39°00'N lat (east of Delaware Bay). The latter concentration potentially represents the northernmost known range extension of any large numbers of G. macrorhynchus in the study area. Strandings of the short-finned pilot whale have occurred as far north as New Jersey (Mead 1975b; Katona et al. 1978).

The short-finned pilot whale was most abundant (and most separated from concentrations of G. melaena) during May-December. Based on this sighting distribution, the short-finned pilot whale did not move onto the shelf (as did the long-finned pilot whale). Rather, G. macrorhynchus remained in the deeper, Gulf Stream influenced slope waters of the mid-Atlantic region. Only 23 pilot whale sightings occurred in shelf/shelf-edge waters of the mid-Atlantic during May-December (from Table 9). However a total of 145 sightings (86% of all mid-Atlantic sightings during these months) occurred in mid-Atlantic slope waters.

The northern limit of G. macrorhynchus sightings continually shifted southward toward Cape Hatteras throughout autumn. By December pilot whale sightings in the mid-Atlantic occurred in slope waters east of Cape Hatteras and by January G. macrorhynchus again moved south of the study area.
We believe that *G. macrorhynchus* are disjunct, both ecologically and seasonally from *G. melaena* in the mid-Atlantic. Payne et al. (1989) suggested that *G. macrorhynchus* are an abundant, regularly occurring seasonal component of the pilot whale community in mid-Atlantic/slope waters.

**Ecological and Management Considerations**

Two causes of *G. melaena* mortality are known to occur in shelf/shelf-edge waters of the northeastern United States, strandings and incidental take in foreign fishery operations.

Between 1973 and 1990, approximately 400 *G. melaena* stranded throughout New England (north of Long Island, data courtesy of Greg Early, New England Aquarium, Boston, MA). Most of these strandings occurred in nine separate 'mass-stranding' events at a limited number of locations in the southwestern Gulf of Maine adjacent to Cape Cod between October and December (Greg Early, New England Aquarium Stranding Network, pers. comm.). The seasonal distribution of *G. melaena* likely facilitates the timing and location of mass-stranding events in this region. Although strandings of individual animals have occurred between Cape Hatteras and Long Island, the mass-strandings north of Long Island represent 95% of the total number of pilot whales which have stranded along the eastern United States since 1973. The overall impact of the mass-strandings on the pilot whale population (based on abundance estimates from CeTAP 1982) appears minimal (Waring et al. 1990).

It is of ecological interest that between 1900 and 1980 approximately fifty percent of known stranding (or potential drive-fishery) events in Massachusetts occurred from June through September (n = 38/71, data courtesy of F. Wenzel, Plymouth Marine Mammal Research Center, Plymouth, Massachusetts). These summer strandings included several mass-strandings of >100 individuals. There have been no mass-stranding events during summer since 1973 (F. Wenzel, pers. comm.).

At present, individual pilot whale strandings in Massachusetts are rare.
during summer. Near-shore sightings of the magnitude necessary to create a mass-stranding or "drive" fishery have not been recorded in recent decades. A comparison of available historical, stranding or "drive fishery" information (Clark 1887) to the present sighting data suggest that the summer distribution of pilot whales, and possibly the abundance, in southern New England/southwest Gulf of Maine waters (those waters adjacent to Massachusetts and Cape Cod) has changed considerably during the latter-half of this century.

The long-finned pilot whale was the most frequently caught marine mammal in east-coast foreign fishing activities between 1977-1988 (Fairfield and Waring 1991; Waring et al. 1990). Most of the pilot whale captures occurred in mid-Atlantic/southern New England shelf-edge waters during March-July (Waring et al. 1990). Since 1984 ninety-three percent of the incidental take has occurred in the Atlantic mackerel fishery (Waring et al. 1990). Based on the co-occurrence of G. melaena and mackerel, the number caught in the nets and examination of stomach contents from several pilot whales caught in the fishery, Waring et al. (1990) suggested that mackerel was an important prey species (not alternate prey as has been suggested for other finfish species, Sergeant 1962; Mercer 1967; Mitchell 1975b) of pilot whales (likely G. melaena) during winter and early-spring.

The long-finned pilot whale has been caught incidental to the pelagic drift-gillnet fishery for swordfish (Earle 1990). The full impact of the incidental take is not yet known.

Harbor Porpoise Phocoena phocoena
Seventy-five percent of all harbor porpoise sightings in the study area (n = 688/921) occurred in the Gulf of Maine between March-October (Table 10). These sightings were distributed into two seasonally disjunct clusters north of 40°00'N lat (Fig. 12). One cluster of sightings occurred, generally, in the upper Gulf of Maine from 42°30'N lat north during late summer-early au-
tumn. The second occurred in the southwestern Gulf of Maine/western Georges Bank waters between 42°30'N and 42°00'N lats from autumn through early spring.

Sightings south of 40°00'N lat were few in number during any season and widely scattered.

**Seasonal Distribution and Movements**

The winter distribution of harbor porpoise is poorly known when compared to other seasons. The number of sightings during January–February (n = 9, Table 10) was significantly less than the numbers which were reported spring through autumn. Prescott and Fiorelli (1980) suggested that harbor porpoise winter on 'offshore' banks. However, no large wintering harbor porpoise concentrations were offshore during the CeTAP/NMFS surveys. Several January–February sightings along the northeastern edge of Georges Bank (Fig. 12a) were individuals possibly moving south from the Bay of Fundy/Scotian Shelf region.

Mid-winter sightings of harbor porpoise in the Gulf of Maine have been reported previously from the Bay of Fundy (Neave and Wright 1968, 1969) to Cape Cod Bay (Mayo 1982). Also, anecdotal sightings in coastal waters south of 42°00'N lat increase during winter and early-spring indicating a southward movement during winter. Harbor porpoise have been observed at the mouth of Delaware Bay (south of Cape May) and inside Chesapeake Bay during winter. Rowlett (1980) also reported harbor porpoise in small numbers from Baltimore Canyon during the winter 1977-1978.

Winter strandings of harbor porpoise have also occurred from New England to Cape Hatteras; and rarely to Florida (reported in Polacheck and Wenzel 1990). Despite the large numbers of harbor porpoise which stranded on Cape Hatteras during a 'severe' 1977 winter (SEAN 1975–1978), Rowlett (1980) considered sightings to North Carolina as being rare. Therefore, at present, we believe that significant concentrations of harbor porpoise occur north of 35°00'N lat (Chesapeake Bay) but that the southern limit of dispersed sight-
ings continues below Cape Hatteras during winter.

The number of harbor porpoise sightings in southern New England/Gulf of Maine waters adjacent to the Great South Channel increased significantly during March-April from the previous 2-month period (Table 10). The largest single sighting (300+ individuals) was reported from the west side of the Great South Channel on 31 March, 1978 (Stone et al. 1983). The distribution of sightings also extended north along the outside of Cape Cod to Cape Cod Bay-Stellwagen Bank, and into the deeper basins of the central Gulf of Maine (Fig. 12b). The general movement of harbor porpoise was northeast through the Great South Channel and into the Gulf of Maine by April, further indicating that a large percentage of the New England harbor porpoise population winters south of the Gulf of Maine.

A total of 691 sightings (seventy-five percent of all harbor porpoise sightings) occurred May-August (Table 10). By May the sightings were distributed, generally, north of 40°30′N lat (most sightings occurred between 40°30′N and 42°30′N, Fig. 12c) indicating that most of the population no longer occurred below the Great South Channel. During June the sighting distribution shifted northward (Fig. 12d). Mercer (1985) stated that harbor porpoise sightings off New Hampshire (Jeffreys Ledge) occurred rarely after June (animals being farther north at that time). By July-August ninety-seven 97% of all harbor porpoise sightings (n = 380/388, Table 10) occurred north of 43°00′N lat in the northern Gulf of Maine/Bay of Fundy (Fig. 12e). Sightings throughout the southwestern Gulf of Maine (Jeffreys Ledge to Stellwagen Bank) and Cape Cod Bay are rare at this time (Fig. 12e). Therefore, the distribution of porpoise completely shifted from the southwest Gulf of Maine-western Georges Bank (spring) to north of 43°00′N lat by July.

Gaskin (1977) indicated that (at this time) the northern Gulf of Maine and the Bay of Fundy might support as much as 80% of the total summer popula-
tion of harbor porpoise south of the Gulf of St. Lawrence. Approximately half of this known population feeds within a radius of 20 miles from the mouth of Head Harbour Passage (western Bay of Fundy). The movements of harbor porpoise into the Bay of Fundy are correlated quite closely with increased water temperatures to 8°C (Gaskin 1977) and with increased abundance of Atlantic herring and mackerel (Smith and Gaskin 1974; Gaskin et al. 1975; Smith et al. 1983; Gaskin and Watson 1985; Read and Gaskin 1985; Recchia and Read 1989).

The distribution of porpoise in the Bay of Fundy was also related to subsurface topography (Gaskin et al. 1975; Watts and Gaskin 1985) particularly the margins of basins and channels in areas of restricted water flow (areas of fish accumulation which the porpoises exploit, Read and Gaskin 1985).

The largest concentrations of porpoise are still north of 43°30'N during September (Fig. 12f), however a significant decrease in the number of sightings occurred throughout the Gulf of Maine/Bay of Fundy during September-October (Table 10) as harbor porpoise moved south during autumn. Sightings became widespread with local concentrations found only near Jeffreys Ledge and Basin (Fig. 12g). Mercer (1985) stated that harbor porpoise were again seen along the coast of New Hampshire from mid-October to late-December. The number of porpoise observed between September-December (Figs. 12f-12h) in the Gulf of Maine do not account for the numbers observed during July-August north of 43°00'N (Table 10). Harbor porpoise possibly move south from the Bay of Fundy-Scotian shelf along the Georges Bank shelf/slope interface, as well as along the western edges of the Gulf of Maine.

Ecological and Management Considerations

It is possible that the distribution and seasonal occurrence of harbor porpoise throughout the study area has shifted in recent decades. Connor (1971) and (Ulmer 1977) reported harbor porpoise (in small groups) in the summer months (during the 1940's) in Lower New York Bay. It is difficult to determine what 'a small number' implied, however harbor porpoise, at present,
are rarely observed in the study area outside the upper Gulf of Maine/Bay of Fundy during summer. Such a seasonally reduced sighting distribution generally implies an overall reduction in abundance, a shift in the distribution, or both.

Also, 120 sightings of harbor porpoise were reported from Georges Bank primarily during May-June (Table 10). All but one of these sightings occurred between 1978-1981. There are several possible explanations for the lack of sightings on Georges Bank during the latter part of the survey period. Between 1981-1988 all Georges Bank survey data were reported from NMFS/NEFC vessels, rather than from aircraft used by CeTAP, 1978-1980. The differences between these two platforms (i.e. height of the observer off the water, angle of observations) would account, at least in part, for the observed differences in the number of sightings (Kraus et al. 1983). Therefore we might expect a possible reduction in the number of harbor porpoise sightings during the shipboard surveys. However, given the thousands of observer days (in suitable sea state to observe porpoise) conducted on Georges Bank during 1981-1988, we cannot accept a complete reduction to zero in the number of reported sightings due solely to platform bias.

Another possible explanation is that harbor porpoise have shifted their distribution inshore (away from Georges Bank) to southern New England/Gulf of Maine waters since the late 1970's-early 1980's. There was a 75% reduction in herring biomass on Georges Bank between 1967-1976 (Sissenwine et al. 1984) and in 1977 the commercial fishery for herring failed completely. There was virtually no evidence of a Georges Bank herring population between 1977-1983, despite hundreds of days of research vessel trawl operations and ichthyoplankton sampling (Sissenwine et al. 1984). We know that harbor porpoise movements are closely correlated with herring. It follows that in response to the complete collapse of a Georges Bank herring stock, harbor porpoise may have
shifted their distribution. We suggest that in response to the complete collapse of a Georges Bank herring stock harbor porpoise shifted their distribution nearshore during the early 1980's (away from Georges Bank) and into coastal southern New England/Gulf of Maine waters.

Several sources of anecdotal or opportunistic sightings also support this hypothesis. Several years of shipboard surveys to Nantucket Shoals during the winter 1991 resulted in more harbor porpoise sightings than were reported in the combined CeTAP/NMFS database for the months January–February, 1978–1988 (D. Wiley, Internationa Wildlife Coalition, Falmouth, Massachusetts and A. Read, Woods Hole Oceanographic Institute, Woods Hole, Massachusetts, pers. comm.). Conversely, CeTAP (1982) reported few sightings from the same region during the aerial overflights. Also, nearshore Gulf of Maine fishermen have suggested that harbor porpoise numbers have increased in recent years. A shift in the distribution of porpoise to coastal/nearshore Gulf of Maine waters would result in increased density (individuals per unit area) and local increases in the abundance of porpoise.

The recent harbor porpoise 'awareness' by fishermen has also been the direct result of increased interactions between the harbor porpoise and the Gulf of Maine/Bay of Fundy bottom-gillnet fishery. It is possible that the number of sightings and the rate of incidental take in this fishery observed by the fishermen have increased as a result of the decreased herring stocks on Georges Bank in the late 1970's followed by a shift in the distribution (and an increased density) of harbor porpoise to nearshore waters of the Gulf of Maine.

The current number of harbor porpoise taken incidental to the gillnet fishery in the Gulf of Maine seems, initially, to be large (Payne et al. 1990b) relative to available estimates of the harbor porpoise Gulf of Maine/Bay of Fundy subpopulation (subpopulation as described by Gaskin 1984).
Read and Gaskin (1988) suggested that harbor porpoise in the Bay of Fundy/Gulf of Maine may be in the initial stages of a decline. Woodley and Read (in press) further suggested that the Gulf of Maine/Bay of Fundy harbor porpoise cannot continue to sustain even moderate levels of incidental mortality. Because of this known (Prescott and Fiorelli 1980; Prescott et al. 1981; Gaskin 1984; Gilbert and Wynne 1983, 1984, 1985, 1988; Read 1990; Read and Gaskin 1988, 1990), but not yet quantified by-catch of harbor porpoise, the Gulf of Maine/Georges Bank gillnet fisheries for Atlantic mackerel (Scomber scombrus) and groundfish spp. were classified as "Category 1" fisheries under the 1988 reauthorization of the Marine Mammal Protection Act (MMPA) (Federal Register 1989). The NMFS/NEFC is presently providing observers to this fishery to determine the extent of the incidental take. Also, comprehensive surveys to estimate abundance of this subpopulation are in progress (Polacheck 1989a, 1989b; Polacheck and Smith 1989; Polacheck and Thorpe 1990) as present estimates of harbor porpoise in the Gulf of Maine (CeTAP 1982; Kraus et al. 1983) are dated and considered inadequate.

Harbor porpoises are also taken in herring weirs in the Bay of Fundy (Smith et al. 1983). However, the apparent impact of this fishery on harbor porpoise appears minimal relative to the gillnet fishery (Smith et al. 1983).

**Beluga DELPHINAPTERUS LEUCAS**

The distribution of beluga is north circumpolar (Sergeant and Brodie 1975; Reeves and Mitchell 1989; Brodie 1990). Although considered rare in the study area at least 24 "extralimital" sightings of beluga have been observed from the Canadian maritimes south to New Jersey (Connor 1971; Fisher and Sergeant 1954; Goode 1884; Mairs and Scattergood 1958; Sergeant and Fisher 1957; Waters and Rivard 1932; Reeves 1976b) since the early-1900's (summarized in Reeves and Katona 1980). Many of these sightings involved several individuals who remained in the sighting area for extended periods of time (several
days to nearly 2 months).

**Seasonal Distribution and Movements**

There were five sightings (four of these are possibly the same individual) of beluga reported by CETAP (1982). Most of these occurred off the southern coast of Long Island between March and June.

The southernmost subpopulation of beluga occur in the St. Lawrence (Finley et al. 1982; Pippard 1985; Sergeant and Hoek 1988; Sergeant 1986). Sergeant and Brodie (1975) and Sergeant et al. (1970) suggested that beluga from this isolated subpopulation enter the Gulf of Maine/Bay of Fundy region by following the cold Gaspe Current around the coast of Cape Breton, Nova Scotia.

**Ecological and Management Considerations**

A large proportion of beluga sightings in New England were of individuals captured in herring wiers (Reeves and Katona 1980) suggesting that, at least for the period of time they were in New England waters, beluga may have been feeding on schools of herring or mackerel.

There have been no strandings of beluga along the eastern seaboard (Reeves and Katona 1980) in spite of the numerous inshore sightings south of the expected range of this species. Therefore, Reeves and Katona (1980) suggested that beluga need not be adversely affected by extended stays in New England, considerably southward of their normal range.

**Sperm Whale Physeter macrocephalus**

Sperm whales have the most extensive distribution of any large whale (Gosho et al. 1984; Rice 1990). In the northwest Atlantic they are found in deepwater basins of the Caribbean and Gulf of Mexico (Schmidly 1981; Gunter 1954; Collum and Fritts 1985; Watkins et al. 1985) north to northern Canada, the Davis Straits, Iceland and waters west of Jan Mayan and Norway (Mitchell 1975c; Sigurjonsson et al. 1989; Leatherwood et al. 1976; Reeves et al. 1986; Winn et al. 1979; Rice 1990). Their upper latitudinal limit is age/sex relat-
ed and is roughly 40°00'N during mid-winter with seasonal shifts north in summer. Their winter distribution (and summer distribution of females with calves) corresponds approximately with the 15°C sea surface isotherm (Rice 1990). During summer the large males move the farthest north (to approximately 70°00'N lat, Gosho et al. 1984). Large males were the only whales taken by shore stations in Nova Scotia (Mitchell and Kozicki 1984).

The distribution of sperm whale sightings in the study area was centered in slope waters between 35°00'N-39°00'N lats throughout the year (Fig. 13). Eighty-two percent (n = 340/413 sightings, Table 11) occurred in slope waters. The shelf-edge/slope interface represented the nearshore distributional limit of sightings for this species throughout much of the year. Limited shelf-sightings occurred in southern New England waters (Table 11) between Hudson Canyon and the Great South Channel, and in deep Gulf of Maine basins inside the Northeast Channel (Fig. 13).

Sperm whale sightings in slope waters beyond the seaward limits of the study area are considered common. However, sperm whale sightings in slope waters are not randomly distributed. During the NMFS/NEFC Gulf Stream survey, August 1990, sperm whales were abundant along the northern edge of the Gulf Stream in 27-29°C waters. There was a noticeable gap in the distribution of sightings between the shelf-edge/slope interface and the northern edge of the Gulf Stream during this survey.

**Seasonal Distribution and Movements**

Sperm whale sightings were sporadic in slope waters along the outer edge of the study area during January-February (Fig. 13a). Only five percent (n = 22/413) of the sperm whale sightings occurred during this 2-month period (21 of these occurred in slope waters, Table 11). The largest concentration of sightings occurred in slope waters east of Cape Hatteras (Fig. 13a). The greatest abundance for this species at this location throughout the year also
occurred during January-February (CeTAP 1982). These sightings indicate that during January-February most sperm whales are still in slope waters seaward of the study area and movement into the study area occurs at that location at that time.

The number of sperm whale sightings increased significantly during March-April (Table 11). Eighty-two percent (n = 71/87) of all March-April sightings occurred in southern New England/mid-Atlantic slope waters (Table 11) in 2 noticeable concentrations—one from Cape Hatteras north to Hudson Canyon, and another in slope waters below the Great South Channel (Fig. 13b). An obvious gap in the sperm whale sighting distribution existed between these two concentrations (Fig. 13b) and only 4 sperm whale sightings occurred in Georges Bank slope waters at this time. Shelf sightings during March-April were limited to the mid-Atlantic shelf/edge (n = 11/12 shelf sightings, Table 11).

From May-August 48 sperm whale sightings occurred in Georges Bank slope waters (Table 11) indicating a northward shift in the distribution of sperm whales during summer (Figs. 13c-13e). This was approximately 21% of the total number of sperm whale sightings during this period, and 83% of all sightings which occurred in Georges Bank slope waters throughout the year (n = 48/58, Table 11). Correspondingly, the maximum abundance of sperm whales below Georges Bank was recorded by CeTAP (1982) during this period.

There was also an increase in mid-Atlantic slope sightings during July-August (Table 11). The largest concentrations of sperm whale sightings during July occurred in slope waters between 37°00'N and 39°00'N lats (Fig. 13d). Sperm whales still appeared to be entering the study area as far south as Cape Hatteras. By August the slope water distribution of sperm whales extended northward towards Corsair Canyon, Georges Bank (Fig. 13e).

During September-October the number of sperm whale sightings in mid-
Atlantic and Georges Bank slope waters decreased from September-October levels (Fig. 13f, Table 11). Approximately sixty-seven percent (n = 27/44 of the total number of sightings, Table 11) occurred in southern New England waters indicating, we believe, a continued clockwise movement of sperm whales east/northeast from the mid-Atlantic into southern New England waters, and east from Georges Bank slope waters out of the study area.

Sperm whale sightings were most numerous on the shelf from July-October. Approximately 87% of all shelf sightings of sperm whales (n = 34/39) occurred during this period primarily in southern New England waters (Table 11) between Montauk Point, Long Island and the Great South Channel (Figs. 11d-11f). Sperm whales occurred predictably in this location during these months. The greatest abundance of sperm whales in southern New England shelf waters also occurred at this time (CeTAP 1982). Sperm whales may move onto the southern New England shelf in response to warmwater intrusions, followed by increased prey (squid spp.) densities.

Sperm whale sightings also occurred predictably in the Gulf of Maine (Georges Basin) and in the Northeast Channel along the southern edge of Browns Bank from late-summer through November. Ninety percent of all Gulf of Maine sperm whale sightings (n = 10/11, Table 11) occurred inside the Northeast Channel from July-December. Historically a whaling fishery based out of Nova Scotia targeted on sperm whales in slope waters seaward of the Northeast Channel, May to December (Mitchell 1975c; Sutcliffe and Brodie 1977; Mitchell and Kozicki 1984). Sperm whale sightings in the upper Bay of Fundy are considered rare (McAlpine 1985).

During November-December sightings were reduced in number and occurred either in mid-Atlantic slope waters, or in southern New England shelf waters (Table 11, Fig. 13g).
Pygmy and Dwarf Sperm Whales *Kogia* spp.

The ranges of the pygmy sperm whale *Kogia breviceps* and the dwarf sperm whale *K. simus* completely overlap in waters of the eastern United States and the Gulf of Mexico (Handley 1966; Schmidly 1981; Caldwell and Caldwell 1990). Neither species are known from polar waters and strandings do not indicate any seasonal shifts in distribution (Caldwell and Caldwell 1990). These have been considered rare, offshore species but the stranding records indicate otherwise. Most strandings occur in Florida and strandings of *K. breviceps* outnumber those of *K. simus* by a factor of several times (O'dell et al. 1985). However Schmidly (1981) suggested that, due to misidentifications, some of the old records of *K. breviceps* are likely to be *K. simus*. Sightings are rare however available sighting data suggests that the Gulf of Mexico and Caribbean may constitute significant proportions of the range of the pygmy *K. breviceps* and dwarf sperm whales *K. simus* (Leatherwood et al. 1976; Loehoefer et al. 1980).

Only one sighting of *Kogia* spp. occurred within the study area during the standardized surveys. This sighting occurred in slope waters (>1000 ft) on 8 June 1981 east of Delaware Bay (CeTAP 1982). Strandings of *Kogia* have occurred north to at least Nova Scotia (Sergeant et al. 1970).

Beaked Whales Spp.

Four species of *Mesoplodon* beaked whales (True’s beaked whale *M. mirus*, Antillean beaked whale *M. europaeus*, Blainville or dense-beaked whale *M. densirostris*, and North Sea beaked whale *M. bidens*) are known from strandings between Cape Hatteras and Newfoundland (Allen 1906, 1939; Andrews 1914; True 1910, 1913; Raven 1937, 1942; Ulmer 1941; Brimley 1943, 1945; Moore 1966, 1968; Sergeant and Fisher 1957; Sergeant et al. 1970; Mead 1975b, 1990a; Leatherwood et al. 1976; Reeves and Ulmer 1976; Banefield 1977; Ulmer 1977; Katona et al. 1978; Dix et al. 1986; Houston 1990a, 1990b; Mead 1990a; Lien and Barry 1990; Lien et al. 1990). The Antillean beaked whale is the species
which strands most commonly along the eastern coast of North America, primarily south of Cape Hatteras (Mead 1990a). The dense-beaked whale has the widest distribution (based on stranding data) of these *Mesoplodon* species (Houston 1990a; Mead 1990a). Most of these beaked whale species extend their range south into the Gulf of Mexico and Caribbean (Ulmer 1947; Gunter 1954, 1955; Moore 1953, 1958, 1966; Golley 1966; Caldwell 1964; Erdman et al. 1973; Schmidly 1981).

The goose-beaked whale or Cuvier's beaked whale *Ziphius cavirostris* is the most cosmopolitan of the beaked whales (from stranding records, Heyning 1990; Mead 1990a). It occurs within the study area (True 1910; Backus and Schevill 1961; CeTAP 1982) south into the Caribbean and Gulf of Mexico (Caldwell and Caldwell 1971; Erdman et al. 1973; Schmidly 1981; Mead 1990a).

All beaked whale species are known to prey upon squid *spp.* (Mitchell 1975a; Mead 1990a) and, although seasonal movements not well known, it is likely that they move in slope waters which seasonally get progressively warmer (Carter et al. 1981; Price and Fairfield 1985). The considerable stranding data and limited sighting data indicate that beaked whales are abundant in slope waters generally seaward of the study area.

**Seasonal Distribution and Movements**

Forty beaked whale sightings (recorded primarily *Mesoplodon spp.*) were observed (Table 12, Fig. 14). Seventy-seven percent (*n = 31*) occurred in slope waters (average depth at-sighting >1000 ft, from CeTAP 1982) during summer and autumn. One sighting (3 individuals) was photographed from a NMFS research vessel on 9 June 1979 south of Hudson Canyon at 39°19'N lat-72°09'W long (reported in Hain et al. 1981). These individuals were tentatively identified (from the photographs) as *M. densirostris*.

CeTAP (1982) also reported 6 sightings (16 individuals) of the goosebeaked or Cuvier's beaked whale. All but one of the sightings were reported from
shelf-edge/slope waters between the Great South Channel and Cape Hatteras (average depth >500f, from CeTAP 1982). Two sightings, one on 23 October 1979 along the shelf edge east of Cape Hatteras (reported in Hain et al. 1981) and the second on 9 July 1988 below Lydonia Canyon, consisted of a mother and a calf/juvenile (author PMP, personal observation). The locations and average at-sighting water temperature of 24.5°C for three of the *Ziphius* sightings (CeTAP 1982) are consistent with the slope and known temperate to tropical water distribution of this species.

CeTAP (1982) also recorded two rare sightings of the Northern bottlenosed whale *Hyperoodon ampullatus* in the study area, one on 30 May 1980 along the shelf edge east of Georges Bank and another on 12 June 1981 east of Delaware Bay in waters >1000f and >700f respectively, consistent with their known deepwater distribution. However, the distribution of *H. ampullatus* in the western North Atlantic generally extends in deepwater from just south of Sable Island, Nova Scotia in an area called the "Gully" to northern Labrador and Greenland (Benjamin and Christensen 1979; Mead 1990b). Mitchell and Kozicki (1975a) also reported a bottlenose whale stranding in the Bay of Fundy.

**Ecological and Management Considerations**

Twelve beaked whale were killed incidental to the swordfish driftnet fishery of the eastern United States during the summer 1989 (Earle 1990). These were later identified as North Sea beaked whale *M. bidens* from lower jaw specimens. During August 1990 NMFS/NEFC initiated a series of surveys to the northern edge of the Gulf Stream to monitor the occurrence of beaked whale *app.* relative to the extent of the incidental take in the driftnet fishery. Beaked whales (several *Mesoplodon* species and *Ziphius*) were observed frequently along the northern edge of the Gulf Stream (sea surface temperatures 28°C-29°C and depths >2000f) during that survey.

**Minke Whale Balaenoptera acutorostrata**

Minke whale sightings occurred over wide regions of the shelf but were
most abundant north of 40°00'N lat in regions of high bottom-relief (Fig. 15). This tendency for minke whales to concentrate near edges of banks, or rapidly changing bottom topography is characteristic of this species throughout the northwest Atlantic (Sergeant 1963; Winn and Perkins 1976; Perkins and Whitehead 1977; Larsen 1981; Lynch and Whitehead 1984; Stewart and Leatherwood 1985; Piatt et al. 1989). Over ninety percent of all minke whale sightings in the study area occurred in shelf waters north of the mid-Atlantic region (n = 712/758, Table 13).

CETAP (1982) suggested that minke whale densities were greatest in a U-shaped area which extended east from Montauk Point, Long Island, southeast of Nantucket Shoals to the Great South Channel, then northward along the 50f contour outside Cape Cod to Stellwagen Bank and Jeffreys Ledge (Fig. 15). Most minke whale sightings occurred in the Gulf of Maine (n = 497, Table 13). Minke whale sightings were also abundant from the Great South Channel northeast along the northern edge of Georges Bank. Minke whale sightings below below Hudson Canyon (below 40°00'N lat) were infrequent. Only 22 sightings (<1% of all sightings) occurred in mid-Atlantic shelf waters (Table 13). Minke whale sightings inside, and east of Chesapeake Bay, have been reported (Schwartz 1962; Rowlett 1980) but were considered uncommon.

Seasonal Distribution and Movements
During January-February minke whale sightings were rare (Table 13). Several occurred in southern New England nearshore waters (<15f) and in mid-Atlantic waters (Table 13), generally from mid-shelf to the 50f contour (Fig. 15a). The paucity of sightings during January-February suggest that minke whale shelf abundance is possibly reduced during that period.

The number of minke whale sightings increased in southern New England shelf waters (Table 13) east of Long Island during March-April (Fig. 15b). Eighty-three percent of all minke whale sightings in slope waters during
March—April (n = 10/12, Table 13) also occurred in southern New England waters (Fig. 15b) suggesting a seasonal movement onshelf between the Hudson Canyon and Georges Bank. An increased number of sightings also occurred in the Gulf of Maine generally along the 50f contour from the western flank of the Great South Channel to Jeffreys Ledge (Fig. 15b).

The number of minke whale sightings increased significantly west of 72°00'W Long during May-June (Fig. 15c). The sighting distribution in the Gulf of Maine shifted northwest from Stellwagen Bank/Jeffreys Ledge along the 50f contour into the northern Gulf of Maine. Also, the number of sightings in southern New England/Georges Bank waters (near the Great South Channel) increased significantly during May-June (Table 13). Most May-June sightings below 40°00'N lat were concentrated in shelf/shelf-edge waters near Hudson Canyon (Fig. 15c).

By July-August (Fig. 15d) the sighting distribution in the western Gulf of Maine extended north into the Bay of Fundy. The scattered sightings on Georges Bank (during May-June) congregated on the Northeast Peak in July-August (Fig. 15d). Also the May-June southern New England/Georges Bank shelf-edge sightings were fewer in number at this time. Instead a string of mid-shelf sightings extended from Montauk Point, Long Island below Nantucket Shoals and the Great South Channel (Fig. 15d). These sighting data indicate that movement onto the shelf during July-August was complete, and that minke whales continued a clockwise movement east-northeast from southern New England waters throughout the Gulf of Maine.

From September-October to November-December there was a significant decrease in the number of sightings throughout the Gulf of Maine/Bay of Fundy (Table 13). CoTAP (1982) considered winter sightings southeast of Nantucket (south of 40°00'N) as rare further indicating an overall decrease in abundance throughout shelf waters of the study area. Sightings outside the Gulf of
Maine at this time were uncommon. Approximately ninety percent (n = 167/188, Table 1) of all September-December sightings occurred in a patchy continuum along the western margins of the Gulf (Figs. 15e-15f). Throughout the year minke whales were sympatric with fin whales *Balaenoptera physalus*. During winter minke whales may move offshore into deeper shelf-edge/slope waters (a seasonal movement pattern suggested for fin whales by Leatherwood et al. 1976) resulting in the decreased seasonal abundance observed by CeTAP (1982).

**Ecological and Management Considerations**

Minke whales are the only baleen whale for which partitioning of habitat (exclusive adjoining feeding ranges in individually-identified whales) has been demonstrated (Dorsey 1983; Dorsey et al. 1990). The distribution of minke whales in the northwest Atlantic has often been related to their prey (Jonsgard 1951, 1982; Sergeant 1963; Mitchell 1974a, 1975b; Mitchell and Kozicki 1975b; Whitehead and Carscadden 1985). Edds and MacFarlane (1987) thought that habitat partitioning may also be a function of prey density or overall prey abundance.

**Fin Whale *Balaenoptera physalus***

Fin whales are a wide-ranging species throughout the North Atlantic summering from the eastern coast of North America north to the Arctic, Greenland, Iceland and northeast above Norway to the Barents Sea and Spitzbergen (Jonsgard 1966a, 1966b; Mitchell 1974b, 1975d; Leatherwood et al. 1976; Sergeant 1966, 1977; Mizroch et al. 1984a; Gambell 1985a). In the western North Atlantic they winter from the ice-edge south into the Gulf of Mexico and Caribbean (Schmidly 1981; Gambell 1985a).

Fin whales were present during all seasons (at some level of abundance) in southern New England shelf waters from Delaware Bay to the shelf-edge, from the New York Bight southeast to the Hudson Canyon/slope interface and from Montauk Point east to Cox Ledge (and below Martha’s Vineyard). Fin whale densities were the greatest in the Gulf of Maine primarily from the base of
the Great South Channel (including inside the V-shaped basin of the Great South Channel formed by the 50f contour) northwest along the 50f contour into the southwestern Gulf of Maine over Stellwagen Bank to Jeffreys Ledge (Fig. 16). Sixty-nine percent \( (n = 2,259/3,291 \text{ sightings}) \) of all the sightings occurred within the Gulf of Maine (Table 14) primarily in the latter area. The distribution of sightings shifted clockwise from the Great South Channel-Stellwagen Bank region in spring, to the northern Gulf of Maine-Bay of Fundy region mid-summer, then onto the Scotian Shelf and northeast peak of Georges Bank from mid-summer through November. These seasonal movements have also been demonstrated for individual fin whales (Mattila et al. 1983; Agler et al. 1990; Seipt et al. 1990).

Concentrations of fin whales (with seasonal shifts in abundance from region to region) also occurred along the shelf-edge (between the 50-100f contours) from 36°00′N lat north around the 50f perimeter of Georges Bank (Fig. 16). However, only 4% of all fin whale sightings \( (n = 128/3,291) \) occurred in slope waters, approximately one-half of these \( (n = 63) \) occurring seaward of the southern New England shelf-edge (Table 14).

Fin whales were conspicuously absent (or sightings are very much reduced in numbers) in coastal waters below 40°00′N lat (except the mouth of Chesapeake Bay) and directly east of Cape Hatteras (Fig. 16). Approximately 6% \( (n = 197) \) of all sightings occurred in mid-Atlantic waters (Table 14). Fin whale sightings were also recorded in low numbers from the central portion of the Gulf of Maine and the central, shoals-portion of Georges Bank, Nantucket Shoals (Figure 16).

**Seasonal Distribution and Movements**

Only 2% of all fin whale sightings \( (n = 70/3,291 \text{ from Table 14}) \) occurred during January-February. Although reduced in number, these sightings were widely distributed, generally occurring in local concentrations within each
region of the study area (Fig. 16a). Noticeable concentrations were located in mid-Atlantic/southern New England waters. Relative abundance levels outside Delaware Bay increased winter and early spring (CeTAP 1982). CeTAP (1982) suggested that this area was very important to fin whales during winter.

During January-February fin whales also occurred in the southwestern Gulf of Maine from Stellwagen Bank to Jeffreys Ledge, and along the northern edge of Georges Bank (Fig. 16a). Mid-winter densities of fin whales were greatest in the southwest Gulf of Maine, principally on Stellwagen Bank and in the Great South Channel (MBO 1988).

The number of fin whale sightings throughout the study area during March-April was significantly greater than that observed during January-February (Table 14). These increases occurred along the shelf-edge from Norfolk Canyon north to Lydonia Canyon, and in southern New England (east of Montauk Point) and Gulf of Maine waters. The number of mid-Atlantic sightings peaked during March-April then decreased steadily throughout the remainder of the year, Table 14). The largest concentrations of fin whales at this time occurred in the southwest Gulf of Maine along the 50f contour (Fig. 16b).

During May-June the distribution of sightings shifted northward away from the mid-Atlantic (Fig. 16c). Between Cape Hatteras and 40°00′N lat (generally north of 37°30′N lat) fin whale concentrations occurred only southeast of the Delaware Bay (mid-shelf inside the 50f contour), along the Hudson Canyon (inside the 50f contour) and east of Montauk Point, Long Island (Fig. 16c). Rowlett (1980) also noticed an increase in the abundance of fin whales during early-spring outside the Chesapeake Bay in response, he believed, to increased mackerel densities.

By May-June, seventy-seven percent of all fin whale sightings (n = 903/1,170, Table 14) occurred in the Gulf of Maine primarily from the Great
South Channel northwest to Jeffreys Ledge. The distribution of fin whale sightings continued to shift northeast during July-August (Fig 16d). There was a large increase in the number of sightings in the southern New England region during July-August (Table 14) from Montauk Point east to below Martha's Vineyard (Fig. 16d) concurrent with a continued decrease in the number of sightings in the mid-Atlantic. The southern limit of noticeable concentrations during July-August occurred along the shelf-edge southeast of Delaware Bay.

Fin whale sightings also increased in the northern Gulf of Maine-Bay of Fundy during July-August. The cluster of fin whale sightings which occurred along the 50f contour of northwest Georges Bank during May-June (Fig. 16c) dispersed, either shifting northwest along the western margin of the Gulf of Maine, or east along the northern edge of Georges Bank to the Northeast Peak/Scotian Shelf (Fig. 16d).

A significant decrease in the number of fin whale sightings (by approximately 50%) occurred throughout the study area during September-October (Table 14). During this period only 33 fin whale sightings occurred in the southern New England region, a decrease of nearly 85% in this region from July-August. At this time most fin whale sightings occurred northeast of a line extending from the New York Bight to the Hudson Canyon (Fig. 16e). The large concentration of fin whale sightings which occurred east of Montauk Point from March through August was no longer present. Also, the concentration of sightings in the Bay of Fundy was no longer present. The northern limit to large fin whale aggregations in the Gulf of Maine extended north only to Jeffreys Ledge (Fig. 16e).

Fin whale abundance decreased dramatically during autumn (CeTAP 1982). Sightings were limited, generally, to the southwest Gulf of Maine and the northern edge of Georges Bank by November (Fig. 16f). The large number of fin
whale sightings which occurred from the Northeast Peak south along the Georges Bank shelf-edge mid-summer through October (Figs. 16d-16e) were no longer present (Fig. 16f). Leatherwood et al. (1976) suggested that many fin whales may move offshore during late-autumn and winter.

**Ecological and Management Considerations**

The most obvious ecological and management consideration with regards to fin whales in shelf waters of the northeastern United States is their potential impact as predators, and/or competitors, in the system. In terms of biomass, fin whales are the dominant cetacean species within the study area comprising between 31% (autumn) and 47% (winter) of the total cetacean biomass (Scott et al. 1963; Kenney et al. 1985). Since the largest aggregations of fin whales are found north of 40°00'N lat (generally in the southwest Gulf of Maine and southwestern Georges Bank), and since the Gulf of Maine-Georges Bank systems are distinguished from the southern New England-mid-Atlantic regions by the relatively high-use of the Gulf of Maine by baleen whales, these biomass estimates (therefore consumption estimates) are much greater in the Gulf of Maine (exceeding 50% of total whale biomass during several seasons) than for the entire study area.

During 1986-1987 the number of fin whale sightings in mid-shelf/shelf-edge waters from the northern edge of Georges Bank to the Hudson Canyon was greater (as compared to a more typical pattern of abundance in 1984-1985) (Figs. 16g-16h). Concurrent to this increase the number of fin whale sightings in the southwest Gulf of Maine (Stellwagen Bank) declined during 1986 and 1987 (Payne et al. 1990c). Concurrent to the mid-summer decrease in the number of fin whales in the southwest Gulf of Maine, the number of fin whale sightings we believe that the increased number of sightings in southern New England waters during 1986-1987 were the result of a noticeable decline in sand lance on Stellwagen Bank (Bowman et al. 1984; Nelson and Ross 1989, 1991) during the same period and a subsequent small-scale shift in the distribution of fin
whales to the south and southeast. During 1988 sand lance abundance on Stellwagen Bank was at a regional maxima (data from Nelson and Ross 1989) and fin whale numbers on Stellwagen Bank were comparable to pre-1986 levels (Payne et al. 1990c).

**Blue Whale Balaenoptera musculus**
In the western North Atlantic blue whales occur regularly from the Gulf of St. Lawrence, and off eastern Nova Scotia and southern Newfoundland (Mansfield 1985; Sergeant 1953, 1966; Mitchell 1975d; Sears et al. 1987, 1990).

Historical records of blue whale strandings in the study area (many now re-identified as fin whales) were reported by Allen (1916). Neave and Wright (1968) reported blue whale sightings from the Bay of Fundy. However the validity of these sightings was questioned by Schevill (1968) indicating the rarity of the species in the Gulf of Maine.

**Seasonal Distribution and Movements**
During August 1980 CeTAP (1982) reported 2 blue whales on the Scotian shelf-edge 70 miles southeast of Cape Sable, Nova Scotia. However the first confirmed sighting of a blue whale in the Gulf of Maine occurred north of Race Point, Cape Cod (42°07'N-70°22'W) on 4 October 1986 (Wenzel et al. 1988). This whale was also reported the following day approximately 10km north of the original position (Fig. 17).

The following spring, on 18 May 1987, three blue whales were observed at 41°18'N-68°42'W from a NMFS/NEFC research vessel on northwest Georges Bank (Fig. 17). On 29 July 1987 another blue whale was observed on southwest Georges Bank at 40°38'N-68°04'W. The latter whale was observed near several right whales *Eubalaena glacialis* and basking sharks *Cetorhinus maximus*. A blue whale reported southeast of Cape Ann, Massachusetts on 9 August 1987 was resighted on 11 August north of Race Point, Massachusetts (42°14'N-70°20'W). Yet another blue whale was observed east of Nauset Beach, Cape Cod (41°48'N-
69° 45'W) on 30 August 1987. There were no blue whales sighted in the study area between 1988-1990.

Ecological and Management Considerations
Blue whales feed almost exclusively on euphausiids (Jonsgard 1955, 1966a; Nemoto 1957, 1959; Mitchell 1975d; Mizroch et al. 1984b; Yochem and Leatherwood 1985); however they also take copepods of the genus *Calanus* (Nemoto 1970; Kawamura 1980). The influx of blue whale sightings throughout the southern Gulf of Maine during the summer 1986 and 1987 co-occurred with an increased abundance of *C. finmarchicus* and an increased number of right and sei whale *B. borealis* (Payne et al. 1990c) sightings in the Gulf of Maine, species which feed in a similar manner and on similar prey types.

The blue whale sightings during 1986-1987 indicated a dramatic change in the distribution of this species. It confirmed the hypothesis of CeTAP (1982) that seasonal movements of blue whales occurred in near proximity to the study area, likely in slope waters. Also, the whale identified on 9 and 11 August was photographed previously in the Gulf of St. Lawrence (from comparisons of photographs taken at-sighting with those found in Sears et al. 1987, 1990) further suggesting a single population in the northwest Atlantic.

**Sei Whale* Balaenoptera borealis**
Sei whales in the northwest Atlantic may consist of two stocks (Mitchell and Chapman 1977; Mizroch et al. 1984c; Gambell 1985b), one centered in the Labrador Sea and another with its center of abundance off eastern Nova Scotia. Southern New England shelf-edge/slope waters are presently considered the southern limit of the feeding range for the latter stock of this species.

Sei whale sightings generally occurred north of 40°00'N lat (Fig. 18). The sighting distribution centered around the perimeter of Georges Bank from the base of the Great South Channel between the 50f-1000f contours, north along the shelf-edge/slope interface through the Northeast Channel into the deeper basins of the Gulf of Maine (Fig. 18). Also eighty-two percent of all
sei whale sightings reported during these surveys occurred April-August, indicating a strong seasonal movement onto the southern New England/Georges Bank shelf-edge at that time. Sightings throughout the remainder of the study area were scattered and infrequent.

Occasional strandings have also been reported (Mead 1977).

**Seasonal Distribution and Movements**

Mid-winter sei whale sightings are rare. There were no sightings of sei whales reported in the study area from November through January 1978-1988, and only four sightings February-March. The number of sei whale sightings increased in April, and then only at the base of the Great South Channel (Fig. 18a).

Most May-August sei whale sightings occurred north of 40°00’N lat along the Georges Bank shelf-edge/slope interface northeast to the Northeast Peak and Scotian shelf (Fig. 18b). The number of sei whale sightings increased throughout southern New England shelf regions, indicating a movement onto the shelf north of Hudson Canyon during this period (Fig. 18b). Sei whale sightings were generally absent from mid-Atlantic shelf/slope waters (n = 4/86 sightings, Table 15).

Sei whales arrived on Georges Bank during May-June, then move into the Gulf of Maine through the Great South Channel and the Northeast Channel. Also, sei whales moved northward from Georges Bank shelf-edge/slope waters onto the Scotian Shelf in June (Mitchell 1974b; Mitchell and Chapman 1977). This sighting distribution followed the intrusion of warmwater around the northern edge of Georges Bank and onto the Scotian Shelf.

By September the number of shelf sightings decreased significantly (Table 15). The largest concentrations of sei whales at this time generally occurred from the Northeast Channel northeast onto the Scotian Shelf (Fig. 18c). From mid-September to mid-November the number of sei whales on the Scotian Shelf
also decreased as the whales moved offshore and southward (Michell and Chapman 1977).

Sei whales have been reported from the Bay of Fundy (Neave and Wright 1968) although they are not considered common in this region (Mitchell and Chapman 1977; Kraus and Prescott 1981; 1982).

Ecological and Management Considerations

Sightings of sei whales in the southwestern Gulf of Maine and Cape Cod Bay are very rare during any season (Mayo et al. 1988). Watkins and Schell (1979) reported sei whales feeding off Cape Cod in 1975, and Mayo et al. (1988) recorded only a single whale in thousands of survey cruises conducted in Cape Cod Bay and on Stellwagen Bank between 1978 and 1985. Mercer (1985) reported multiple sightings of 3 sei whales in Ipswich Bay (western Gulf of Maine) during September, and another sei whale on Jeffreys Ledge in October 1985. Then, during the summer 1986, sei whale numbers increased dramatically in the southwest Gulf of Maine (Weinrich et al. 1986; Mayo et al. 1988; Payne et al. 1990c), moving through the Great South Channel and onto Stellwagen Bank. Mayo et al. (1988) reported 351 sightings of 38 individually identified sei whales between June-October 1986 (not reported from NMFS/NEFC surveys) and mother-calf pairs were commonly observed (Weinrich et al. 1986). The occurrence of sei whales in 1986 was followed by an equally dramatic decline during 1987 and 1988.

Sei whales will prey on small schooling fishes, but feed principally on Calanus species in all oceans (Omura and Nemoto 1955; Nemoto 1959; Kawamura 1973, 1974; Rice 1977; Gambell 1985b). The increase in sei whale abundance in the Gulf of Maine co-occurred with a regional maximum abundance of C. finmarchicus (Payne et al. 1990c), a preferred prey of sei and right whales in the northwest Atlantic (Mitchell 1975d, 1975e; Jonsgard and Darling 1977; Mitchell and Chapman 1977; Watkins and Schell 1979; Winn et al. 1986) and a regional low level of sand lance, a potential competitor with sei (and right whales) for
copepods.

Jonsgaard and Darling (1977) described "invasion years" where unusually large numbers of sei whales occur in an area. Kapel (1985) also described an "invasion year" by sei whales which was associated with an increase in surface water temperatures. These years are generally followed by an equally sharp decrease in the number of whales in the same area. An invasion year in response to increased prey abundance accurately describes the occurrence of sei whales on Stellwagen Bank during 1986.

Payne et al. (1990c) hypothesized that competition between sei whales and plantiverous finfish for similar prey in the Gulf of Maine (copepods) has influenced the present distribution of the sei whale in the study area. Although sei whales have the ability to forage on fish (Nemoto 1959; Nemoto and Kawamura 1977) they have not exploited the superabundant sand lance in the Gulf of Maine. By remaining at the shelf-edge/slope interface sei whales subsist, possibly, on planktonic (euphausiids and copepods) and possibly fish prey, they might minimize the effect of competition from sand lance for copepods which could occur in Gulf of Maine shelf waters.

Bryde's Whale Balaenoptera edeni

Bryde's whales prefer warmer water temperatures than fin whales (Tershy et al. 1990) and have a more tropical and subtropical distribution than other Balaenoptera species (Best 1975; Ivashin 1980; Cummings 1985a). They possibly follow warm-water currents (Nishiwaki 1967; Omura 1977) and are limited by the 20°C isotherm (Omura 1977). Ivashin (1980) considered a western Atlantic population to occur in the Gulf of Mexico, Caribbean Sea and waters of the southwest North Atlantic.

Seasonal Distribution and Movements

There have been no Bryde's whale sightings reported from the study area. Mead (1977) reported one stranding from within the Chesapeake Bay (incorrectly
reported by Miller (1927) as a sei whale. Otherwise, strandings and sightings along the eastern coast of the United States have occurred south of Cape Hatteras (south of 33°00'N lat, Mead 1977) and into the Gulf of Mexico (Schmidtly 1981).

**Humpback Whale* Megaptera novaeangliae**


Although discrete stocks have been suggested in feeding areas of the northwest Atlantic, Mattila et al. (1989) and Mattila and Clapham (1989) present evidence for both spatial and genetic mixing of these different feeding stocks in the wintering grounds. The major winter concentrations of humpback whales in the northwest Atlantic occur along the Antillean chain in the West Indies, principally on Silver and Navidad Banks, north of the Dominican Republic (Winn et al. 1975; Balcomb and Nichols 1978; Whitehead and Moore 1982; Hay 1985a; Mattila and Clapham 1989; Mattila et al. 1987, 1989). Smaller concentrations of whales are scattered from Mona Passage, Puerto Rico (Mattila 1983, 1984; Martin et al. 1984), Samana Bay, Dominican Republic (Mattila and Clapham 1989) throughout the Lesser Antilles, from Virgin Bank in the northwest to the Gulf of Paria in the southeast (Erdman et al. 1973; Levenson and Leapley 1978; Mattila and Clapham 1989).

The migratory route between regions of winter breeding and summer feeding in the northwest Atlantic occurs in deeper, slope waters off the continental
Several possible offshore routes between these winter and summer areas have been suggested (Katona et al. 1980; Martin et al. 1984; Stone et al. 1987). Furthermore, Stone et al. (1987) identified individuals from Bermuda which are members from all the feeding and wintering grounds occurring in proportions relative to the size of the feeding and wintering samples; thus some of the whales that winter together on Silver Bank and at Puerto Rico are still together during spring migration past Bermuda. Therefore the summer feeding stock identities might develop only after humpbacks have passed Bermuda on their migration north (Stone et al. 1987). Stone et al. (1987) further suggested that Bermuda might be an opportunistic feeding area as humpbacks move north to preferred feeding areas.

Seasonal Distribution and Movements

Within the shelf waters of the northeastern United States humpback whales have a restricted distribution (Fig. 19). Although a few sightings occurred in the mid-Atlantic (n = 12/1,472, Table 16), this species generally occurred north of 40°00’N lat in several well-defined concentrations. The largest number of humpback whale sightings occurred in the Gulf of Maine (Table 16) along a patchy continuum from the V-shaped 50f contour of the Great South Channel-northwest Georges Bank, northeast outside Cape Cod over Stellwagen Bank to Jeffreys Ledge (Fig. 19). Humpback whales were present throughout the year in this area with seasonal shifts in abundance. Smaller concentrations of humpbacks also occurred from the southern edge of Grand Manan Island-mouth of the Bay of Fundy south along the western Scotian Shelf-Briars Island region to the perimeter of Georges Bank, and in southern New England waters from Montauk Point, Long Island east to Cox’s Ledge and south to the shelf-edge (Fig. 19). Humpback whales were infrequent on Georges Bank (n = 64, Table 16) throughout the study period.

The number of humpback whale sightings in the study area were significantly less during January-February (as compared to other periods, Table 16,
Fig. 19a). Only 10 January-February sightings were reported (only 6 in the study area, Table 16). During January-February humpbacks have been observed overwintering in the Great South Channel, near the mouth of Chesapeake Bay and on the shelf as far south as Cape Hatteras (Fig. 19a). They have also been reported in Cape Cod Bay during winter (Payne et al. 1984; Geraci et al. 1989).

The total number of sightings during March-April (n = 151, Table 16) was significantly greater than during January-February. Only 14 of these sightings occurred during March; therefore during April humpback whales appeared along the southern New England shelf-edge between Hudson Canyon and the Great South Channel (generally below the Great South Channel), then moved through the Great South Channel into the southwestern Gulf of Maine (Fig. 19b). For the Gulf of Maine stock, the Great South Channel has been suggested as the major exit/entry between the Gulf of Maine feeding area and the deeper, offshore migration route (Kenney et al. 1981). There were few slope sightings reported for humpback whales during the 1978-1988 study period (n = 11, Table 16). Therefore, it is apparent that humpbacks do not spend any length of time in slope waters once they have reached the shelf-edge/slope interface below the Great South Channel.

During May-June the number of humpback whale sightings increased dramatically (Table 16). Humpbacks were located in southern New England waters from Montauk Point, Long Island east to Cox’s Ledge (Fig. 19c). Although a few whales remained in southern New England/Georges Bank shelf waters throughout summer, most humpbacks in the study area were found in the Gulf of Maine during May-June (n = 541/592, Table 16). The distribution of humpback whales in the Gulf of Maine occurred in several discrete clusters between 41°00’N and 43°00’N lats within a narrow corridor extending from the Great South Channel north to Jeffreys Ledge along the 50f contour (Fig. 19c). These clusters
generally occurred east of Cape Cod-Nantucket along the western flank of the Great South Channel, on Stellwagen Bank and on Jeffreys Ledge.

The number of humpback whale sightings in the northern Gulf of Maine-Bay of Fundy and western Scotian Shelf continued to increase during July-August as whales moved north from the southwestern Gulf of Maine-Georges Bank regions (Fig. 19d). Several concentrations of whales also occurred along the shelf-edge/canyon region of Georges Bank. Increased densities of humpback whales during late summer have been previously reported from the Bay of Fundy (Neave and Wright 1968; Kraus and Prescott 1981; 1982).

Ninety-three percent of the humpback whale sightings during September-October (n = 232/250) occurred in the Gulf of Maine (Table 16). The number of sightings on the southern New England shelf decreased during this period (Table 16) and the whale sightings east of Montauk Point were no longer present (Fig. 19e).

Humpback whales remained in the southwest Gulf of Maine through December (Fig. 19f), however there was a significant decrease in the number of sightings (Table 16) and overall abundance during November-December. Humpbacks moved southwest from the northern Gulf-Bay of Fundy regions and northeast Georges Bank during this period. Reports of humpback whales from the southwest Gulf of Maine to the Great South Channel were also reduced in number at this time. Based on the lack of sightings throughout the remainder of the study area, most humpbacks must migrate south to wintering grounds in slope waters seaward of the study area.

Ecological and Management Considerations

During the mid 1970's the center of the humpback whale feeding distribution in the Gulf of Maine shifted southward in response to increased densities of sand lance in the lower Gulf of Maine (Mullane and Rivers 1982; Payne et al. 1986). When considered with previous sighting data and observations of feed-
ing humpbacks (Overholtz and Nicolas 1979; Kenney et al. 1981; Mayo 1982, 1983; Hain et al. 1982; Weinrich et al. 1985; Winn and Reichley 1985; Mayo et al. 1988) there is little doubt that sand lance has been the most important prey of humpbacks in the Gulf of Maine since the mid-1970’s.

This predator-prey relationship was further emphasized during 1986 when sand lance abundance on Stellwagen Bank declined. Between 1982-1985 the number and distribution of humpback whale sightings in the southwest Gulf of Maine remained fairly stable (Figs. 19g-19h). Then during 1986 sand lance abundance declined to near-zero (based on NMFS/NEFC spring and autumn bottom trawl surveys data, presented in Nelson and Ross 1991) and humpbacks evacuated this area (Fig. 19i) for the first time since the sand lance population explosion in 1975 (Payne et al. 1990c). Most of the humpbacks relocated to the Great South Channel (Fig. 19i) or moved northeast over Georges Bank to the western Scotian Shelf. During 1987 a small increase in sand lance abundance on Stellwagen Bank resulted in the return of a few humpback whales to the area (Fig. 19i). A regional maximum abundance of sand lance on Stellwagen Bank in 1988 (from Nelson and Ross 1991) was followed by an increased abundance of humpbacks on Stellwagen to pre-1986 levels (Payne et al. 1990c). Similar shifts in the distribution of humpback whales in response to changes in the distribution and abundance of prey have been described elsewhere (Lien et al. 1979; Perkins and Beamish 1979; Bryant et al. 1981; Whitehead and Lien 1982; Whitehead 1983; Lynch and Whitehead 1984; Whitehead and Carscadden 1985).

During winter humpbacks have also been observed feeding on Atlantic mackerel in Cape Cod Bay and east of Nantucket. The most significant die-off of baleen whales in the study area occurred during November-December 1987 and January 1988, when 14 humpbacks died in Cape Cod Bay after eating Atlantic mackerel containing a dinoflagellate neurotoxin (Geraci et al. 1989).

Humpbacks have been entangled in gillnet fishing gear on several occa-
sions in the southwest Gulf of Maine (Kraus 1990a).

Northern Right Whale *Eubalaena glacialis*

Despite the rarity of this species, right whale aggregations within the Gulf of Maine-Bay of Fundy regions have been well defined (Fig. 20). Approximately ninety-percent of all right whale sightings (n = 625/700, Table 17) occurred in the Gulf of Maine. The large number of sightings was due largely to increased sighting effort as a result of dedicated right whale surveys (see METHODS-Collection of Whale Sighting Data). There have been no large aggregations of right whales found in the study area south of 40°00'N lat.

From March to at least mid-October right whales move between several locations north of 41°00'N lat. During late-winter through spring most sightings occurred in a patchy distribution from the Great South Channel (generally in the V-shaped basin formed by 50f contour) north throughout the southwest Gulf of Maine (including Cape Cod Bay) to Jeffreys Ledge and Basin (Fig. 20). During late summer-autumn right whale sightings north of 40°00'N lat are concentrated in the lower Bay of Fundy, and on the Browns Bank-southern Scotian shelf (Fig. 20). Right whale occurrence in these two areas are temporally disjunct, generally, from those in the southwest Gulf of Maine.

Right whales also have a seasonal occurrence (January-April) in the mid-Atlantic (Table 17) near Cape Hatteras (Fig. 20). A winter (January to early-March) right whale fishery occurred, historically, from South Carolina-Georgia north to Cape Hatteras (Holder 1883; Ear1 1887a, 1887b; Brimley 1894; summarized in Reeves and Mitchell 1986, 1988). The coastal coves from South Carolina to Florida (and possibly the Gulf of Mexico, Moore and Clark 1963) have also been well documented as historical calving areas (Reeves et al. 1978). At least part of the North Atlantic population still overwinters along the coast from North Carolina to Florida (Kraus et al. 1986, 1989; Winn 1984) and relatively newborn calves have been observed in the Georgia-Florida Bight.
(Kraus et al. 1986). This wintering group has been tied with those whales that move into the Gulf of Maine-lower Bay of Fundy during the spring and summer (Kraus et al. 1986).

Right whale sightings north and northeast of the Scotian Shelf are considered rare (Lien et al. 1989; Sigurjonsson et al. 1989). However, a right whale observed between Iceland and eastern Greenland in July 1987 (Sigurjonsson et al. 1989) was later photographed at 42°01'N-65°43'W (south of Nova Scotia) during June 1989 (S. Kraus, pers. comm.) extending the range of a potential single population of right whales in the western North Atlantic from Georgia-Florida to Greenland-Iceland.

Seasonal Distribution and Movements

Right whale sightings are extremely limited north of Cape Hatteras during January-February (Fig. 20a). Nine of the 13 sightings during this 2-month period occurred in the mid-Atlantic/southern New England regions (Table 17). Right whales were observed east of Cape Hatteras in five different years of the study period primarily from January through April (Figs. 20a-20b). During January-February right whale sightings also occurred in the southern Gulf of Maine-Cape Cod Bay (Fig. 20a).

The present sighting data, combined with historical information south of Long Island (True 1904; Ulmer 1961; Reeves 1976a; Reeves et al. 1978; Reeves and Brownell 1982; Reeves and Mitchell 1986) indicate a progressive northward movement through the mid-Atlantic/southern New England regions during mid-winter. This loosely structured northward movement coalesces in in the lower Gulf of Maine-Great South Channel region (Figs. 24a-24c) between February and May (Allen 1908; Allen 1916; Mayo 1982; Watkins and Schevill 1982; Scott et al. 1985; Schevill et al. 1986; Mayo et al. 1988; Kenney et al. 1986; Wishner et al. 1988; Brown and Winn 1989; Hamilton and Mayo 1990).

During March-April right whale sightings increased north of 40°00'N lat from the shelf-edge below the V-shaped 50f contour of the Great South
Channel/western Georges Bank north to Cape Cod Bay and Stellwagen Bank (Fig. 20b). Right whales in Cape Cod Bay have been observed skim feeding, socializing and courting since the early 1950s (Watkins and Schevill 1976, 1979; Mayo et al. 1985, 1987; Mayo and Marx 1990; Schevill et al. 1986; Hamilton and Mayo 1990). Mayo et al. (1985) suggested that Stellwagen Basin-eastern Stellwagen Bank are also important areas for social activity.

Right whale sightings increased significantly during May-June (Table 17) due not only to a movement of right whales into the area but also, at least in part, to increased survey effort throughout the lower Gulf of Maine/Great South Channel. By May-June right whale sightings occurred from the lower Gulf of Maine-Great South Channel into the lower Bay of Fundy and Scotian shelf regions (Fig. 20c). A few right whales sometimes remained in the southern Gulf of Maine-Great South Channel regions throughout summer. However from July through October the number of sightings in the Gulf of Maine decreased dramatically (Table 17) and the right whale distribution moved northward (Figs. 20d-20e) and becomes centered in the lower Bay of Fundy and on the southern Scotian shelf (CeTAP 1982; Reeves et al. 1983; Cummings 1985b; Kraus 1985; Kraus and Prescott 1982; Kraus et al. 1984, 1986, 1989; Hay 1985b; Mitchell et al. 1986; Winn et al. 1986, 1987; Gaskin 1987; Stone et al. 1988; Murison and Gaskin 1989). This seasonal pattern was generally repeated in all years between 1978 and 1988, except 1986 when right whales were observed on Stellwagen Bank virtually every day throughout the summer (Hamilton and Mayo 1990; Payne et al. 1990c). Right whale activity in the Bay of Fundy continues through October, however most of the whales disperse southward by November (Fig. 20f).

During November-December only 26 right whale sightings occurred in the study area (Table 17), 85% of these (n =22) occurred in the Gulf of Maine. Some right whales migrate southward from the Bay of Fundy-Scotian Shelf re-
gions through the Gulf of Maine (Figs. 20e-20f). However, much of the right
whale southward migration route is unknown. The few individuals observed
November-December in the southwestern Gulf of Maine from Jeffreys Ledge to
Cape Cod Bay (Fig. 20f) do not account for the numbers observed throughout
mid-summer in the Bay of Fundy-Scotian Shelf regions. There were no right
whale sightings in the eastern Bay of Fundy-Browns Bank and Scotian Shelf
during November-December (Fig. 20f). Right whales may move southward outside
of Georges Bank along the shelf-edge, or in slope waters seaward of the study
area. Winn et al. (1986) suggested that right whales do not pause for any
protracted time in shelf/slope waters during their southward migration, but
rather move offshore eventually appearing off Georgia-Florida or near Cape
Hatteras, completing the annual cycle.

**Ecological and Management Considerations**

The commercial "extinction" of right whales represents one of the most
serious depletions of a large whale species in the western North Atlantic
(Reeves and Mitchell 1986). Despite decades of protection Schevill et al.
(1986) suggested that right whale numbers around Cape Cod Bay have not changed
significantly since the 17th century. Possible reasons speculated for the
non-recovery of this species include the combined effects of ship traffic,
marine pollution and coastal development in North Atlantic calving grounds
(Reeves 1982; Braham and Rice 1984; Hay 1985b), competition for available prey
with other copepod-feeding whales (Mitchell 1975d; Mitchell et al. 1986) and
finfish (Kenney et al. 1986; Payne et al. 1990c) and human induced mortality
through entanglement and collision with vessels (Kraus 1990b). NOAA/NMFS
(1990) considered the latter to be the most important impact on right whales
at the present.

Recovery actions recommended by NOAA/NMFS (1990) included a reduction in
the risk of ship collisions through education and enforcement, regulation of
certain fishing gear types which entangle right whales, the regulation of recreational whale watching activities directed at right whales and the designation of certain areas as critical habitat for right whales.
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in the Gulf of Maine in relation to densities of the sand eel Ammodytes 

whales (Globicephala spp.) in shelf/shelf-edge and slope waters of the 

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TABLE 4. The number of common dolphin sightings used in the plots of distribution by regions and two-month periods.

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Table 6. The number of white-beaked dolphin sightings used in the plots of distribution by two-month periods.

Table 7. The number of grampus or Risso's dolphin sightings used in the plots of distribution by regions and two-month periods.

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Table 9. The number of pilot whale sightings used in the plots of distribution by regions and two-month periods.

Table 10. The number of harbor porpoise sightings used in the plots of distribution by regions and two-month periods.

Table 11. The number of sperm whale sightings used in the plots of distribution by regions and two-month periods.

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Table 13. The number of Minke whale sightings used in the plots of distribution by regions and two-month periods.

Table 14. The number of fin whale sightings used in the plots of distribution by regions and two-month periods.

Table 15. The number of sei whale sightings used in the plots of distribution by regions and two-month periods.

Table 16. The number of humpback whale sightings used in the plots of distribution by regions and two-month periods.

Table 17. The number of right whale sightings used in the plots of distribution by regions and two-month periods.
TABLE 1. The number of bottlenose dolphin sightings used in the plots of distribution by regions and two-month period.

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1 GOM = Gulf of Maine, GB = Georges Bank, SNE = Southern New England, MA = Mid-Atlantic and SL = Slope
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   SL-sne = slope waters seaward of the southern New England region,
   SL-ma = slope waters seaward of the mid-Atlantic region.
TABLE 2. The number of spotted dolphin sightings used in the plots of distribution by regions and two-month period.

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SL-sne = slope waters seaward of the southern New England region,
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<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td>SL-ma</td>
<td>5</td>
<td>21</td>
<td>10</td>
<td>18</td>
<td>7</td>
<td>5</td>
<td>66</td>
</tr>
<tr>
<td>TOTAL</td>
<td>11</td>
<td>35</td>
<td>18</td>
<td>26</td>
<td>12</td>
<td>13</td>
<td>115</td>
</tr>
</tbody>
</table>

¹ GOM = Gulf of Maine, GB = Georges Bank, SNE = Southern New England, MA = Mid-Atlantic and SL = slope.
SL-gb = slope waters (200 -2,000m in depth) seaward of Georges Bank,
SL-sne = slope waters seaward of the southern New England region,
SL-ma = slope waters seaward of the mid-Atlantic region.
**TABLE 4.** The number of common dolphin sightings used in the plots of distribution by regions and two-month period.

<table>
<thead>
<tr>
<th>Region</th>
<th>Jan-Feb</th>
<th>Mar-Apr</th>
<th>May-Jun</th>
<th>Jul-Aug</th>
<th>Sep-Oct</th>
<th>Nov-Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOM</td>
<td>4</td>
<td>5</td>
<td>8</td>
<td>6</td>
<td>18</td>
<td>7</td>
<td>48</td>
</tr>
<tr>
<td>GB</td>
<td>51</td>
<td>9</td>
<td>39</td>
<td>54</td>
<td>89</td>
<td>75</td>
<td>317</td>
</tr>
<tr>
<td>SNE</td>
<td>68</td>
<td>18</td>
<td>46</td>
<td>20</td>
<td>10</td>
<td>64</td>
<td>226</td>
</tr>
<tr>
<td>MA</td>
<td>31</td>
<td>56</td>
<td>15</td>
<td>12</td>
<td>0</td>
<td>6</td>
<td>120</td>
</tr>
<tr>
<td>SL-gb</td>
<td>4</td>
<td>11</td>
<td>20</td>
<td>5</td>
<td>4</td>
<td>7</td>
<td>51</td>
</tr>
<tr>
<td>SL-sne</td>
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<td>20</td>
<td>29</td>
<td>7</td>
<td>8</td>
<td>6</td>
<td>72</td>
</tr>
<tr>
<td>SL-ma</td>
<td>14</td>
<td>28</td>
<td>41</td>
<td>5</td>
<td>3</td>
<td>9</td>
<td>100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>174</strong></td>
<td><strong>147</strong></td>
<td><strong>198</strong></td>
<td><strong>109</strong></td>
<td><strong>132</strong></td>
<td><strong>174</strong></td>
<td><strong>984</strong></td>
</tr>
</tbody>
</table>

1 GOM = Gulf of Maine, GB = Georges Bank, SNE = southern New England, MA = mid-Atlantic and SL = slope.
SL-gb = slope waters (200-2,000m in depth) seaward of Georges Bank,
SL-sne = slope waters seaward of the southern New England region,
SL-ma = slope waters seaward of the mid-Atlantic region.
TABLE 5. The number of white-sided dolphin sightings used in the plots of distribution by regions and two-month period.

<table>
<thead>
<tr>
<th>Region</th>
<th>Jan-Feb</th>
<th>Mar-Apr</th>
<th>May-Jun</th>
<th>Jul-Aug</th>
<th>Sep-Oct</th>
<th>Nov-Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOM</td>
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<td>190</td>
<td>346</td>
<td>105</td>
<td>84</td>
<td>826</td>
</tr>
<tr>
<td>GB</td>
<td>1</td>
<td>13</td>
<td>33</td>
<td>75</td>
<td>17</td>
<td>6</td>
<td>145</td>
</tr>
<tr>
<td>SNE</td>
<td>4</td>
<td>15</td>
<td>13</td>
<td>22</td>
<td>3</td>
<td>6</td>
<td>63</td>
</tr>
<tr>
<td>MA</td>
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<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>SL-gb</td>
<td>0</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>SL-sne</td>
<td>0</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>SL-ma</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>20</strong></td>
<td><strong>127</strong></td>
<td><strong>247</strong></td>
<td><strong>447</strong></td>
<td><strong>128</strong></td>
<td><strong>98</strong></td>
<td><strong>1067</strong></td>
</tr>
</tbody>
</table>

1 GOM = Gulf of Maine, GB = Georges Bank, SNE = southern New England, MA = mid-Atlantic and SL = slope.
SL-gb = slope waters (200-2,000m in depth) seaward of Georges Bank,
SL-sne = slope waters seaward of the southern New England region,
SL-ma = slope waters seaward of the mid-Atlantic region.
Table 6. The number of white-beaked dolphin sightings used in the plots of distribution by two-month period.

<table>
<thead>
<tr>
<th>JAN-FEB</th>
<th>MAR-APR</th>
<th>MAY-JUN</th>
<th>JUL-AUG</th>
<th>SEP-OCT</th>
<th>NOV-DEC</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16</td>
<td>11</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>35</td>
</tr>
</tbody>
</table>
TABLE 7. The number of grampus or Risso's dolphin sightings used in the plots of distribution by regions and two-month period.

<table>
<thead>
<tr>
<th>Region</th>
<th>Jan-Feb</th>
<th>Mar-Apr</th>
<th>May-Jun</th>
<th>Jul-Aug</th>
<th>Sep-Oct</th>
<th>Nov-Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOM</td>
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<td>0</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>GB</td>
<td>0</td>
<td>1</td>
<td>11</td>
<td>11</td>
<td>5</td>
<td>0</td>
<td>28</td>
</tr>
<tr>
<td>SNE</td>
<td>1</td>
<td>3</td>
<td>9</td>
<td>60</td>
<td>34</td>
<td>0</td>
<td>107</td>
</tr>
<tr>
<td>MA</td>
<td>0</td>
<td>1</td>
<td>13</td>
<td>30</td>
<td>4</td>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td>SL-gb</td>
<td>0</td>
<td>5</td>
<td>4</td>
<td>18</td>
<td>12</td>
<td>7</td>
<td>46</td>
</tr>
<tr>
<td>SL-sne</td>
<td>2</td>
<td>1</td>
<td>36</td>
<td>56</td>
<td>32</td>
<td>6</td>
<td>133</td>
</tr>
<tr>
<td>SL-ma</td>
<td>13</td>
<td>32</td>
<td>30</td>
<td>50</td>
<td>24</td>
<td>21</td>
<td>170</td>
</tr>
<tr>
<td>TOTAL</td>
<td>16</td>
<td>46</td>
<td>103</td>
<td>228</td>
<td>113</td>
<td>36</td>
<td>552</td>
</tr>
</tbody>
</table>

1 GOM = Gulf of Maine, GB = Georges Bank, SNE = southern New England, MA = mid-Atlantic and SL = slope.
SL-gb = slope waters (200 - 2,000m in depth) seaward of Georges Bank,
SL-sne = slope waters seaward of the southern New England region,
SL-ma = slope waters seaward of the mid-Atlantic region.
Table 8. The number of killer whale sightings used in the plots of distribution by two-month periods.

<table>
<thead>
<tr>
<th></th>
<th>JAN-FEB</th>
<th>MAR-APR</th>
<th>MAY-JUN</th>
<th>JUL-AUG</th>
<th>SEP-OCT</th>
<th>NOV-DEC</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
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<td>4</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>13</td>
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</tbody>
</table>
TABLE 9. The number of pilot whale sightings used in the plots of distribution by regions and two-month period.

<table>
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<tr>
<th>Region</th>
<th>Jan-Feb</th>
<th>Mar-Apr</th>
<th>May-Jun</th>
<th>Jul-Aug</th>
<th>Sep-Oct</th>
<th>Nov-Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
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<td>45</td>
<td>39</td>
<td>268</td>
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<tr>
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<td>2</td>
<td>21</td>
<td>46</td>
<td>47</td>
<td>30</td>
<td>148</td>
</tr>
<tr>
<td>SNE</td>
<td>6</td>
<td>36</td>
<td>76</td>
<td>18</td>
<td>16</td>
<td>19</td>
<td>171</td>
</tr>
<tr>
<td>MA</td>
<td>2</td>
<td>16</td>
<td>5</td>
<td>16</td>
<td>3</td>
<td>4</td>
<td>46</td>
</tr>
<tr>
<td>SL-gb</td>
<td>8</td>
<td>34</td>
<td>40</td>
<td>18</td>
<td>3</td>
<td>12</td>
<td>115</td>
</tr>
<tr>
<td>SL-sne</td>
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<td>31</td>
<td>24</td>
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<td>5</td>
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<tr>
<td>SL-ma</td>
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<td>17</td>
<td>39</td>
<td>55</td>
<td>39</td>
<td>50</td>
<td>201</td>
</tr>
<tr>
<td>TOTAL</td>
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<td>291</td>
<td>253</td>
<td>166</td>
<td>159</td>
<td>1,033</td>
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</tbody>
</table>

TABLE 10. The number of harbor porpoise sightings used in the plots of distribution by regions and two-month period.

<table>
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<th>Region</th>
<th>Jan-Feb</th>
<th>Mar-Apr</th>
<th>May-Jun</th>
<th>Jul-Aug</th>
<th>Sep-Oct</th>
<th>Nov-Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOM</td>
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<td>62</td>
<td>173</td>
<td>380</td>
<td>73</td>
<td>18</td>
<td>711</td>
</tr>
<tr>
<td>GB</td>
<td>2</td>
<td>18</td>
<td>95</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>120</td>
</tr>
<tr>
<td>SNE</td>
<td>2</td>
<td>37</td>
<td>30</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>76</td>
</tr>
<tr>
<td>MA</td>
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<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>SL</td>
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<td>5</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>TOTAL</td>
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<td>123</td>
<td>303</td>
<td>388</td>
<td>79</td>
<td>19</td>
<td>921</td>
</tr>
</tbody>
</table>

1 GOM = Gulf of Maine, GB = Georges Bank, SNE = southern New England, MA = mid-Atlantic and SL = slope.
TABLE 11. The number of sperm whale sightings used in the plots of distribution by regions and two-month period.

<table>
<thead>
<tr>
<th>Region</th>
<th>Jan-Feb</th>
<th>Mar-Apr</th>
<th>May-Jun</th>
<th>Jul-Aug</th>
<th>Sep-Oct</th>
<th>Nov-Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
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<td>GOM</td>
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<td>0</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>GB</td>
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<td>0</td>
<td>8</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>SNE</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>11</td>
<td>14</td>
<td>8</td>
<td>39</td>
</tr>
<tr>
<td>MA</td>
<td>0</td>
<td>11</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>SL-gb</td>
<td>3</td>
<td>4</td>
<td>14</td>
<td>34</td>
<td>3</td>
<td>0</td>
<td>58</td>
</tr>
<tr>
<td>SL-sne</td>
<td>4</td>
<td>18</td>
<td>25</td>
<td>12</td>
<td>13</td>
<td>3</td>
<td>75</td>
</tr>
<tr>
<td>SL-ma</td>
<td>14</td>
<td>53</td>
<td>47</td>
<td>65</td>
<td>10</td>
<td>18</td>
<td>207</td>
</tr>
<tr>
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<td>101</td>
<td>127</td>
<td>44</td>
<td>32</td>
<td>413</td>
</tr>
</tbody>
</table>

1 GOM = Gulf of Maine, GB = Georges Bank, SNE = southern New England, MA = mid-Atlantic and SL = slope.
SL-gb = slope waters (200 - 2,000m in depth) seaward of Georges Bank, SL-sne = slope waters seaward of the southern New England region, SL-ma = slope waters seaward of the mid-Atlantic region.
TABLE 12. The number of beaked whale *spp.* sightings used in the plots of distribution by regions for all seasons.

<table>
<thead>
<tr>
<th>Region</th>
<th>GOM</th>
<th>GB</th>
<th>SNE</th>
<th>MA</th>
<th>SL-gb</th>
<th>SL-sne</th>
<th>SL-ma</th>
</tr>
</thead>
<tbody>
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<td>4</td>
<td>4</td>
<td>10</td>
<td>7</td>
<td>14</td>
</tr>
</tbody>
</table>
TABLE 13. The number of Minke whale sightings used in the plots of distribution by regions and two-month period.

<table>
<thead>
<tr>
<th></th>
<th>Jan-Feb</th>
<th>Mar-Apr</th>
<th>May-Jun</th>
<th>Jul-Aug</th>
<th>Sep-Oct</th>
<th>Nov-Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GOM</td>
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<td>37</td>
<td>112</td>
<td>180</td>
<td>153</td>
<td>14</td>
<td>497</td>
</tr>
<tr>
<td>GB</td>
<td>1</td>
<td>5</td>
<td>55</td>
<td>41</td>
<td>9</td>
<td>1</td>
<td>112</td>
</tr>
<tr>
<td>SNE</td>
<td>1</td>
<td>13</td>
<td>46</td>
<td>37</td>
<td>4</td>
<td>2</td>
<td>103</td>
</tr>
<tr>
<td>MA</td>
<td>3</td>
<td>9</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>22</td>
</tr>
<tr>
<td>SL-gb</td>
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<td>3</td>
<td>0</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>SL-sne</td>
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<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>SL-ma</td>
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<td>1</td>
<td>1</td>
<td>1</td>
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<td>267</td>
<td>169</td>
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<td>758</td>
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</table>

TABLE 14. The number of fin whale sightings used in the plots of distribution by regions and two-month period.

<table>
<thead>
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<th>Region 1</th>
<th>Jan-Feb</th>
<th>Mar-Apr</th>
<th>May-Jun</th>
<th>Jul-Aug</th>
<th>Sep-Oct</th>
<th>Nov-Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
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<td>262</td>
<td>903</td>
<td>615</td>
<td>325</td>
<td>127</td>
<td>2259</td>
</tr>
<tr>
<td>GB</td>
<td>6</td>
<td>21</td>
<td>86</td>
<td>57</td>
<td>55</td>
<td>21</td>
<td>246</td>
</tr>
<tr>
<td>SNE</td>
<td>16</td>
<td>69</td>
<td>103</td>
<td>225</td>
<td>33</td>
<td>15</td>
<td>461</td>
</tr>
<tr>
<td>MA</td>
<td>18</td>
<td>64</td>
<td>55</td>
<td>41</td>
<td>10</td>
<td>9</td>
<td>197</td>
</tr>
<tr>
<td>SL-gb</td>
<td>2</td>
<td>13</td>
<td>8</td>
<td>7</td>
<td>7</td>
<td>2</td>
<td>39</td>
</tr>
<tr>
<td>SL-sne</td>
<td>1</td>
<td>21</td>
<td>8</td>
<td>15</td>
<td>14</td>
<td>4</td>
<td>63</td>
</tr>
<tr>
<td>SL-ma</td>
<td>0</td>
<td>7</td>
<td>7</td>
<td>10</td>
<td>1</td>
<td>1</td>
<td>26</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>70</td>
<td>457</td>
<td>1170</td>
<td>970</td>
<td>445</td>
<td>179</td>
<td>3291</td>
</tr>
</tbody>
</table>

1 GOM = Gulf of Maine, GB = Georges Bank, SNE = southern New England, MA = mid-Atlantic and SL = slope.
SL-gb = slope waters (200 - 2,000m in depth) seaward of Georges Bank,
SL-sne = slope waters seaward of the southern New England region;
SL-ma = slope waters seaward of the mid-Atlantic region.
TABLE 15. The number of sei whale sightings used in the plots of distribution by regions and two-month period.

<table>
<thead>
<tr>
<th>Region</th>
<th>Jan-Apr</th>
<th>May-Aug</th>
<th>Sep-Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOM</td>
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<td>5</td>
<td>18</td>
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</tr>
<tr>
<td>MA</td>
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</tr>
<tr>
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<td>0</td>
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</tr>
<tr>
<td>SL-ma</td>
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<td>1</td>
<td>0</td>
<td>1</td>
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<tr>
<td>TOTAL</td>
<td>32</td>
<td>48</td>
<td>6</td>
<td>86</td>
</tr>
</tbody>
</table>

1 GOM = Gulf of Maine, GB = Georges Bank, SNE = southern New England, MA = mid-Atlantic and SL = slope.
SL-gb = slope waters (200 - 2,000m in depth) seaward of Georges Bank,
SL-sne = slope waters seaward of the southern New England region,
SL-ma = slope waters seaward of the mid-Atlantic region.
TABLE 16. The number of humpback whale sightings used in the plots of distribution by regions and two-month period.

<table>
<thead>
<tr>
<th>Region</th>
<th>Jan-Feb</th>
<th>Mar-Apr</th>
<th>May-Jun</th>
<th>Jul-Aug</th>
<th>Sep-Oct</th>
<th>Nov-Dec</th>
<th>Total</th>
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<td>541</td>
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<td>1284</td>
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<td>5</td>
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<td>592</td>
<td>401</td>
<td>250</td>
<td>72</td>
<td>1472</td>
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1 GOM = Gulf of Maine, GB = Georges Bank, SNE = southern New England, MA = mid-Atlantic and SL = slope.
SL-gb = slope waters (200 -2,000m in depth) seaward of Georges Bank,
SL-sne = slope waters seaward of the southern New England region,
SL-ma = slope waters seaward of the mid-Atlantic region.
<table>
<thead>
<tr>
<th>Region</th>
<th>Jan-Feb</th>
<th>Mar-Apr</th>
<th>May-Jun</th>
<th>Jul-Aug</th>
<th>Sep-Oct</th>
<th>Nov-Dec</th>
<th>Total</th>
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<td>2</td>
<td>15</td>
</tr>
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<td>1</td>
</tr>
<tr>
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<td>0</td>
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<td>0</td>
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<tr>
<td>SL-ma</td>
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<td>TOTAL</td>
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<td>101</td>
<td>324</td>
<td>147</td>
<td>89</td>
<td>26</td>
<td>700</td>
</tr>
</tbody>
</table>

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