



NOAA Technical Memorandum NMFS-NE-117

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Review of Distribution of the Long-finned Pilot Whale (*Globicephala melas*) in the North Atlantic and Mediterranean

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April 1999

Note on Species Names

The NMFS Northeast Region's policy on the use of species names in all technical communications is generally to follow the American Fisheries Society's lists of scientific and common names for fishes (*i.e.*, Robins *et al.* 1991^a), mollusks (*i.e.*, Turgeon *et al.* 1998^b), a decapod crustaceans (*i.e.*, Williams *et al.* 1989^c), and to follow the Society for Marine Mammalogy's guidance on scientific and common names for marine mammals (*i.e.*, Rice 1998^d). Exceptions to this policy occur when there are subsequent compelling revisions in the classifications of species, resulting in changes in the names of species (*e.g.*, Cooper and Chapleau 1998^e).

^aRobins, C.R. (chair); Bailey, R.M.; Bond, C.E.; Brooker, J.R.; Lachner, E.A.; Lea, R.N.; Scott, W.B. 1991. Common and scientific names of fishes from the United States and Canada. 5th ed. *Amer. Fish. Soc. Spec. Publ.* 20; 183 p.

^bTurgeon, D.D. (chair); Quinn, J.F.; Bogan, A.E.; Coan, E.V.; Hochberg, F.G.; Lyons, W.G.; Mikkelsen, P.M.; Neves, R.J.; Roper, C.F.E.; Rosenberg, G.; Roth, B.; Scheltema, A.; Thompson, F.G.; Vecchione, M.; Williams, J.D. 1998. Common and scientific names of aquatic invertebrates from the United States and Canada: mollusks. 2nd ed. *Amer. Fish. Soc. Spec. Publ.* 26; 526 p.

^cWilliams, A.B. (chair); Abele, L.G.; Felder, D.L.; Hobbs, H.H., Jr.; Manning, R.B.; McLaughlin, P.A.; Pérez Farfante, I. 1989. Common and scientific names of aquatic invertebrates from the United States and Canada: decapod crustaceans. *Amer. Fish. Soc. Spec. Publ.* 17; 77 p.

^dRice, D.W. 1998. Marine mammals of the world: systematics and distribution. *Soc. Mar. Mammal Spec. Publ.* 4; 231 p.

^eCooper, J.A.; Chapleau, F. 1998. Monophyly and interrelationships of the family Pleuronectidae (Pleuronectiformes), with a revised classification. *Fish. Bull. (U.S.)* 96:686-726.

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Acronyms

CeTAP	=	(University of Rhode Island) Cetacean and Turtle Assessment Program
GFRI	=	Greenland Fisheries Research Institute
MBO	=	Manomet Bird Observatory
NASS	=	North Atlantic Sighting Survey
NEFSC	=	(NMFS) Northeast Fisheries Science Center
NMFS	=	NOAA National Marine Fisheries Service
SCANS	=	Small Cetacean Abundance in the North Sea Survey

ABSTRACT

The spatial and seasonal distribution of the long-finned pilot whale (*Globicephala melas*) in the North Atlantic is summarized based on published and some unpublished data. The data are presented separately for 12 countries, and within each country by type of data: 1) evidential (*i.e.*, sightings, strandings, harvests, bycatches); and 2) inferential (*i.e.*, oceanographic processes, prey occurrences). The locations of sightings are presented in distribution maps for each country. The locations of the several sighting surveys and other field activities are summarized, but the distribution of sighting effort is not displayed. For each country, the general distribution pattern is summarized, seasonal differences are shown, and possible seasonal movement patterns are suggested. The Atlantic-wide distribution is then summarized, based on these individual country summaries.

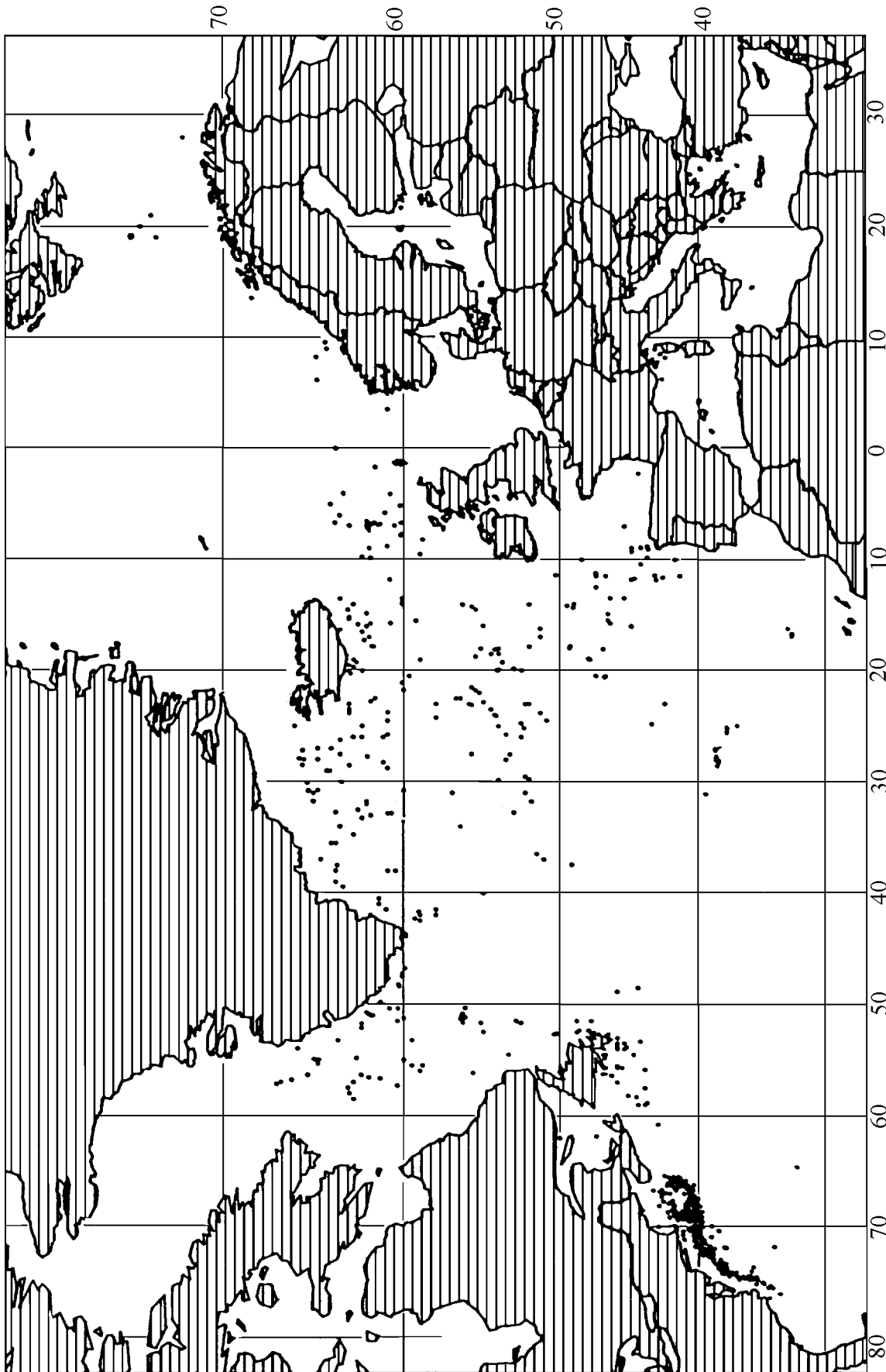


Figure 1. Distribution of long-finned pilot whales in the North Atlantic and Mediterranean Sea based on sighting data from 1952 to 1992.

INTRODUCTION

The long-finned pilot whale (*Globicephala melas* Traill 1809) is also referred to as the blackfish, pothead, northern pilot whale, Atlantic pilot whale, caa'ing whale, and grindehval. Most literature references to the long-finned pilot whale use the short common name of "pilot whale" in conjunction with the scientific name to distinguish it from the short-finned pilot whale (*Globicephala macrorhynchus* Gray 1846). The long-finned pilot whale is a robust whale with a large bulbous head and a flattened forehead. Its coloration is black with an anchor-shaped patch of grayish white on the throat extending into a gray stripe along the underside surrounding the navel and genital areas. Pectoral flippers, long and sharply pointed, reach one-fifth the length of the body (Caldwell and Caldwell 1983). Males can be up to 6 m long and weigh 2,400 kg; females are roughly 25% smaller (Sergeant 1962; Martin *et al.* 1987; Kasuya *et al.* 1988).

The distribution of pilot whales in the North Atlantic (Figure 1) extends from Cape Hatteras to Greenland in the west, to Iceland and possibly the Barents Sea in the north, and to northwestern Africa and the Mediterranean in the east (Sergeant 1962; Leatherwood *et al.* 1976; Evans 1980; Nores and Pirez 1988). For hundreds of years, strandings of pilot whales have occurred regularly along the coasts of the North Atlantic (Brown 1975; Geraci and St. Aubin 1977; Martin *et al.* 1987; McFee 1990).

The principal sources of data on distribution patterns fall into two categories: 1) evidential (*i.e.*, dedicated and incidental sightings, strandings, directed harvests, bycatches in commercial fisheries); and 2) inferential (*i.e.*, oceanographic processes, prey occurrences). Dedicated sighting surveys have been conducted by several nations/territories, including the United States, Canada, Iceland, Faeroe Islands, Denmark, Norway, France, Spain, Great Britain, and Italy. Prior to 1987, sighting surveys for cetaceans in the Northeast Atlantic were limited in both area and duration (Buckland *et al.* 1993). During 1987 and 1989, large-scale cetacean sighting surveys were conducted in the Northeast Atlantic. In the Northwest Atlantic, a line-transect survey was conducted in 1980 (Hay 1982), aerial surveys in 1978-82, and shipboard surveys in 1980-88 (Cetacean and Turtle Assessment Program 1982; Payne and Heinemann 1993). Data have regularly been collected on natural strandings in many countries. Catch data have been collected from drive fisheries in the Faeroe Islands and United States, with records from the former dating back several centuries. Biological samples have been collected from Canadian and Faeroese fisheries, and from natural strandings and bycatches in commercial fisheries in the United States.

Most of these data have been analyzed to determine local or regional distribution patterns. Lacking, however, is an integration of the large-scale distribution patterns of pilot whales. In this paper, we describe the data available

from each of 12 countries in the North Atlantic, and through the use of summary maps attempt to depict overall distribution and movement patterns.

UNITED STATES

Recorded data on pilot whales began a few days after the Pilgrims arrived from England, as pilot whales stranded near the Pilgrims' first landing site. Recordings from the drive fishery of Cape Cod, Massachusetts, lasted until the 1950s. Since then, dedicated shipboard and aerial surveys have been conducted to map the distribution of marine mammals in the eastern U.S. coastal and off-shore waters. Additional research has involved life history data collection from strandings and from incidental takes during commercial fishing operations. These data sets provide the basis for assessing pilot whale distribution patterns along the Mid- and North Atlantic regions of the United States.

Dedicated Sighting Surveys

Beginning in 1978, the United States initiated dedicated cetacean surveys of the northwestern shelf of the North Atlantic Ocean. This effort, the Cetacean and Turtle Assessment Program (CeTAP), which ran from November 1978 to January 1982, was sponsored by the U.S. Department of the Interior's Bureau of Land Management for making decisions on oil and gas exploration and development. The goal of the surveys was to characterize marine mammals and turtles in the Mid- and North Atlantic regions of the U.S. outer continental shelf. The surveys were initially conducted by air and sea, but shipboard surveys were suspended in 1980, with the aerial surveys continuing for the remainder of the program.

A second program of surveys was conducted from January 1980 to December 1988 through a contract with the Manomet Bird Observatory (MBO) of Manomet, Massachusetts, under the auspices of the National Marine Fisheries Service's (NMFS's) Northeast Fisheries Science Center (NEFSC) in Woods Hole, Massachusetts. Shipboard surveys were performed aboard NMFS fishery research vessels as the ships traveled along designated cruise tracks. The objective of the surveys was to provide long-term monitoring of the distribution and abundance of cetacean and seabird populations, which could be directly compared to the distribution and abundance of fish stocks in the same waters (Payne *et al.* 1984; Smith *et al.* 1988).

The two survey programs covered all of the continental shelf and shelf-edge waters between Nova Scotia, Canada, and Cape Hatteras, North Carolina. The CeTAP surveys extended from the coastline seaward to include outer continental shelf waters. The seaward projection included waters 9.3 km (5 nautical miles) beyond the 1,830-m depth contour, which included the associated deepwater canyons

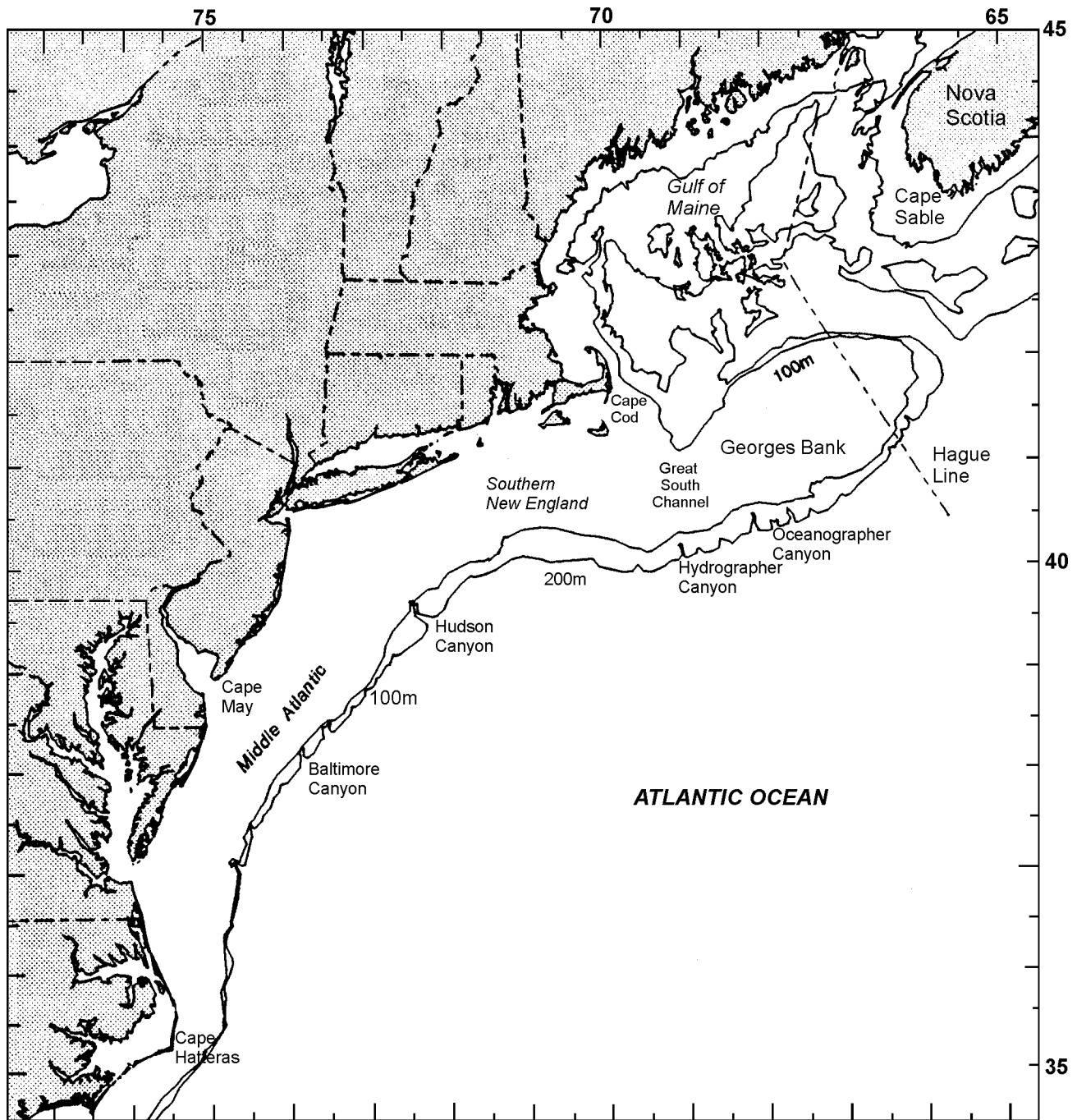


Figure 2. Coverage of CeTAP sighting surveys of the continental shelf and shelf edge from 1978 to 1981 (Source: Cetacean and Turtle Assessment Program 1982).

(Cetacean and Turtle Assessment Program 1982; Figure 2). The MBO surveys were in waters less than 910 m, with most surveys in waters less than 183 m (Payne and Heinemann 1993). This coverage by the two survey programs encompassed a large portion of the long-finned pilot whale's range in the western North Atlantic and a part of the northern distribution of the short-finned pilot whale.

The short-finned pilot whale ranges from Cape Hatteras south to the Caribbean (Caldwell and Caldwell 1983; Leatherwood *et al.* 1976). The two species appear to overlap seasonally between approximately 35°N latitude (Cape Hatteras) and 38°-39°N latitude (Payne *et al.* 1991). Identification to the species level is difficult at sea. Accordingly, the dedicated survey sightings refer only to the genus level (*Globicephala*).

A total of 619 sightings of pilot whales were recorded in the two survey series. Depths associated with sightings ranged from 15 to 5,121 m. This range reflects both survey effort and the movements of the whales between inshore and offshore waters. Pilot whales were often sighted with other cetacean species, especially bottlenose dolphins (*Tursiops truncatus*). Cow-and-calf pairs and juveniles were primarily seen along the shelf edge from Cape Hatteras to the Gulf of Maine, mainly in the spring and summer, with fewer observed in the autumn and winter (Cetacean and Turtle Assessment Program 1982). The sightings concur with Sergeant's (1962) suggestion that pilot whale calves are born from May to November, peaking in August.

There have been only limited surveys in waters greater than 2,000 m in depth. This limitation has created a gap in our understanding of the utilization of these waters by cetaceans. During the summers of 1990 and 1991, the NEFSC conducted marine mammal surveys in the shelf edge and offshore waters to the Gulf Stream between Cape Hatteras and Georges Bank (Waring *et al.* 1992). The surveys ran from August 5 to August 18, 1990, and from June 8 to July 10, 1991. Nearly two-thirds of the 1990 survey effort was along the shelf edge off Georges Bank and within the Gulf Stream. The remaining one-third concentrated around a warm-core ring near Georges Bank and in a 9.3-km buffer zone of the Gulf Stream northern wall. The greater portion of the 1991 survey effort primarily concentrated in shelf-edge waters between the 200- and 2000-m contours, with a smaller portion conducted in off-shelf waters (Waring *et al.* 1992).

In 1990, a total of 68 pilot whales were sighted. The sightings occurred primarily along the northern wall of the Gulf Stream, along the shelf break, and near Oceanographer Canyon, with a couple of sightings recorded in the mid-portion of the Gulf Stream near Cape Hatteras. During the 1991 survey, a total of 724 pilot whales were sighted. Most of the 1991 sightings occurred along the shelf break, in Oceanographer, Hydrographer, and Corsair Canyons, along the southern edge of Georges Bank, and along the northern wall of the Gulf Stream (Waring *et al.* 1992). In both years, the whales were principally found in groups of 2-5 individuals.

The combined CeTAP, MBO, and NEFSC sighting data indicate that pilot whales occur primarily along the continental shelf edge between the 100- and 2000-m contours from Cape Hatteras northerly to Georges Bank. A few sightings also occurred inshore of the 100-m contour, as well as seaward of the 2,000-m contour. These latter sightings are consistent with observations from deep ocean weather stations indicating that pilot whale distribution includes some or all of the deep ocean (Brown 1961).

During late winter to early spring, pilot whale concentrations along the shelf edge at approximately 35°N join additional pilot whales (presumed from deeper off-shore waters) and move northward along the shelf edge between the 100- and 1000-m contours onto the continental shelf (Payne *et al.* 1991; Figure 3). Between early March and May, pilot whales substantially increase in number along the shelf edge between 38°N and 42°N latitude (Figure 4).

During summer, pilot whales are broadly distributed over the shelf (Cetacean and Turtle Assessment Program 1982; Payne *et al.* 1984, 1991; Figure 5). The greater percentage of sighted pilot whales occur along the shelf edges of the northeastern portion of Georges Bank and onto the Scotian Shelf. During May through October, pilot whales predominantly occur on central Georges Bank, primarily along its northern edge (Hain *et al.* 1981; Cetacean and Turtle Assessment Program 1982; Payne *et al.* 1984, 1991). This summer movement continues northward into the Gulf of Maine and into Canadian waters (Sergeant and Fisher 1957; Sergeant 1962; Mercer 1975).

During autumn, the largest concentrations of pilot whales occur along the southwestern edge of Georges Bank (Figure 6). By late autumn to early winter, many pilot whales have already moved offshore and southward (Cetacean and Turtle Assessment Program 1982; Payne *et al.* 1991). The survey sightings are thus consistent with the Katona *et al.* (1978) and Sergeant (1962) hypothesis that some pilot whales move southward into deep offshore waters during the winter. Although, a component of the population appears to be seasonably migratory, the sighting data indicate that pilot whales are common year-round residents of particular continental shelf areas, notably the southern margin of Georges Bank (Cetacean and Turtle Assessment Program 1982).

Strandings

Pilot whale strandings on Cape Cod, Massachusetts, have been known to occur since 1620, and were common in Cape Cod Bay during the 17th century (Weeden 1894; Tower 1907; Hart 1924; Thompson 1928). Since 1819, when newspapers began recording strandings, there have been 92 stranding events on Cape Cod. In addition to natural strandings, drive fisheries caused 70 strandings between 1828 and 1950.

Strandings follow a seasonal cyclical pattern. Strandings between 1832 and 1899 occurred primarily during Septem-

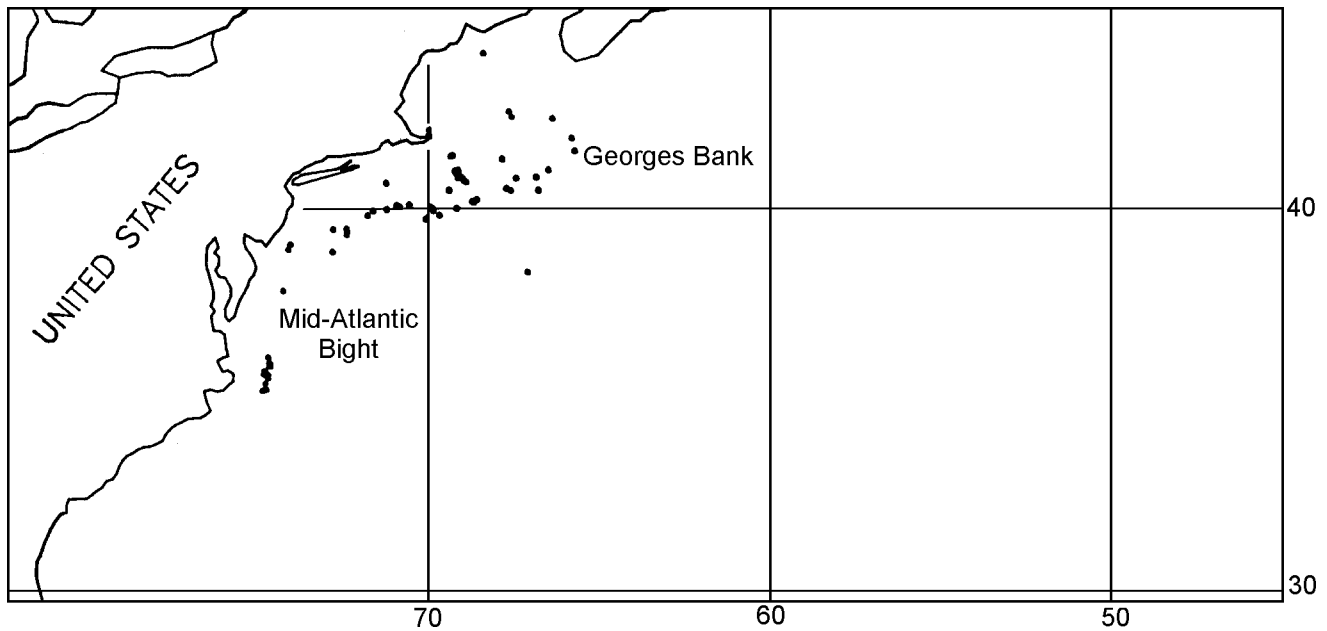


Figure 3. Late winter - early spring distribution of pilot whales off the eastern United States based on sighting data from 1978 to 1992 (Source: Cetacean and Turtle Assessment Program 1982; Payne *et al.* 1991; Waring *et al.* 1992).

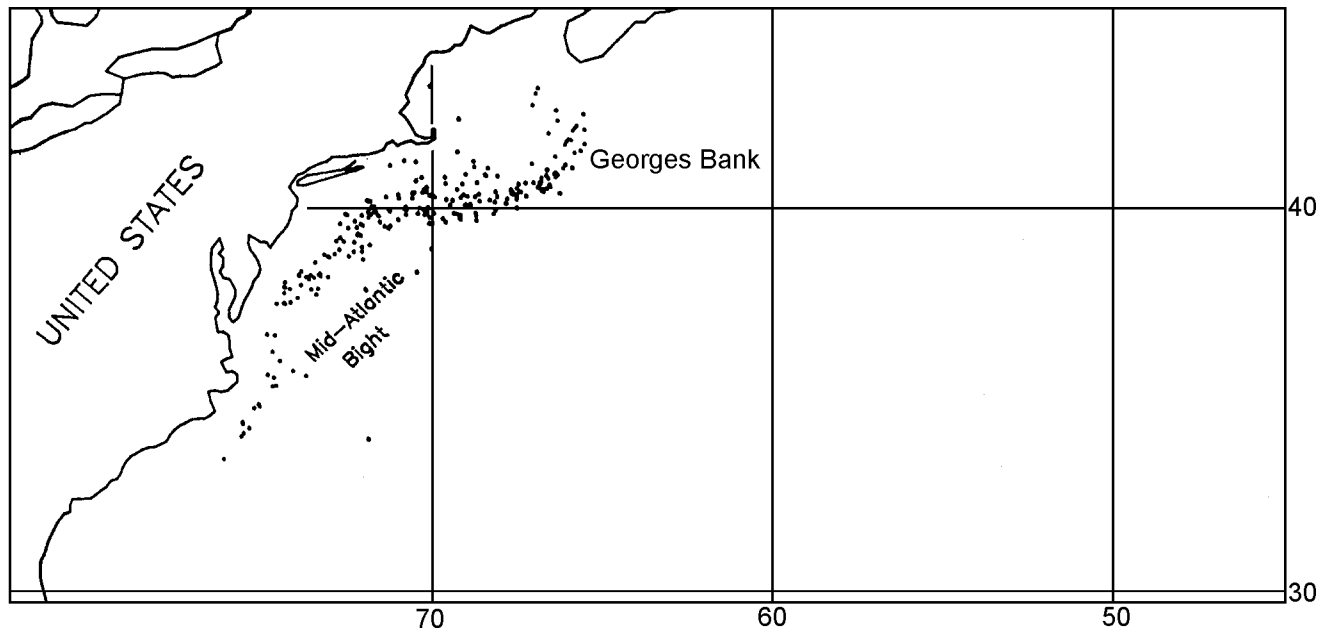


Figure 4. Spring distribution of pilot whales off the eastern United States based on sighting data from 1978 to 1992 (Source: Cetacean and Turtle Assessment Program 1982; Payne *et al.* 1991; Waring *et al.* 1992).

ber through November, while strandings between 1900 and 1959 occurred during July and August. From 1960 to present strandings have returned to later in the year, occurring during September through December (McFee 1990).

The stranding pattern may be due to cyclical ocean temperatures that may regulate the movement of prey species and, therefore, the movement of pilot whales. During summer and autumn 1987, cooler ocean temperature and lower salinity may have influenced the migration of Atlantic mackerel (*Scomber scombrus*) and longfin inshore squid

(*Loligo pealeii*) -- both prey of long-finned pilot whales -- during the following winter. Mackerel routinely migrate to Cape Hatteras during February and March (Anderson and Paciorewski 1980). However, during winter 1988, commercial fisheries data suggest that mackerel did not migrate, remaining instead near Hudson Canyon (Fairfield *et al.* 1989).

Residents of Cape Cod have reported fish congregating within Cape Cod Bay prior to pilot whale strandings. Although the identity of these fish was unknown, it is pos-

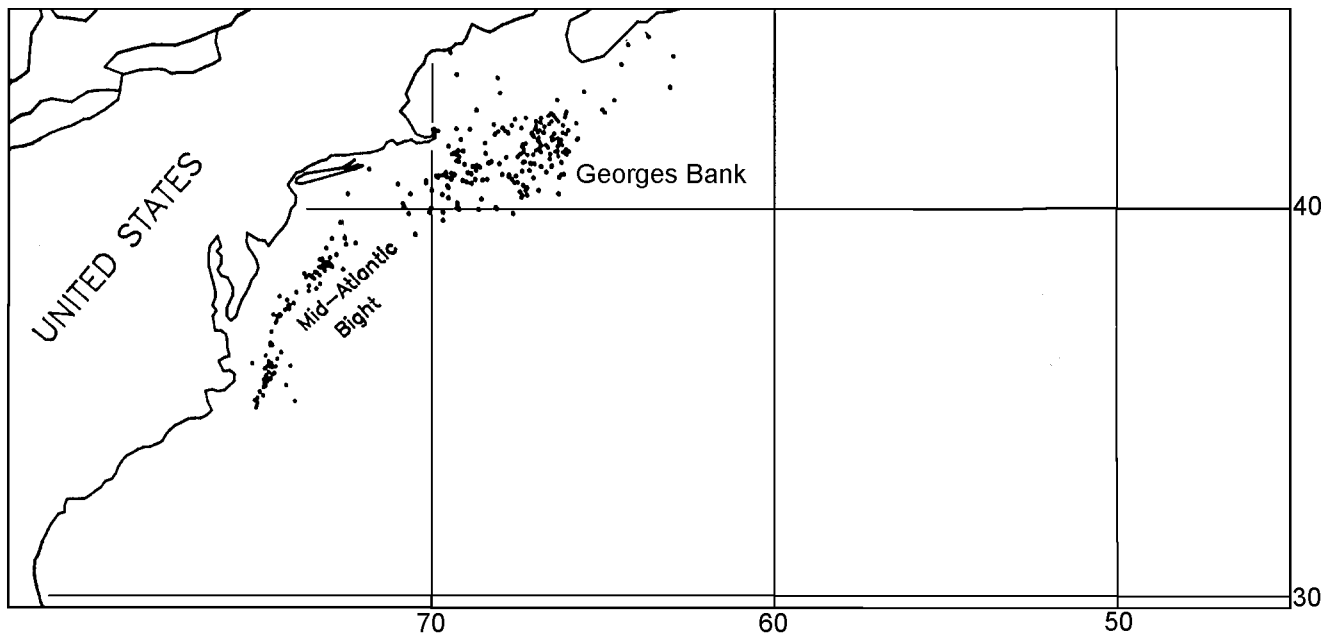


Figure 5. Summer distribution of pilot whales off the eastern United States based on sighting data from 1978 to 1992 (Source: Cetacean and Turtle Assessment Program 1982; Payne *et al.* 1991; Waring *et al.* 1992).

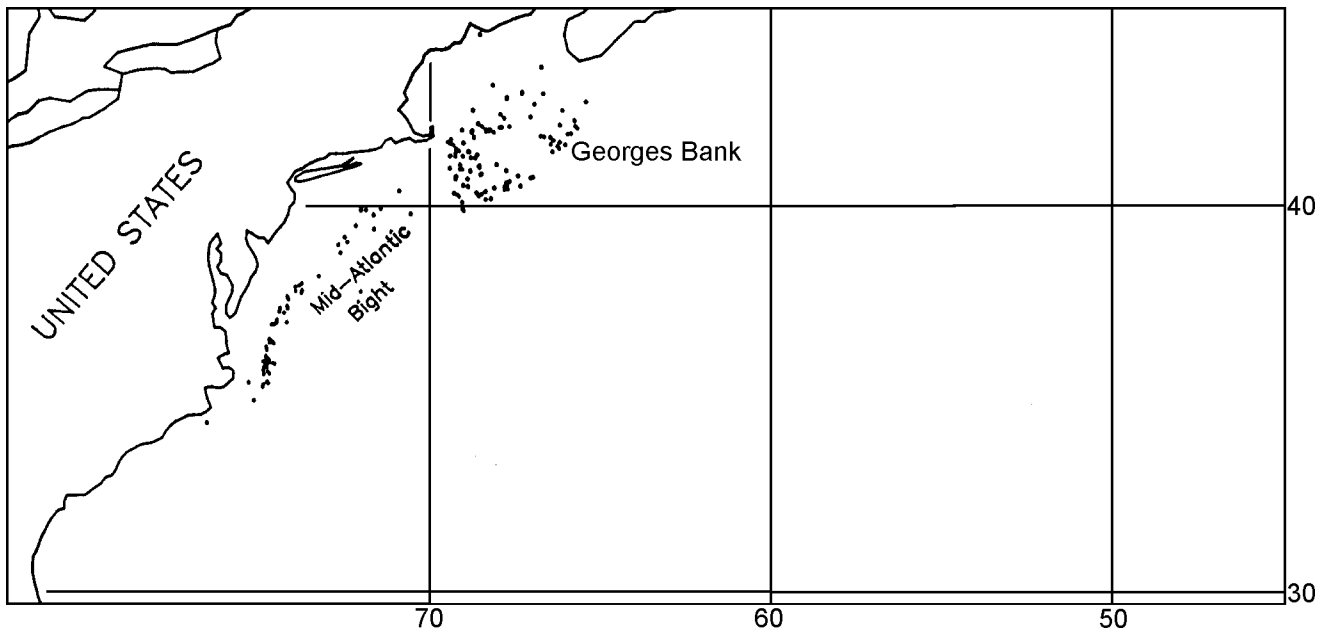


Figure 6. Autumn distribution of pilot whales off the eastern United States based on sighting data from 1978 to 1992 (Source: Cetacean and Turtle Assessment Program 1982; Payne *et al.* 1991; Waring *et al.* 1992).

sible that they were Atlantic mackerel and/or longfin in shore squid. When squid do migrate inshore, they may have a short occupancy period within Cape Cod Bay (Arnold *et al.* 1974; Macy 1982). The pilot whales entering Cape Cod Bay could have been in pursuit of mackerel and/ or squid. Unfortunately, stranded pilot whales reveal very little about their recent foraging as their stomachs are almost always empty.

Cape Cod Bay has varying water depths that could trap the whales when the tide goes out. In fact, almost 70% of

the strandings have occurred in the varying depths of the inner bay (McFee 1990).

Incidental Takes in Commercial Fisheries

Beginning in 1977, fisheries compliance inspectors (*i.e.*, observers) were required aboard all foreign fishing vessels operating within the U.S. Exclusive Economic Zone (*i.e.*, 200-mile zone), in compliance with the Fishery Conserva-

tion and Management Act of 1976. The observer coverage resulted in increased reporting of marine mammal sightings and incidental takes (*i.e.*, bycatch) by the fishing fleets.

Between 1984 and 1988, 93% of all pilot whale incidental kills occurred in the foreign fishery for Atlantic mackerel within the Mid-Atlantic Bight. This fishery followed mackerel concentrations which occur along the shelf edge during winter and spring (Anderson and Paciorkowski 1980). Pilot whales concentrate along the shelf edge from December through May, and are mainly taken in the spring along the shelf edge. Sixty-two percent of the pilot whale bycatch during 1977-88 occurred between March and July, with the remainder between December and February. The bycatch occurred primarily near the 100-m contour (Waring *et al.* 1990; Fairfield *et al.* 1989).

Since 1987, a drift gillnet fishery for swordfish has developed in which incidental catches of both short-finned and long-finned pilot whales are taken (unpubl. data¹). The fishery has operated from Cape Hatteras in winter to Georges Bank in summer, and is usually associated with the continental shelfbreak, especially in association with Gulf Stream features. Bycatches of pilot whales in the Cape Hatteras region in winter are most likely all short-finned pilot whales, and in the Georges Bank region in summer are most likely all long-finned pilot whales, based on those animals identified to species.

Oceanography

Kenney and Winn (1986) indicate that after the western inshore Gulf of Maine, the continental shelf edge is the second-most-used cetacean habitat off the northeastern United States. In turn, pilot whales are the second-most-observed cetacean -- behind the bottlenose dolphin -- in that habitat (Hain *et al.* 1985). Kenney and Winn (1987) suggest that this shelf-edge habitat use is due to complex oceanographic processes elevating productivity and providing an important habitat for the squid and fish prey of cetaceans (Coelho 1985; Maurer and Bowman 1985; Rowell *et al.* 1985).

Pilot whales may also use submarine canyons, in addition to the shelf edge, as feeding areas. Church *et al.* (1984) suggest that circulation patterns induced by undersea canyon topography promote oceanographic mixing. Squid may be more numerous around canyons and canyon heads due to high availability of food caused by nutrient upwelling. According to Kenney and Winn (1987), Atlantic spotted dolphins (*Stenella frontalis*), which feed on squid (Perrin *et al.* 1973), showed higher densities within the submarine canyon areas.

In addition, pilot whale sightings were associated with warm-core rings (Waring *et al.* 1992).

U.S. Summary

Pilot whales are distributed along the eastern United States, migrating seasonally along the edge of the continental shelf. Some animals appear to be year-round residents on the southern edge of Georges Bank, suggesting continuous abundance and availability of prey items in that region. Squid appear to be an important prey item but pilot whales are known to eat mackerel, and to inhabit areas with no squid. The nutrient-rich continental shelf edge and slope support an extensive food web important to pilot whales and other toothed cetaceans. Various oceanographic processes on the shelf edge and slope, including local upwelling and direct interaction with the Gulf Stream through warm-core rings, generate high levels of productivity.

CANADA

The majority of information on pilot whale biology in Canada has been derived from commercial whaling operations. Sergeant (1962) based his research on samples from harvested whales, and the apparently high rate of exploitation has spurred subsequent studies of population densities. Additional data come from sightings aboard fishing and coast guard vessels, whale watching operations, fishery research operations, and from some land-based operations. Strandings have also contributed to the life history of pilot whales in this region. Since strandings are few, they are considered together with the fishery.

Ocean and Land-Based Sightings

Historically, pilot whales have been common seasonal migrants to Canadian waters (Sergeant and Fisher 1957; Sergeant 1962; Mercer 1967, 1975). They range from the offshore waters of Labrador, to the coastal and inshore waters of Newfoundland, to the waters around Nova Scotia and Prince Edward Island. Lynch (1987) noted that most sightings of pilot whales occurred during autumn, and were concentrated along the eastern coast of Newfoundland and off the Avalon Peninsula (Figure 7). Pilot whales have been sighted in the Labrador Sea from late May to late July, as well as in more southerly locations in the North Atlantic Drift (Sergeant 1968). Sightings have been irregular on the southwestern and western coasts of Newfoundland (Sergeant and Fisher 1957).

Sergeant (1962) suggested that the main wintering area of the Newfoundland stock was in the waters of the North Atlantic Current, east of the Grand Bank. Winter sightings of pilot whales by Sergeant and Fisher (1957) and by Schevill

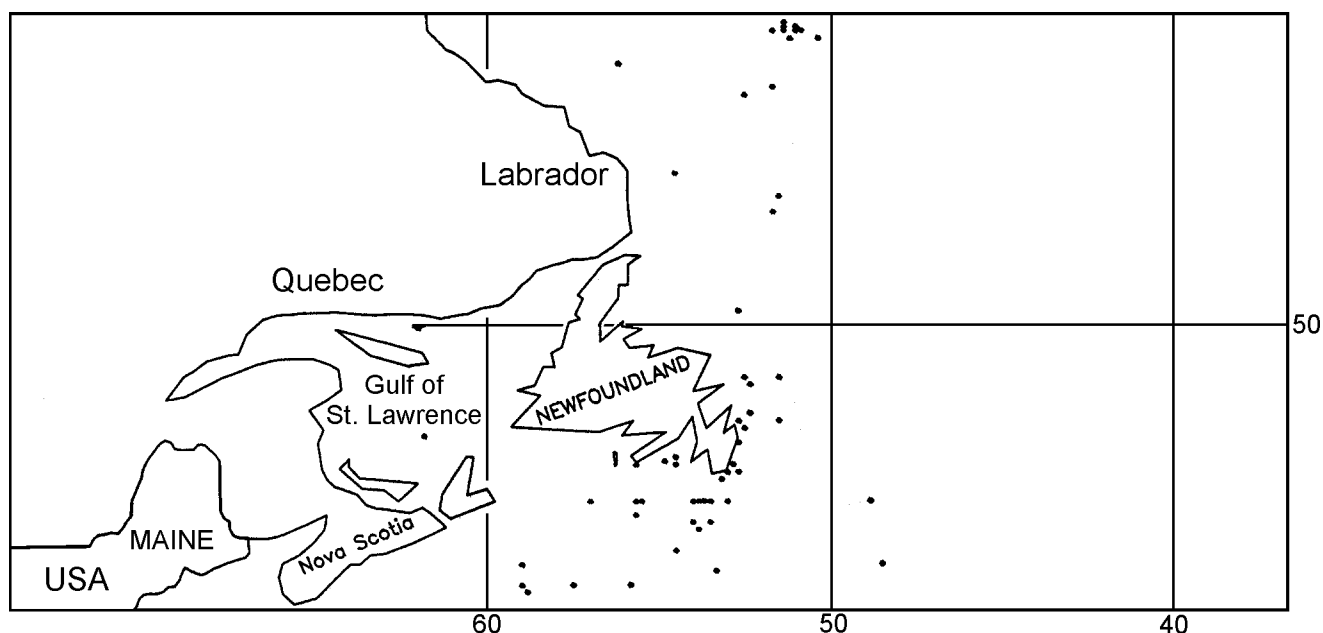


Figure 7. Distribution of long-finned pilot whales off Newfoundland based on sighting data from 1979 to 1982 (Source: Cetacean and Turtle Assessment Program 1982; Payne *et al.* 1991; Waring *et al.* 1992).

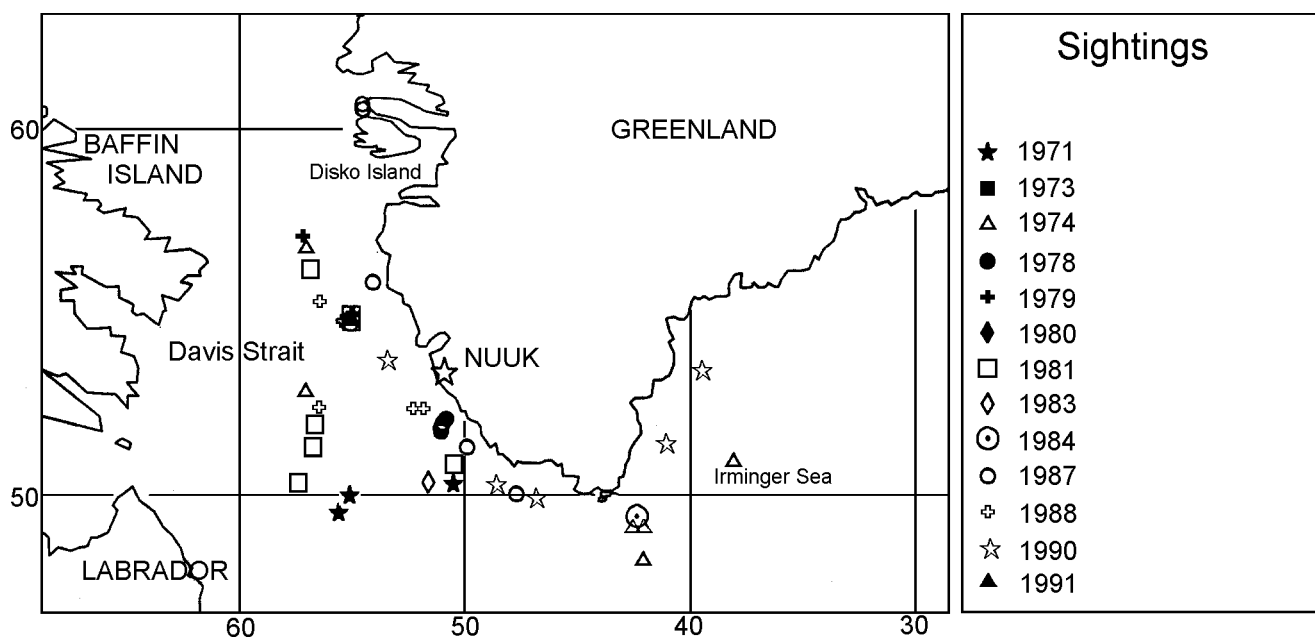


Figure 8. Distribution of long-finned pilot whales off Greenland based on sighting data from 1981 to 1991 (Source: Cetacean and Turtle Assessment Program 1982; Payne *et al.* 1991; Waring *et al.* 1992).

(pers. comm. to Mercer 1967) are consistent with this suggestion.

Pilot whale sightings off Canada have fluctuated, with a recent peak in 1981; however, sightings in the late 1980s and early 1990s have been infrequent (Lynch 1987; Jon Lien, pers. comm.²). During 1979-82, Lynch (1987) reported few sightings of pilot whales off Labrador or the Grand Bank. Sightings and strandings (less than five animals per stranding) of pilot whales have most recently occurred off Nova

Scotia and Prince Edward Island in the early 1990s (Jon Lien, pers. comm.³).

Oceanography and Prey Distribution

Seasonal migrations of pilot whales in Canadian waters may relate to distribution of their prey. The concentration of pilot whales along the eastern coast of the Canadian

Atlantic Maritimes coincides with large aggregations of northern shortfin squid (*Illex illecebrosus*) -- their prime prey in these waters (Sergeant 1962). The arrival of northern shortfin squid in Canadian waters depends on hydrographical conditions, feeding, and reproductive cycles (Sergeant and Fisher 1957; Roper *et al.* 1984). Movement of these squid onto the Scotian Shelf takes place during the spring and summer when water temperatures are increasing. In addition, there is evidence that bottom water temperature influences squid distribution (Scott 1978). The preferred temperature range of the shortfin squid is 5°-15°C (Frost and Thompson 1933).

Adult northern shortfin squid occur over the continental shelf from the southeastern United States to Newfoundland and Labrador during summer and autumn. Black *et al.* (1987) proposed that in late autumn adults move southward to the grounds off Cape Hatteras to spawn.

The inshore movement of pilot whales into bays normally begins in mid-July, and closely follows the movement of northern shortfin squid. The whales arrive shortly after the squid, and leave slightly before the last squid departs in the autumn; no whale sightings have been recorded in Winter (Mercer 1975; Lynch 1987). Lynch (1987) reports pilot whales were sighted off the northeastern and/or northwestern coasts of Newfoundland before the shortfin squid arrived. During the late summer and autumn, vast numbers of shortfin squid inhabit the coastal waters and inshore bays (Squire 1957; Black *et al.* 1987), but most recently, the squid have been absent from Newfoundland waters. The relationship between inshore movement of pilot whales and shortfin squid appears to occur only in the Newfoundland area (Mercer 1975). Shortfin squid have shown almost or complete absence from inshore waters at times, with no detectable regularity (Templeman and Fleming 1953). The failure of squid to enter the bays has resulted in low or no catches of pilot whales (Sergeant and Fisher 1957).

In offshore waters, pilot whales also follow the movements of northern shortfin squid. During the spring and early summer, squid concentrate at the edge of the continental shelf in waters warmer than 5°C. This shelf-edge concentration of squid occurs when overlying cold arctic water impedes the vertical dispersal and horizontal movement of the squid to shallow areas on the shelf (Mercer 1975; Black *et al.* 1987). Within the same time period, pilot whales are widespread off Nova Scotia, Labrador Sea, Gulf of St. Lawrence, and along the edge of the Grand Bank. Throughout the summer, pilot whales feed on shortfin squid that concentrate on the southwestern edge of the Grand Bank (Brown 1961; Sergeant and Fisher 1957; Black *et al.* 1987). Pilot whales are reported to pass through the bank during the autumn, moving to offshore waters that are presumably their wintering grounds (Sergeant and Fisher 1957; Sergeant 1962).

Although northern shortfin squid are the primary prey of pilot whales in Newfoundland, fish are also occasionally taken as prey (Mercer 1975). From 1951 to 1956, Sergeant's

(1962) examination of pilot whale stomach contents revealed only shortfin squid. In late 1957, the rapid disappearance of shortfin squid in inshore waters was followed by the disappearance of most pilot whales. The remaining whales, however, preyed on Atlantic cod (*Gadus morhua*). In 1959, when the squid had begun to return, many whales were still feeding on cod.

Pilot Whale Drive Fishery and Strandings

For several centuries prior to 1900, small harvests of pilot whales were taken in the bays of Newfoundland by whalers and fishermen who drove herds ashore or harvested pilot whales that had stranded (Templeman 1966). Modern commercial whaling began in 1947 and lasted until December 1972 when Canada implemented a ban on commercial whaling. Trinity Bay was the major whale fishery station in Canada. Whales were also taken in Bonavista Bay and in Notre Dame Bay (Sergeant 1962). During the 26 yr of the fishery, approximately 54,000 pilot whales were taken, primarily by driving whales into the shallow bays and killing them by lancing. In 1956, pilot whale kills peaked at 9,799. Subsequently, the numbers killed declined, with only a few hundred taken annually during the late 1960s to early 1970s (Mitchell 1974; Mercer 1975).

Sergeant (1962) concluded that the commercial fishery had no effect on the population, and proposed that the short-term decline of pilot whale landings subsequent to record catches in 1956 was due to hydrographic conditions. Sergeant's conclusion was based on density-dependent factors between shortfin squid and pilot whales. However, Mercer (1975) concluded that the 4-yr period upon which Sergeant based his conclusion was not long enough to influence the generation time of pilot whales which is 6 yr. On the other hand, Mercer (1975) and Mitchell (1974), using the cumulative catch of pilot whales between 1951 to 1961, concluded that the initial pre-exploited population was between 50,000 and 60,000 animals, and that overexploitation was the main cause of the decline of the pilot whale population.

Recent estimates of pilot whale abundance in the Newfoundland/Labrador and Grand Bank region are highly variable. An aerial survey in 1980 of the coastal and off-shore (approximately 100 nautical miles) waters of eastern Newfoundland and southeastern Labrador estimated pilot whale abundance to be between 6,731 and 19,603 animals (Hay 1982). However, an analysis of land and sea-based sighting records from 1976 to 1983 concluded that the abundance of pilot whales off Newfoundland was unknown (Lynch 1987).

Strandings have occurred primarily at Sable Island, Nova Scotia (Sergeant *et al.* 1970; Geraci and St. Aubin 1977). Between 1957 and 1976, approximately 12 strandings occurred on Sable Island ranging from 1 to 130 animals. These whales were probably foraging for prey, and were trapped as the tides receded.

Canadian Summary

Pilot whales have historically been seasonally abundant in Canadian waters, with highest abundances in summer and autumn. Local movements of pilot whales have reflected movements of prey species such as northern shortfin squid. Winter distribution patterns are not well known, but may include areas east of the Grand Bank. The abundance of pilot whales declined in Canadian waters in recent decades due to overfishing, and possibly due to changes in the distribution of preferred prey species. Recent distribution patterns are substantially different than historical ones.

GREENLAND

Information on pilot whales in Greenland waters is primarily from catch statistics and, more recently, from dedicated observations compiled by the Greenland Fisheries Research Institute (GFRI) in Nuuk, Greenland, and Copenhagen, Denmark. Pilot whaling has always been minimal by the Greenlanders, but the catch data provide historical yearly and seasonal information.

Dedicated Sighting Surveys and Catch Statistics

Sightings of pilot whales in Greenland occur annually with the majority of sightings off the western coast south of Disko Island (Figure 8). The sightings have varied from individuals to groups of thousands, but the average group size ranges between 8 and 50 individuals. Only a few observations have been made on the eastern coast of Greenland. This discrepancy could be due to two factors: 1) East Greenland has a substantially smaller human population than West Greenland, and therefore less potential for sighting of pilot whales; and 2) pack ice along East Greenland lasts longer, limiting the access of pilot whales into inshore waters.

The movement of pilot whales appears to be influenced by oceanographic factors. In summer, pilot whales move through Greenland waters using deepwater corridors of 200 m or more (Heide-Jørgensen and Bunch 1991). This northwestern movement coincides with the distribution of pilot whales in northern waters of the eastern North Atlantic around 62°N in August, September, and October, and around 59°N from May through November (Brown 1961).

Because dedicated sighting surveys for cetaceans were not conducted off Greenland prior to the late 1970s, data from catch statistics provide the only historical information on abundance and distribution. The GFRI has compiled whale catch records since 1828 (Table 1). The majority of pilot whale catches have been taken between Nuuk and Disko Island. A few whales have been caught south of

Nuuk but only about 1% have been taken in East Greenland. Most catches occur during June-September (Heide-Jørgensen and Bunch 1991).

Dedicated sighting cruises began in 1979, and since 1987 have been supplemented with aerial surveys (Larsen et al. 1989; Larsen and Nielsen 1990). The distribution of pilot whales from these surveys is consistent with that derived from historical catch data. Over 97% of the sightings have been recorded south of Disko Island.

Oceanographic- and Biological-Related Distribution

There are indications that the abundance of pilot whales off West Greenland is linked to prey abundance and fluctuating ocean temperatures. During periods of low water temperatures in the Davis Strait, no pilot whales were caught (Heide-Jørgensen and Bunch 1991). Sergeant and Fisher (1957) reported that both northern shortfin squid and pilot whales move into the Davis Strait from Canada during warm temperature periods. Historically, shortfin squid have not inhabited West Greenland waters, but have occurred off southern Greenland (Roper *et al.* 1984).

The same factors that influence the occurrence of pilot whales also influence the occurrence of other marine species (Heide-Jørgensen and Bunch 1991). A warm period in the North Atlantic has led to a northward shift in the geographical distribution of many boreal marine animals. These rising ocean temperatures in West Greenland have caused the Atlantic cod population to increase, creating a topodeme that appears to have migration circuits entirely within the local fjords (Baker 1978). Inversely, when the temperatures have decreased, the cod population has declined, as have pilot whale catches and sightings.

Greenland Summary

Historically, pilot whales have never been very abundant in Greenland. A small percentage of whales in Canada may venture northward into Greenland waters. That Greenlanders have never targeted pilot whales as heavily as other cetaceans provides some evidence that the abundance of pilot whales in Greenland has never been large.

As in Canada, the presence or absence of preferred prey may alter the sightings of pilot whales. Water temperature may also influence the occurrence of prey and pilot whales in Greenland waters.

ICELAND

Iceland has been an active whaling nation for many years, and initial sighting information on pilot whales has come from observers aboard whaling vessels. More re-

Table 1. Total number of pilot whales taken in targeted fisheries by month and by region in Greenland from 1828 to 1991¹

Region	Month							Total
	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	
Nuuk to Disko Island	0	0	720	1,735	543	561	0	3,559
Nuuk to Cape Farvel	0	3	325	90	568	0	60	1,046
East Greenland	36	0	52	173	27	275	0	563
Total	36	3	1,097	1,998	1,138	836	60	5,168

¹From Heide-Jørgensen and Bunch, 1991.

Table 2. Pilot whale sightings in Icelandic and adjacent waters between 1981 and 1989

Date	Survey Area	Survey Type	Number of Sightings	Source
Jun. - Jul. 1981	Denmark Strait; Irminger Sea	surface	16	Sigurjónsson 1983
Jun. 20 - Jul. 20, 1982	W, SE, & E Iceland	aerial	0	Hiby <i>et al.</i> 1984
	Denmark Strait; SE-N Iceland	surface	5	Martin <i>et al.</i> 1984
Aug. 1983	Denmark Strait	surface	2	Sigurjónsson 1985
Jun. 27 - Jul. 20, 1986	All waters surrounding Iceland	aerial	7	Gunnlaugsson and Sigurjónsson 1988
Jun. 24 - Jul. 28, 1987 ¹	SE Iceland - Scotland; SW Iceland; Irminger Sea; Denmark Strait	surface	71	Sigurjónsson <i>et al.</i> 1989; Buckland <i>et al.</i> 1993
Jul. 1-20, 1987 ¹	Adjacent waters surrounding Iceland	aerial	3	Donovan and Gunnlaugsson 1989
Jul. 10 - Aug. 14, 1989 ¹	Icelandic and adjacent waters	surface	124	Sigurjónsson <i>et al.</i> 1991

¹Conducted as part of the North Atlantic Sighting Survey. See text for more information on the survey.

cently, researchers at the Marine Research Institute in Reykjavik have collected sighting data from dedicated sighting surveys (Figure 9). Throughout the 1980s, aerial and shipboard sighting surveys covered the mid-North Atlantic area around Iceland and East Greenland.

Sighting Surveys

Sigurjónsson and Gunnlaugsson (1990) provide a detailed account of whale sightings made during 1979-88 from whaling vessels, but these data are biased as sightings of smaller cetaceans were reported with less accuracy than sightings of baleen whales. The sighting data are summarized into two time periods: before and after July 15. This split reflects seasonal whaling times based on the movement of the large baleen whales migrating into Icelandic waters. The frequency of pilot whale sightings increases after July 15 when concentrations appear west-northwest of Iceland. Some whales have been sighted in shallow waters (less than 400 m), but most sightings occur in water between 400 and 1000 m. As in the shelf waters off the United States, there appears to be a relationship between the high concentration of pilot whales found on the Icelandic edge, and hydrographic conditions such as ocean temperature and upwelling (Foerster and Thompson 1985). The North Atlantic Current flows south of Iceland along the shelf edge towards Norway, and likely influences pilot whale movements.

In June and July 1981, a marking cruise for baleen whales took place in the Denmark Strait. Pilot whale sightings occurred off the southwestern and western coasts of Iceland in water depths between 1,000 and 2,000 m. Approximately 500-800 pilot whales were encountered during the 16 sightings of this survey (Sigurjónsson 1983).

Between 1981 and 1989, Iceland participated in joint international surveys of the North Atlantic, including the North Atlantic Sighting Survey (NASS) (Table 2). The NASS began in 1987 when several nations/territories organized joint shipboard surveys that were conducted from June through August that year, and in summer 1989. The area surveyed was bound by Spitsbergen and the Barents Sea in the north, the Spanish coast to the south, the West Greenland coast to the west, and the Norwegian coast to the east. In addition, an aerial sighting survey occurred in 1987 covering the coastal waters of Norway, West Greenland, and Iceland in conjunction with NASS-87 (Hiby *et al.* 1989).

Strandings

Strandings of pilot whales are rare in Iceland. Only two mass strandings are known; one in western Iceland at Rifshofn, and the other in southwestern Iceland at Thorlakshofn. The Rifshofn stranding occurred in August 1982, when a pilot whale school of approximately 280 indi-

viduals congregated near the harbor entrance. The Thorlakshofn stranding occurred in October 1986, when 143 whales stranded along a gradually sloping beach. Only a few stomachs were examined, but all were empty (Sigurjónsson *et al.* 1993).

Icelandic Summary

Pilot whales do not occur on the northern side of Iceland, but regularly appear off the southern coast. Pilot whales prefer the edge of the shelf, with only occasional movements into shallower waters. Pilot whales have a broad distribution pattern in the northern Central Atlantic, and appear to be most abundant in mid-summer.

NORWAY

In Norway, distribution data on pilot whales have come from historical whaling records, incidental sightings, and sighting surveys. These data have been compiled by the Institute of Marine Research in Bergen since 1967. Norway was also a participant in the NASS sighting cruises that covered the northern extreme of pilot whale distribution (Figure 10).

Sighting Surveys and Incidental Observations

Incidental observations of whales within Norwegian waters took place from 1971 to 1975 aboard whaling vessels. Actual sighting effort depended upon the workload of the vessel and the observer. Observations in the Barents Sea occurred during May-June 1973, July-August 1974, and May-August 1975. The only four sightings of pilot whales made during these cruises occurred in the Barents Sea in May 1975 (Christensen 1977). Dedicated sighting surveys were conducted off Norway from 1987 to 1990 in conjunction with the NASS (Table 3).

During summer 1991, several groups of pilot whales were sighted off Lofoten. Animals had been seen in that region for 3-4 yr in a row (Øien 1991b). Strandings of pilot whales are relatively rare, and those reported may have drifted onto Norwegian shores after dying at sea in more southern waters (Christensen 1990).

Whaling Statistics

Whaling for small cetaceans began in the 1920s and spread throughout Norway by the 1930s. Between 1938 and 1974, the number of participating vessels was regulated, and a compulsory catch report system was in place (Christensen 1975; Øien 1991b). In 1950, a closed season

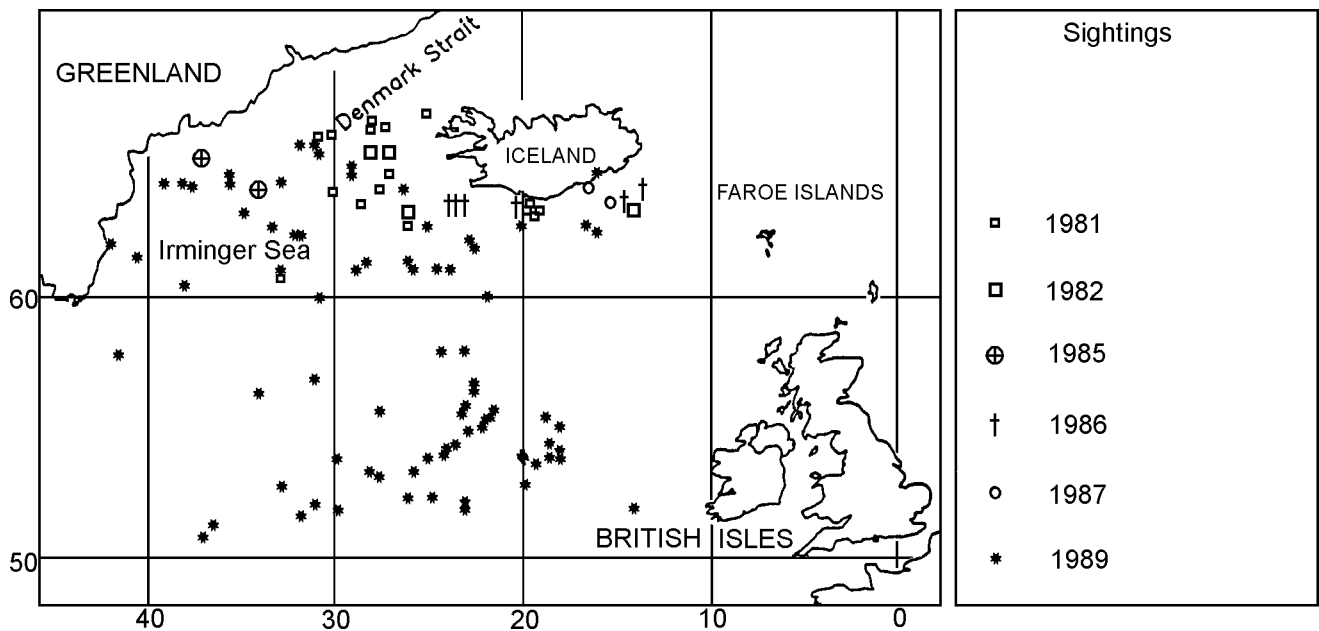


Figure 9. Distribution of long-finned pilot whales off Iceland based on sighting data from 1981 to 1989 (Source: Cetacean and Turtle Assessment Program 1982; Payne *et al.* 1991; Waring *et al.* 1992).

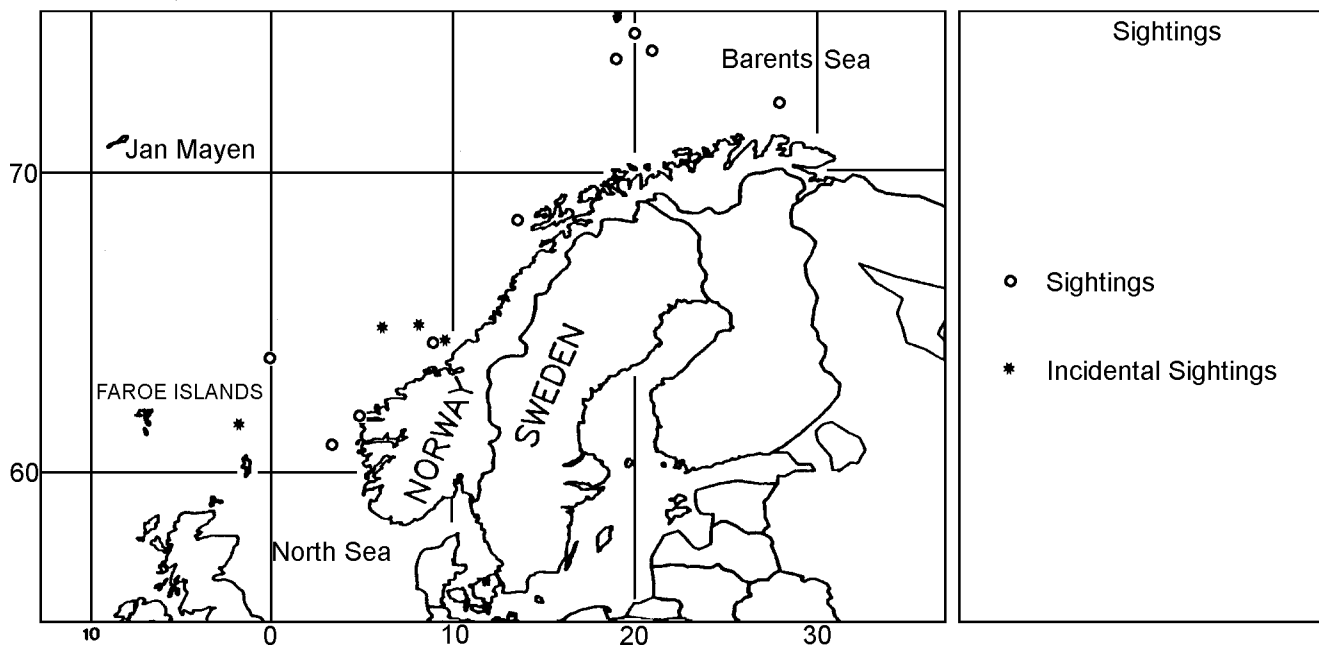


Figure 10. Distribution of long-finned pilot whales off Norway based on incidental sightings from 1971 to 1989 and sighting data from 1989 (Source: Cetacean and Turtle Assessment Program 1982; Payne *et al.* 1991; Waring *et al.* 1992).

was implemented during the first 3 wk of July, with additional time limits administered in subsequent years. Though the catch data reflect these restrictions, the commercial statistics depict in broad terms the patterns of pilot whale distribution. Catch records indicate that pilot whales concentrate in two locations: off Lofoten in northern Norway, and off Møre in southern Norway, primarily in July and August (Øien 1991b).

Norwegian Summary

Pilot whales occur in Norwegian waters, but not in high abundances. Two areas of concentration are indicated by catch statistics: along the western coastline at Lofoten and at Møre, with most catches reported in July and August. Dedicated sighting surveys have revealed relatively few sightings of pilot whales.

Table 3. Pilot whale sightings off Norway from 1987 to 1990

Date	Survey Area	Survey Type	Number of Sightings	Source
1971-75 (whaling vessels)	Barents Sea	Surface	4	Christensen 1977
July 1987 ¹	Barents, Greenland, & Norwegian Seas	Surface & aerial	0	Øritsland <i>et al.</i> 1989
July 1988	Barents, Greenland, & Norwegian Seas	Surface	0	Øien 1990
July 1989 ¹	Barents, Greenland, & Norwegian Seas	Surface	3	Øien 1991a
July 1990	North Sea	Surface	0	Øien 1991b

¹Sightings from North Atlantic Sighting Survey. See text for more information on the survey.

FAEROE ISLANDS

Long-finned pilot whales are commonly sighted around the Faeroe Islands, and have become an integral part of the culture of its inhabitants. A drive fishery in the Faeroes has existed for centuries, with pilot whales being herded into the many bays of the archipelago. An international research effort conducted from 1986 to 1988 to sample whales killed in the drives has provided a substantial amount of information on the life history of this species (Bloch, Desportes, *et al.* 1989; Desportes 1993).

Faeroese involvement in the NASS sighting efforts has provided additional information on pilot whale distribution. Since 1986, whale observers have been placed on commercial fishing vessels to record cetacean sightings. These sightings are being compiled by the Office of the Director of Fisheries and by the Natural History Museum in Torshavn.

Sighting Surveys

Since 1986, observers aboard Faeroese research and inspection vessels have recorded pilot whale sightings (Figure 11) in the Faeroe Islands - Iceland area (Bloch and Hoydal 1988, 1990). During 1987 and 1989, the Faeroese participated in the NASS sighting series with two dedicated sighting cruises. The 1987 survey was in June and July, and the 1989 survey was in July and August. The Faeroese vessel surveyed an area between southeastern Iceland and west-

ern Ireland, bounded by 6°W and 18°W longitude, and 64°N and 52°N latitude. However, no survey activity was conducted inside the 183-m depth contour in the area of the British Isles, Ireland, and Iceland.

There were only 19 sightings recorded during the 1987 survey. Sightings concentrated in three areas: 79% of the sightings were within the Faeroe Islands archipelago, 5% were just northeast of the islands, and 16% were just south of the islands. The 1989 survey had only 11 pilot whale sightings. These sightings occurred west to southwest of the islands (45%) and northwest between the islands and Iceland (55%) (Buckland *et al.* 1993; Joyce *et al.* 1991). The seasonal distribution of pilot whale sightings during these surveys was consistent with the temporal pattern observed during the past 280 yr in the Faeroese drive fishery (Joensen and Zachariassen 1982).

Drive Fishery and Oceanographic- and Biological-Related Distribution

The Faeroese drive fishery is the longest continuously documented harvest of any wild animal, with accounts dating back to 1584 (Hoydal 1987). Although these records contain minor biases, the historical record provides an account of the presence of pilot whales in and around the Faeroe Islands for the past four centuries. The "grinds" or pilot whale drives occur throughout the year, and are most intensive during July through September when pilot whale abundance is highest (Hoydal 1987).

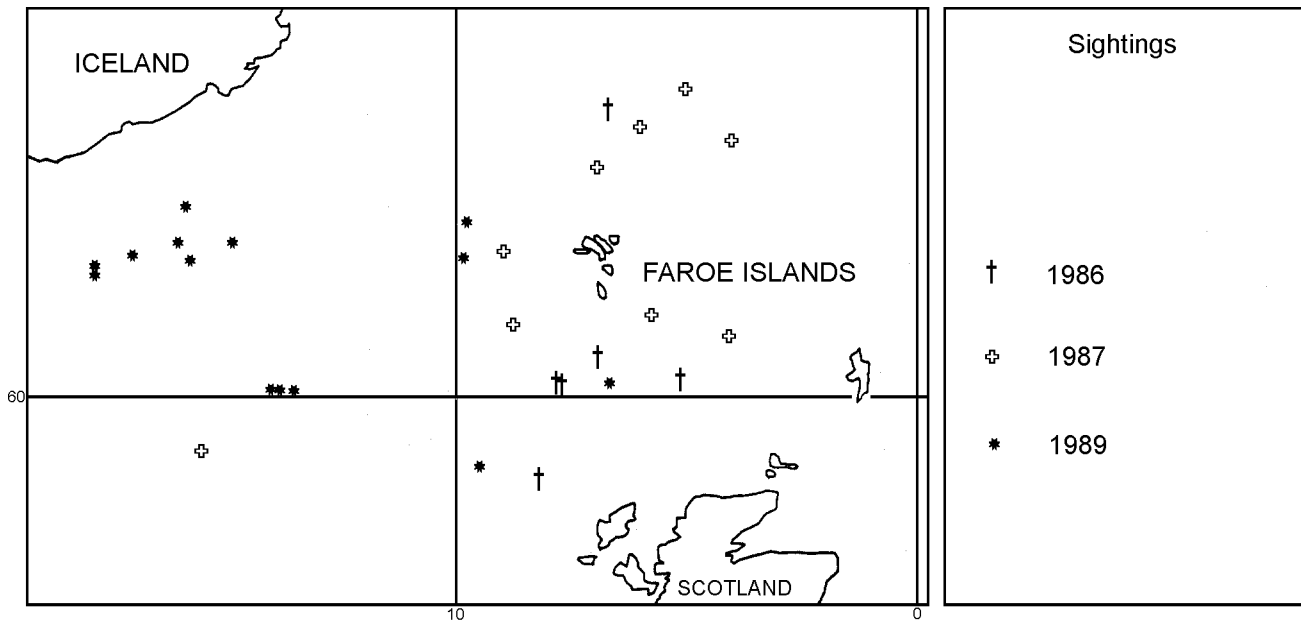


Figure 11. Distribution of long-finned pilot whales off Faeroe Islands based on sighting data from 1986, 1987, and 1989 (Source: Cetacean and Turtle Assessment Program 1982; Payne *et al.* 1991; Waring *et al.* 1992).

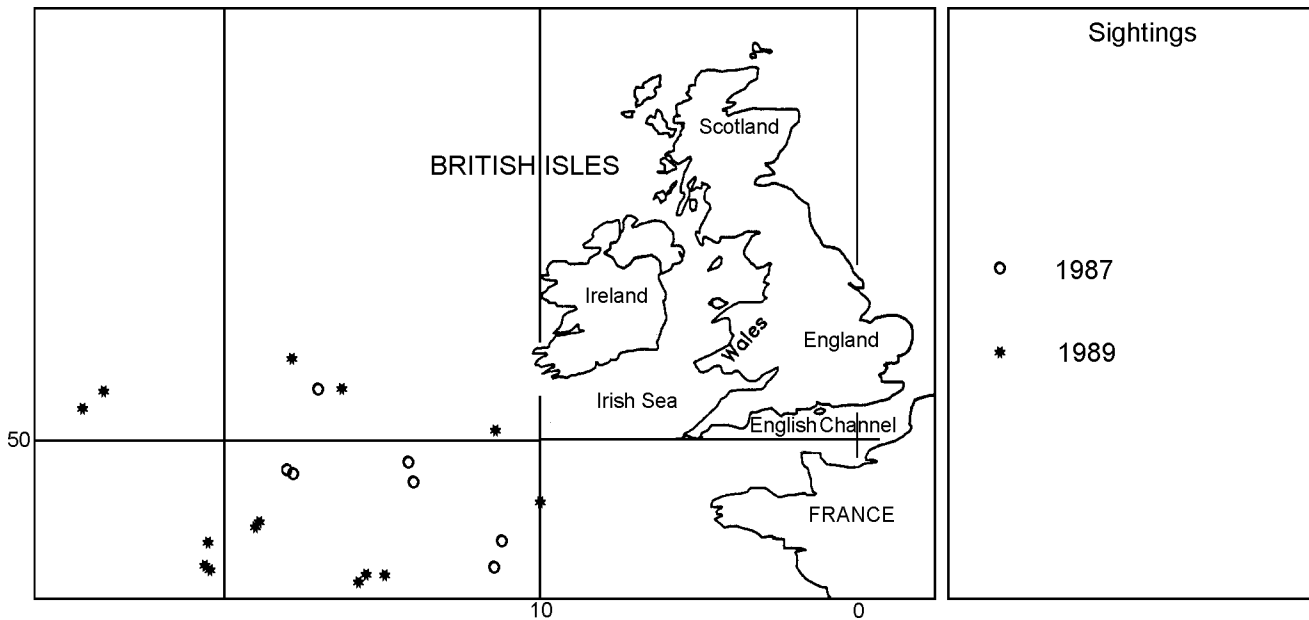


Figure 12. Distribution of long-finned pilot whales off the British Isles based on sighting data for 1987 and 1989 (Source: Cetacean and Turtle Assessment Program 1982; Payne *et al.* 1991; Waring *et al.* 1992).

A positive correlation exists between the occurrence of pilot whales and surface water temperatures (Joensen and Zachariassen 1982; Bloch, Hoydal, *et al.* 1989). As temperatures increase, the available food for whales increases, particularly the European flying squid (*Todarodes saggitatus*) which is the preferred prey of pilot whales in the Faeroese region (Desportes and Mouritsen 1993). This relation is so strong that pilot whales move to deepwater feeding grounds north of the islands in pursuit of other

squid species if flying squid is not available (Desportes and Mouritsen 1993). Hoydal (1987) found a high correlation between the abundance of flying squid and the catches of pilot whales ($r = 0.75$), implying that pilot whales follow their prey. This conclusion is similar to that presented by Sergeant (1962), Mercer (1975), and Heide-Jørgensen and Bunch (1991).

In a comparison of Faeroe Islands and Greenland catch statistics, the peak numbers of pilot whales landed in

Greenland occurred in the 1930s, 1960, and between 1974 and 1980 when sea temperatures had increased. The first and last of those peaks of Greenland landings preceded periods of good catches in the Faeroe Islands, whereas the middle of those peaks in Greenland was at the end of a good catch period in the Faeroe Islands (Hoydal 1987).

Faeroese Summary

Pilot whales occur regularly in the Faeroese archipelago. Movement patterns appear to be related to prey distribution and ocean temperature. If their favorite squid prey is not available, pilot whales leave to feed elsewhere. Most sightings have occurred on the western side of the islands, specifically southwest and northwest of the islands towards Iceland.

BRITISH ISLES

Information on long-finned pilot whales in waters surrounding the United Kingdom and Ireland has historically been derived from incidental observations and from strandings. Spanish and Faeroese vessels surveyed these waters during the 1987 and 1989 NASS sighting series (Figure 12). Recent sighting data have been obtained through the 1994 Small Cetacean Abundance in the North Sea Survey (SCANS), with two sightings south of Ireland and one between the Shetlands and Norway. The 1994 SCANS sought to estimate abundance and identify summer concentrations of small cetaceans in the North Sea. The survey was conducted by the Research Unit for Wildlife Population Assessment at Scotland's St. Andrews University. Weather ships have also reported numerous sightings west of Ireland and Scotland (Anonymous 1990; Evans 1976; G. Desportes, pers. comm⁴).

Land-Based Observations

Sightings of long-finned pilot whales are most common along the northern and southern coasts of Great Britain and the western coast of Ireland, with the highest numbers concentrated off the northern coast of Scotland and the southwestern coast of England (Evans 1976, 1980). During April through June, pilot whales congregate in the Irish Sea, and along the northern and western coasts of England. In November and December, the whales are found off southwestern England and northern Scotland. Pilot whales are present throughout the year off northern Scotland, with peak abundance during March through May. In southwestern England and in Ireland, numbers are highest in April, June, and October. Eastern Great Britain has virtually no sighting records through most of the year, but pilot whales may occur in small numbers in the summer and autumn.

During fall and winter, pilot whales generally disperse into smaller schools. In spring, the whales generally form into larger groups which maintain themselves through September. Pilot whales have usually been sighted individually or in schools of 11-20 individuals. The largest numbers of pilot whales in sighted schools were 75 in April 1977 off northern Wales, and 65 in November 1976 off Cornwall in southern England (Evans 1980). Such high numbers are normally only seen in the drive fishery in the Faeroe Islands during summer. These high numbers suggest that the whales may form large schools at particular times of the year, such as during long migrations or at food concentrations (Evans 1976).

Fraser (1974) suggested that pilot whales occurring in British waters are part of a population occupying the North Atlantic Current. This population has a movement eastward in the late months of the year, bringing the schools to the more southerly parts of the British Isles in winter, but not to the north until spring and summer. During November to December, definite peaks in numbers have regularly occurred in northern Scotland and southwestern England, at least between 1975 and 1980 (Evans 1980).

Since these peaks occur at the opposite geographical ends of the British Isles, the possibility of two separate populations is implied. The northern peak may be the southern extent of the Faeroe Islands population as catches in the Faeroe Islands are concentrated in July and August, with few in winter. Pilot whales appear to be aggregated in waters between the Shetland and Faeroe Islands during much of the summer, but probably move south toward the northern coast of Scotland later in the year (Evans 1980). A relationship may exist between pilot whales reported off France by Duguay (1977) and those observed off the Cornish coasts in November and December, and occasionally in the Irish Sea in April.

Strandings

The majority of observations of pilot whales have occurred from strandings. Strandings are most common on the southwestern coast of England and Wales, and along the Atlantic coast of Ireland (Evans 1980; O'Riordan 1972, 1975; Brown 1975). The number of strandings peaked in 1935, then began a decline along with the catches of sea-food fish species. The dual declines may have been caused by a sea temperature rise and water movements (Southward 1963). Strandings along all coasts of Britain have increased since 1941 (Sheldrick 1976). The frequency of strandings appeared to be correlated with abundance of seafood fish species, although it may also have reflected a high mortality due to lack of prey for the whales (Sheldrick 1976).

Strandings occurred on eastern coasts of Scotland and England prior to 1947. Since then, there has been an increasing number of strandings on the southern and western coasts of the Britain Isles (Evans 1980). The highest

numbers of these strandings have occurred in winter (Fraser 1974). In Ireland, strandings or captures of pilot whales have occurred in every month except September (O'Riordan 1975).

Most occurrences of stranded pilot whales have been single animals; only two large mass strandings have been reported, one with 100 whales and the other with 148 whales. Both of these large mass strandings occurred in spring 1950. Between November 1982 and January 1985, five mass strandings occurred, involving 2340 whales per stranding. Three such strandings occurred in northern Scotland and two in eastern England. The strandings in eastern England indicate that pilot whales will enter shallow areas in pursuit of fish, and may strand while following fish into shoal waters. This behavior appears to be similar to that found in the strandings in Canada and on Cape Cod.

Fraser (1974) suggested that pilot whales move to more southerly parts of the British Isles in winter, but this is not consistent with more recent information by Martin *et al.* (1987) indicating strandings in the north in winter.

British Isles Summary

The waters of the British Isles and Ireland may be a crossroads for the distribution of pilot whales in the eastern North Atlantic. On both ends of the islands, population peaks occur at similar times of the year, suggesting that two separate stocks may frequent these waters. Strandings of single animals are most common, but mass strandings have occurred.

THE NETHERLANDS

Long-finned pilot whales rarely occur off the coast of The Netherlands. Since 1594, there have only been 16 recorded events of pilot whales stranding (Husson and Van Bree 1972, 1976; Smeenk 1986, 1989). All but two strandings involved individual whales; there was one stranding of 61 in 1856 and another of 31 in 1825. Although there may be no direct link between pilot whale abundance and the occurrence of stranded whales, the lack of strandings and sightings suggests that pilot whales do not regularly inhabit Dutch waters.

FRANCE

There have been occasional sightings and strandings, and a few incidental kills in commercial fishery operations, along the coasts of France (Duguy 1977; Evans 1976; Duguy and Hussenot 1982; Anonymous 1988). Pilot whales occur primarily along the Atlantic coast, but are also seen along the eastern sector of the Mediterranean coastline (Duguy 1990). The highest concentration of pilot whales along the Mediterranean coast occurs in July (Vallon *et al.* 1976;

Duguy 1990). During winter, pilot whales may also reside in the Bay of Gascony (Duguy and Aloncle 1975; Duguy 1977). During 1971-76, a total of 16 strandings occurred on French coasts. One pilot whale stranded on the English Channel coast, 12 on the Atlantic coast, and 3 on the Mediterranean coast (Duguy 1977).

SPAIN AND PORTUGAL

Distribution data come mainly from dedicated sighting surveys, as strandings are rare in Iberian waters. Spain initiated the Ballena sighting surveys which were four sighting cruises in the offshore waters of Spain and Portugal during July-September of 1981-82, and was a participant in the 1987 and 1989 NASS multinational survey cruises.

Dedicated Sighting Surveys

Because of coastlines located along the cold waters of the Atlantic and the warm waters of the Mediterranean, Spain provides the varied oceanographic conditions for many species of cetaceans (Casinos and Vericad 1976). Pilot whales are common in Spanish waters, with both shortfinned pilot whales and long-finned pilot whales occurring. Nores and Pérez (1988) suggest the northern limit of the short-finned pilot whale is at 45°N, which is within the Bay of Biscay where long-finned pilot whales have also been sighted.

Two series of sighting cruises were conducted during the 1980s (Figure 13). The four Ballena sighting cruises in 1981-82 lasted upwards of 2 wk per cruise. Sightings of pilot whales from these cruises were all offshore (Aguilar *et al.* 1983; Sanpera *et al.* 1984, 1985; Sanpera and Jover 1986). However, coastal sightings would have been unlikely because none of the survey tracks were inshore.

In addition to the Ballena sighting cruises, additional cruises were undertaken to survey Spanish waters in 1987 and 1989. The NASS-87 cruise, during July 6 - August 3, 1987, covered the areas of western Ireland south to the Iberian coasts. Only 11 pelagic pilot whales were sighted (Lens *et al.* 1989). The NASS-89 cruise, during July 5 - August 9, 1989, covered an area limited by 25°W, the European continental shelf, and between 42°N and 52°N. For survey purposes, the area was divided into two parts consisting of an offshore area and the coastal Bay of Biscay. Pilot whales were widely distributed throughout both areas, but were more frequent in the offshore area. The sightings of whales on the continental slope and in pelagic waters were consistent with sightings made in other surveys. Mixed schools of predominately pilot whales and shortbeaked common dolphins (*Delphinus delphis*) occurred on two occasions (Lens 1991).

Strandings of pilot whales in Spain are a rare event; only four pilot whale strandings occurred during 1973-81 (Grau *et al.* 1986), and these were all on the Mediterranean

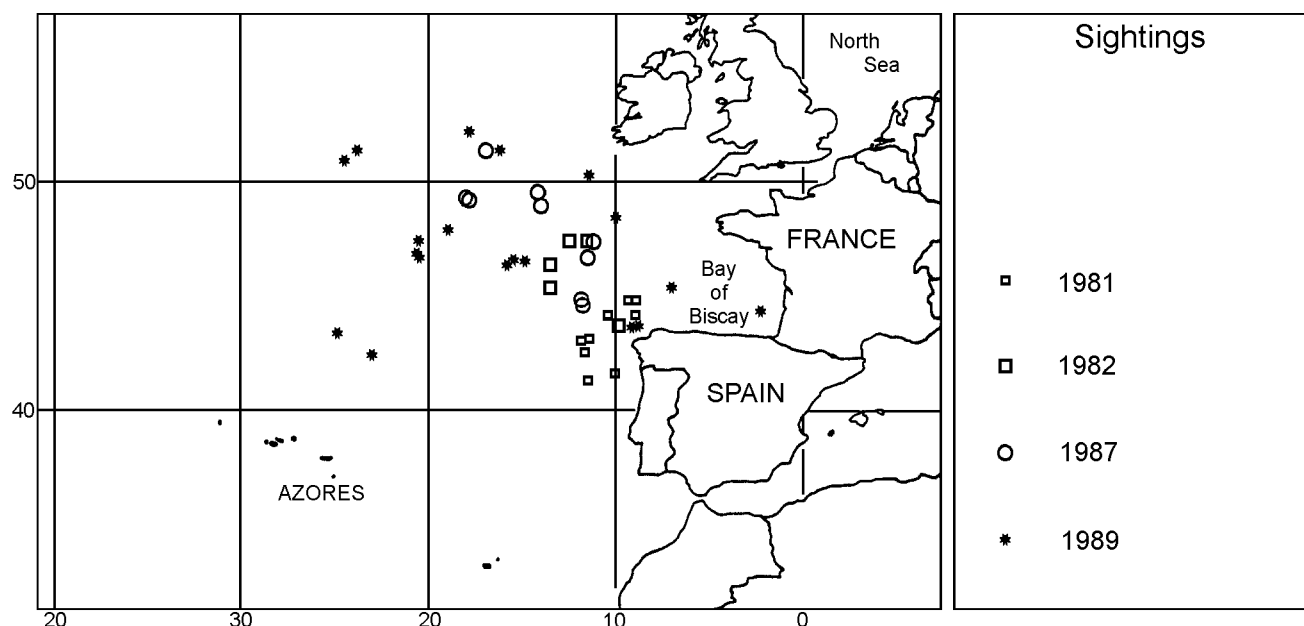


Figure 13. Distribution of long-finned pilot whales off Spain based on sighting data from 1981 to 1989 (Source: Cetacean and Turtle Assessment Program 1982; Payne *et al.* 1991; Waring *et al.* 1992).

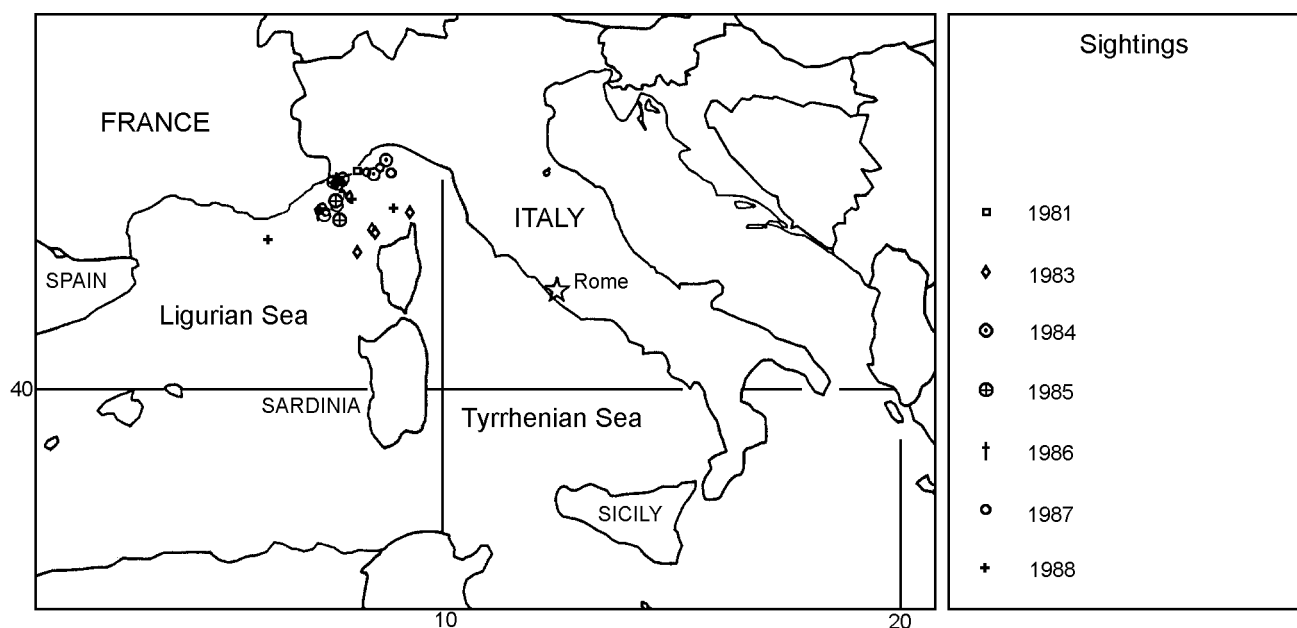


Figure 14. Distribution of long-finned pilot whales off Italy based on sighting data from 1981 to 1988 (Source: Cetacean and Turtle Assessment Program 1982; Payne *et al.* 1991; Waring *et al.* 1992).

coast. There have been no reported strandings of pilot whales in Portugal.

Spanish and Portuguese Summary

The distributions of long-finned and short-finned pilot whales overlap in Spanish waters, with the former species

occurring at least seasonally in the Bay of Biscay. Long-finned pilot whales occur in coastal habitats in the Spanish Mediterranean and the offshore pelagic zones of Spanish Atlantic waters. The pelagic distribution in the eastern Atlantic is consistent with that found in other regions of the North Atlantic, relating strongly to edges and slopes of the continental shelf.

ITALY

The scarcity of literature on cetacean distributions in the Mediterranean has led to conclusions about long-finned pilot whale distribution being founded on occasional strandings of pilot whales and obscure sightings. Although systematic studies of cetacean populations in the Mediterranean Sea are lacking, the most common cetaceans are the common and bottlenose dolphins (Pilleri and Pilleri 1982). Although pilot whale abundance is unknown, it appears that the eastward extent of the distribution of pilot whales in the Mediterranean is in Italian waters; there have been no regularly recorded sightings or strandings in the eastern Mediterranean, Adriatic, or Black Seas (Marchessaux 1980 as cited in Evans 1987; Pilleri and Pilleri 1982; Podestà and Magnaghi 1988).

Within the waters surrounding Italy (Figure 14), pilot whales are considered common, but appear to be locally concentrated in the Ligurian Sea, with undocumented sightings in the southern seas around Sicily (Cagnolaro *et al.* 1983 as cited in Cagnolaro *et al.* 1986; DiNatale 1983). Sightings of pilot whales typically are in waters of 1000 m or more, although they are occasionally very close to the coast (Podestà and Magnaghi 1988). Virtually all of the recorded cetacean sightings have been from crews aboard personal yachts (Pilleri and Pilleri 1982).

There are no records of mass strandings of pilot whales in Italian waters. The stranding events that have occurred have been of individual pilot whales. Many of the whales that have washed up have been decomposed, indicating that they died at sea (Cagnolaro *et al.* 1986; Centro Studi Cetacei 1989, 1990).

Recently, there has been a decline in the number of sightings in areas that were previously regarded as the most populated. This decline sparked a proposal for pilot whale research by the Committee of Marine Vertebrates and Cephalopods of the International Commission for the Scientific Exploration of the Mediterranean Sea (Podestà and Magnaghi 1988).

Bycatches of pilot whales have occurred in the pelagic driftnet fisheries in the Ligurian Sea. In 1988, 10 pilot whales were incidentally caught in the swordfish (*Xiphias gladius*) driftnet fishery. There are possibly more being taken, as many go unreported, die, or sink, or are purposely sunk by fishermen to avoid charges, as Italian law protects cetaceans (Notarbartolo di Sciarra 1990).

Italian Summary

Distribution of pilot whales is concentrated within the Ligurian Sea, based on the limited number of sightings and driftnet bycatch. Unrecorded sightings have occurred in and around Sicily. Individual pilot whales have washed ashore in a decomposed state, indicating death at sea.

DISCUSSION

The long-finned pilot whale is widely distributed in the North Atlantic, with sightings reported in a broad band from roughly 35°N to 65°N in the western Atlantic, and from 40°N to 75°N in the eastern Atlantic (Figure 1). There are no major gaps within this overall distribution where pilot whales have never been reported. Where sightings have been infrequently reported, for example in the central North Atlantic along the Mid-Atlantic Ridge, there has been little searching effort.

The long-finned pilot whale occurs regularly along the continental shelf break, usually in deeper more pelagic waters, but also in the open ocean far removed from continental land masses. It occurs around several islands, especially Greenland, Iceland, and the Faeroe Islands, again at the island shelf breaks in deeper waters.

The distribution of long-finned pilot whales overlaps with that of the short-finned pilot whales along the U.S. coast in the region from 35°N to 40°N, and along the French and Spanish Atlantic coasts from roughly 40°N to 45°N. The distributional overlap in the Central Atlantic is unknown. The relationship of the long-finned pilot whales reported from Spanish and Italian Mediterranean waters to those in the Atlantic is not clear.

A north-south seasonal movement pattern has been suggested for the long-finned pilot whale in nearly all areas, although the Faeroe Islands drive fishery occurs year-round, and in the eastern United States where seasonal sighting surveys have been conducted, animals are present in all seasons (Figures 3-6).

Squid are the preferred prey in all locations where information is available, although Atlantic mackerel and Atlantic cod may also be significant prey items on occasion. Pilot whales may change their distribution patterns as preferred prey species change in abundance.

Directed harvesting of pilot whales has occurred in three main areas -- on Cape Cod, in Newfoundland, and in the Faeroe Islands -- illustrating persistent distribution patterns. At present, a consistent harvest occurs in the Faeroe Islands; aboriginal takes occur occasionally in other areas. Bycatch of this species has occurred in recent years in Atlantic mackerel and squid trawl fisheries of the eastern coast of the United States, and in swordfish drift gillnet fisheries in both U.S. waters and in the Mediterranean Sea.

The species is known to strand naturally, often in large numbers, in several areas, especially along the northern shore of Cape Cod.

One major information gap in our understanding of distribution patterns is the low level of sighting effort in the central North Atlantic, especially seaward of the continental shelf break in U.S. waters, and between 30°W and 50°W between 40°N and 60°N. Another information gap is long-term diet history of pilot whales. Studies by Evans (1980), Desportes (1985), and Desportes and Mouritsen (1993) have

focused on stomach contents, reflecting short-term diet history. Information on long-term diet history of pilot whales of the eastern United States has been reported by Abend and Smith (1995, 1997).

Given the lack of clear breaks in the distribution of pilot whales across the North Atlantic, there is no basis from these data to suggest that there are separate populations in the Atlantic. The situation is less clear between the Mediterranean and the Atlantic. On the other hand, given the occurrence of the species year-round in several distant portions of the Atlantic, there is also no evidence of a single population.

ENDNOTES

1. Available from: Tim D. Smith, National Marine Fisheries Service, Woods Hole, MA.
2. Memorial University of Newfoundland, St. Johns, NF.
3. *ibid.*
4. Museum of Natural History, Torshavn, Faeroe Islands.

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