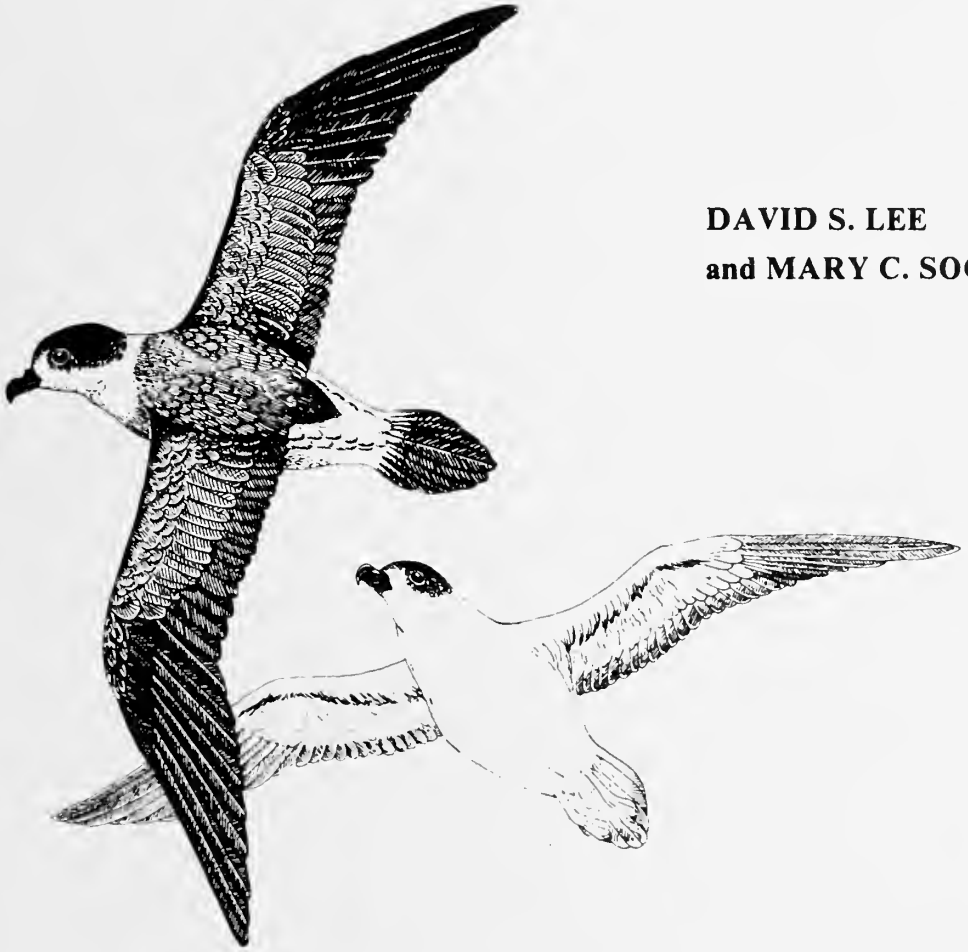
POTENTIAL EFFECTS OF OIL SPILLS ON SEABIRDS AND SELECTED OTHER OCEANIC VERTEBRATES OFF THE NORTH CAROLINA COAST

DAVID S. LEE
and MARY C. SOCCI



Occasional Papers of the
North Carolina Biological Survey
1989-1

NORTH CAROLINA STATE MUSEUM OF NATURAL SCIENCES

PUBLICATIONS OF THE NORTH CAROLINA BIOLOGICAL SURVEY

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Biological Survey publications are distributed by the North Carolina State Museum of Natural Sciences, P.O. Box 27647, Raleigh, N.C. 27611. Checks should be made payable to the NCDA Museum Extension Fund.

ELOISE F. POTTER
Editor

Illustrations by Renaldo Kuhler,
Ruth Brunstetter (manatee), and
Jean Ekwall (title page).

Occasional Papers of the
North Carolina Biological Survey
1989-1
$8, postpaid

ISBN 0-917134-18-4

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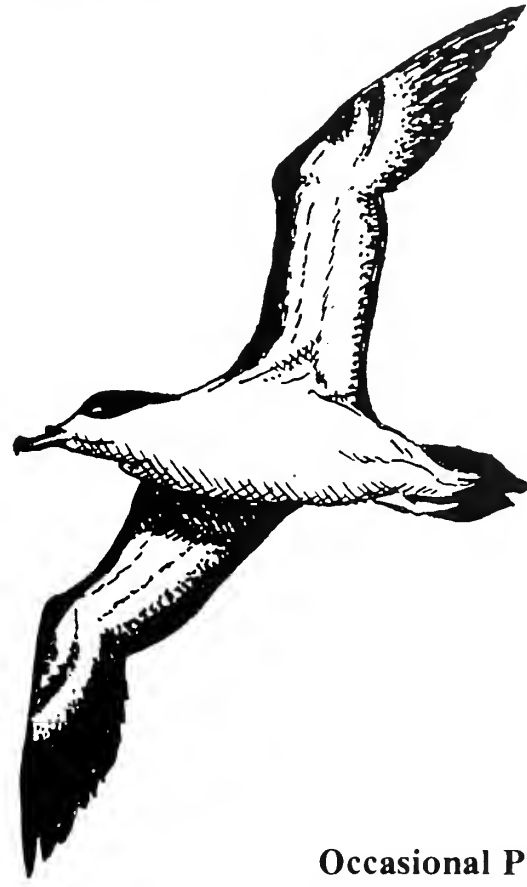

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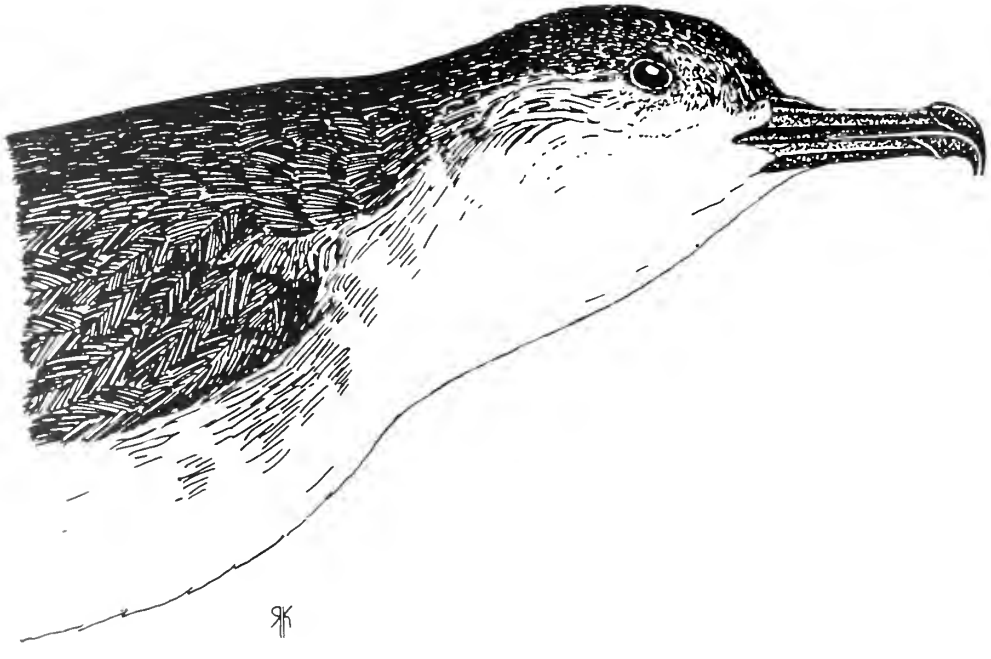

Audubon's Shearwater

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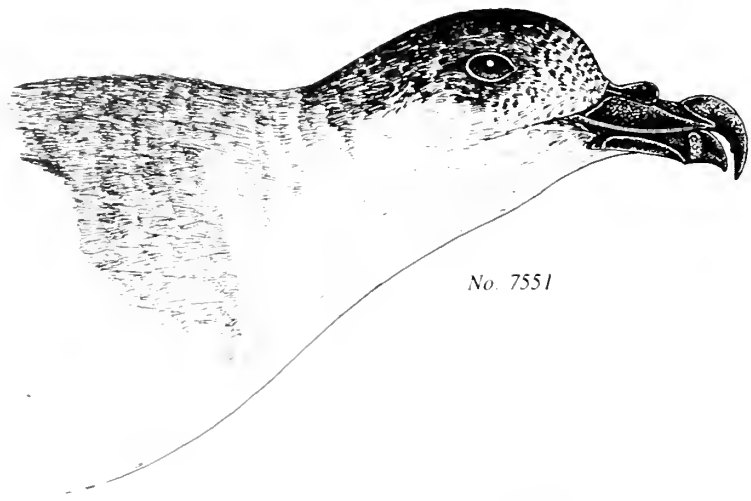
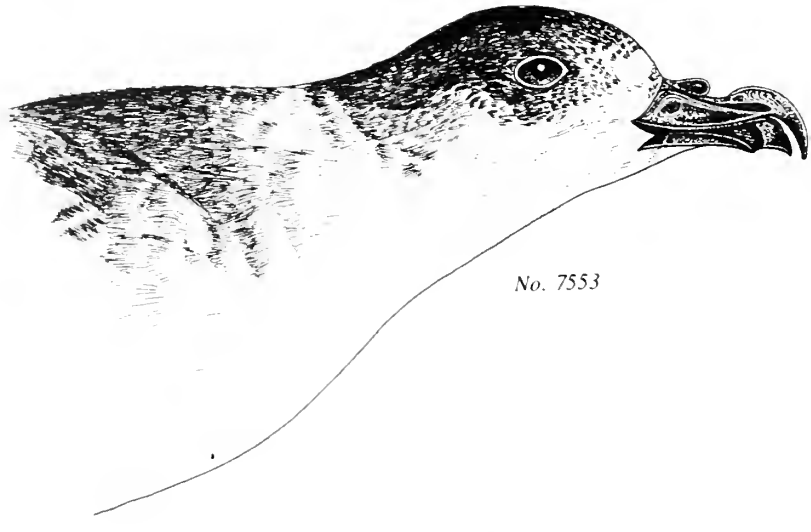
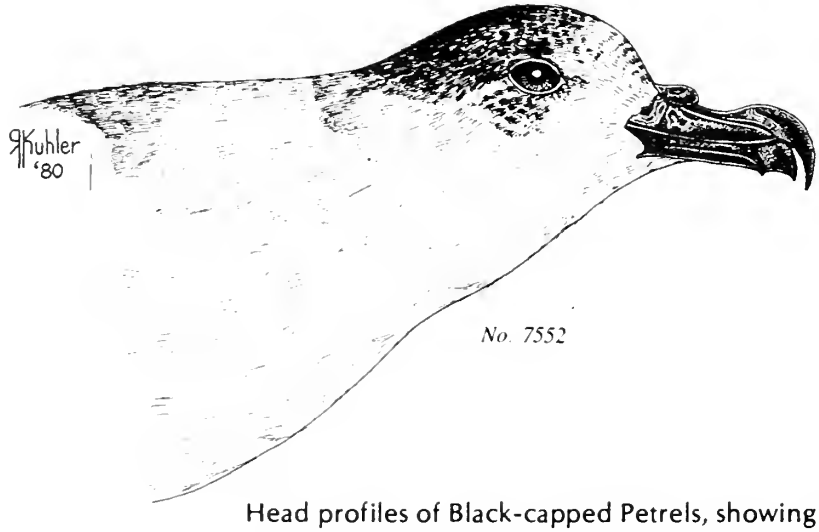






Head profiles of Black-capped Petrels, showing plumage variation from dark (NCSM 7551) to light (NCSM 7752). Note variation in bill shape.

Potential Effects of Oil Spills on Seabirds and Selected Other Oceanic Vertebrates Off the North Carolina Coast

The primary purpose of this report is to delineate the possible detrimental effects of an offshore oil spill[1] on the marine fauna of North Carolina. Understandably, there is much concern about oil reaching North Carolina's beaches and coastal fauna. Unfortunately, the effects of oil on the offshore ecosystem may be even more devastating and less obvious. Many of the offshore fauna, particularly birds, either exist at low populations or have such low reproductive output that population recovery in the event of a kill would be difficult. As will be pointed out, large portions of the total populations of many of these species assemble regularly or seasonally in deep waters off the Outer Banks of North Carolina. Therefore, these species would be particularly vulnerable to oil pollution, and adequate strategies must be developed to protect them if a spill should occur.

Since 1975, the North Carolina State Museum (NCSM) has been studying the marine birds, mammals, and, to a lesser extent, turtles off the coast of North Carolina (Lee 1984, 1986; Lee and Palmer 1981). By chance, the principal study site has been in the general oil-lease area and centered near "The Point," a well-known deep-sea area for sport and commercial fishing southeast of Oregon Inlet. Much of what is presented in this report has been compiled from unpublished information collected during the studies and is on file in the North Carolina State Museum. (Figure 1 illustrates the current oil-lease sites, and Figures 2 through 13 show various monthly observation points recorded during the 14 years of study. Collectively, these figures illustrate the general area of the surveys. Table 1 provides the total number of field days per month devoted to offshore surveys.)

Any group interested in oil exploration or oil drilling off the North Carolina coast must consider the state's unique position in the Atlantic ecosystem. North Carolina has the largest documented marine bird and mammal fauna of any geographic unit in the North Atlantic. In part, the documented diversity is a result of intensive field research. Studies by the NCSM staff have provided some of the most extensive long-term surveys available for any oceanic area. More than one-third of the birds known from the state's offshore waters were first documented by these studies. However, it is primarily the location of the state in relation to tropical and subtropical areas, migration routes, and oceanic currents that accounts for the diversity of species. For example, the winter avifauna is composed essentially of boreal species that winter in or migrate through North Carolina waters. The summer avifauna consists mainly of foraging tropical and subtropical birds or vagrants of species that normally migrate in the eastern Atlantic. Many of these birds, and others discussed in this report, appear to reach either the northern or southern limits of their known or expected ranges in North Carolina waters (Lee and Booth 1979).

Another reason that oil companies must give special consideration to North Carolina's marine avifauna is that most birds have relatively protracted periods of occurrence off the state's shores. There are several factors that account for this, the more obvious of which include (1) local oceanic currents and upwellings that provide important foraging areas for both low- and high-latitude species, (2) extended migratory periods for particular species because of the staggered schedules of various age groups, and (3) a typically long adolescence in some species during which subadults may linger in local waters for extended periods before returning to nesting areas. Therefore, an oil spill in any season could affect a large number of birds.

Several endangered species occur off the North Carolina coast. In addition, many species in the area represent populations of special concern, i.e., they are species whose global populations could be damaged by an oil spill. Although many of the organisms, particularly birds, have not been regarded as endangered by the United States Fish and Wildlife Service, present data suggest possible oversights. Before the NCSM studies, it was not known that significant portions of certain populations concentrate off the Outer Banks, making them particularly vulnerable to kills occurring there. Furthermore, before the threat of oil spills, nothing in their marine environment could be considered immediately harmful.

Appendix I and Appendix II provide complete lists of the marine birds, mammals, and turtles presently known from North Carolina.

[1]The dispersants used to clean up oil spills will not be discussed extensively in this report. It should be noted, however, that dispersants may be as harmful as petroleum to marine birds, mammals, and turtles. Dispersants may not be a viable means of oil control because of their potentially harmful effects.

FORMAT

Relevant data for each of the 25 species of concern are provided. Each species account includes information regarding status in North Carolina, status according to the U.S. Fish and Wildlife Service, world and local populations, seasonal and oceanic zones of local occurrence, feeding habits, and susceptibility to pollution. The rationale for concern or other factors that may relate to species vulnerability are included where appropriate. Additional information is provided under remarks. Tables 2 and 3 summarize factors regarding susceptibility to oil pollution and season of greatest concentration, which is also the season of greatest vulnerability for each species.

Maps indicating sightings of some species are provided (Fig. 16, 18, 20, 34-37). The sightings were mapped from LORAN readings taken over the 14 years of study. The information may reflect accurately the zones of occurrence for most birds; which are conspicuous and easily speciated. Marine mammals and turtles, on the other hand, are difficult to identify and observe, and, maps of their occurrence are problematic. None of the maps takes into account seasonal variations of occurrence, and none shows distributions outside the study area. Analysis of data from the NCSM study area (Fig. 2-13) and other sources shows that the species are neither evenly nor randomly distributed and that different species occupy different oceanic areas and zones.

Nearly all the local distributional information is from NCSM studies. Some data have been incorporated from Schmidly (1981), since aerial observations are more effective than surface studies in locating marine mammals. Data on stranded or beached birds and mammals are not included because they do not necessarily reflect the normal zone or season of occurrence. Clapp et al. (1982) is the primary source for information on susceptibility to oil pollution for each species of bird. The museum does not profess any expertise in this area, since the museum's studies have not included any primary research on the effects of oil on marine fauna. All of the species discussed are represented by specimens and supporting information at the N.C. State Museum or by documentation in the appropriate literature.

PREVIOUS OIL SPILL RESEARCH IN THE SOUTHEAST

Although oil spills have occurred in the Southeast, little information on the effects of oil on the seabirds and other fauna of this area has been recorded and reported. Clapp et al. (1982) attempted to examine the effects of oil on seabirds of the Southern United States. They found only two reports in which there was even minimal information on the number and species of birds killed by major oil spills in the Southeast. The first incident analyzed by Clapp et al. (1982) involved 80 to 100 tons of oil spilled when the Greek tanker *Delian Apollon* ran aground in Tampa Bay in mid-February of 1970 and ruptured its hull (Wallace 1970, Clark 1973). At least 4,500 birds were brought to cleaning and rehabilitation stations as a result of this spill (Sims 1970). As many as 9,000 birds may have died (Clark 1973). Birds brought to cleansing stations were largely ducks, Common Loons, and Red-necked Grebes (Sims 1970).

The second spill occurred in early February 1976 in the lower Chesapeake Bay. About 250,000 gallons of No. 6 fuel oil entered the bay following the sinking of a barge near the mouth of the Potomac River (Roland et al. 1977). Subsequent movement of the oil resulted in the widespread contamination of marshes and beaches. Roland et al. (1977) estimated that 20,000 to 50,000 birds were killed. Horned Grebes accounted for more than half the dead birds counted which is one of the largest known losses of the species to oil. Sea ducks, diving ducks, and Common Loons dominated the remaining losses, but Whistling Swans, Black Ducks, Canada Geese, Double-crested Cormorants, and other species were also killed.

Other oil spills that have occurred in the southern United States, such as the recent spill off the Texas coast, have not been adequately documented for biological study.

EFFECTS OF OIL ON MARINE BIRDS

The primary effect of oil and oil dispersants on birds is the loss of buoyancy and insulation when the feathers become matted (Clapp et al. 1982). Contaminated birds must struggle to stay afloat, and they may quickly chill and die from exhaustion and exposure. Because of the loss of insulation, birds polluted in cold weather or in cold water have a much higher fatality rate than those contaminated in warm weather and in warm water. Although small amounts of oil may lead quickly to death in cold climates (Levy 1980), birds in warmer areas may survive the same degree of pollution (Clapp et al. 1982). Reports from Europe (Bourne and Bibby 1975, Riisgard 1979) indicate that mortality from oil pollution is greater in winter than in summer. Many researchers have focused on the effects of oil on temperate and northern bird species; however, it should be noted that tropical birds have been neglected in the studies. Tropical birds lack the insulation of the cold-water birds and may succumb to oil-induced heat loss at milder temperatures. In addition, all marine birds are particularly susceptible to oil pollution when they are molting. When birds lack their normal insulation, a smaller than usual amount of oil may rapidly cause hypothermia and death.

Birds that ingest oil may suffer a variety of physiological disorders as well as increased mortality (Clapp et al. 1982, Eastin and Murray 1981). Small amounts of oil will reduce the hatching success of duck, heron, gull, tern, and auklet eggs (Eastin and Hoffman 1978, Stickel and Dieter 1979, Ainley et al. 1981, Hoffman and Eastin 1981). Clapp et al. (1982) reported that the direct toxicity of oils is greater for newly laid eggs than for those further along in incubation, and that contamination of eggs at any stage may result in dead or deformed chicks. For example, significant egg mortality occurs when the polluted feathers of the parents come in contact with the eggs. Those chicks that do survive may exhibit deformed bills, incompletely ossified wing or foot bones, abnormally small liver lobes, stunted growth, and other abnormalities (Stickel and Dieter 1979).

Healthy chicks that are contaminated after hatching also suffer ill effects. In one experiment, Herring Gull chicks at Little Duck Island, Maine, were fed 0.2 to 0.5 ml of weathered oil. The chicks grew more slowly for 7 to 9 days after treatment than did controls fed 1 ml of corn oil (Butler et al. 1973). Chicks fed 0.2 ml of crude oil recovered within 2 weeks, but those fed 0.5 ml showed reduced weight gain for about 3 weeks after the initial dosing. Both of the groups fed crude oil also exhibited decreased culmen growth (Butler et al. 1973).

Breeding birds are also affected by oil. Oil in the vicinity of breeding colonies may diminish reproductive capabilities by decreasing the hatching success of contaminated eggs, by disturbing nesting and mating birds (Bourne 1976), and by debilitating birds so much that they may not attempt to breed (Stowe 1982). Studies have shown that the number of eggs laid by Mallards decreases when they are fed diets containing 2.5% crude oil (Eastin and Hoffman 1978, Stickel and Dieter 1979).

In addition, the loss of one member of a breeding pair may mean complete loss of the mate's reproductive potential for that year. Although the loss may be recouped in future generations, most populations of marine birds take years to recover from a single exposure to oil as Ford et al. (1982) recently illustrated. Ford et al. (1982) developed a mathematical model that examines the effects of oil spills on breeding populations of seabirds by using Common Murre and kittiwake populations in the Bering Sea as paradigms. Their model suggests that a catastrophic mortality of adults requires a longer recovery time for a population than does a similar mortality of young. They found that a loss of all infant Common Murres in one year would have a smaller effect on the population's recovery time than would a 5% mortality of adult Common Murres. A small decrease in adult survival or fecundity greatly increased the amount of time required for the affected population to recover. Although Common Murres are birds highly susceptible to oil pollution, the results are probably applicable to other species with high adult survival rates. [High adult survival rates have been shown for several species that occur in the Southeast, including Northern Fulmar, Manx Shearwater, Herring Gull (Dunnet 1982), and Common Tern (DiCostanzo 1980). Likewise, high adult survival rates are likely to occur in all Procelliformes and in all species of gulls and terns breeding in the Southeast.] Ford et al. (1982) also pointed out that current chronic low-level pollution has stressed many bird populations to such an extent that they may not be able to recover from a single catastrophic polluting event.

The actual contamination of birds may occur in several ways, and differences in behavior among species may affect their level of vulnerability to oil. For example, Bourne and Devlin (1969) suggested that most mortality from oil pollution occurs when roosting or feeding birds encounter drifting slicks. Birds that concentrate in flocks of 1,000 or more and scavenge behind fishing trawlers (e.g. gannets and gulls [Powers et al. 1980]), may be especially vulnerable, since they may be attracted to the human activity in the area of an oil spill. This could result in disproportionately large numbers becoming contaminated.

Other birds may actively choose to land on oil slicks, which may account for some of the very high oil-related mortalities reported for the Oldsquaw, a diving duck. Similarly, Common Murres, which dive to escape floating oil, risk surfacing in the oil and becoming severely contaminated (Bourne 1968). Behavioral studies of some diving ducks (Tufted Duck and Pochard) indicate that they avoid patches of oil (Hainard 1959). Gulls (Bourne 1968) and Manx Shearwaters (Casement 1966) actively avoid landing on oil slicks. Some of these birds also avoid oil when swimming; a Herring Gull and a Black-legged Kittiwake that swam into a patch of floating oil immediately took flight (Bourne 1968, Bourne and Devlin 1969).

The number of birds that die following an oil spill is also related to the type of petroleum spilled and how long it remains in the environment. Oil spilled in cold water remains a liquid longer than in warm water and, as a result, is likely to cause more damage. Crude oil is less toxic than refined oils (Hay 1979), and fresh oil causes more damage than older, weathered oils (Bourne and Bibby 1975). Although some oils are so innocuous that birds are able to clean it from their plumage (Birkhead et al. 1973, Phillips 1974), spills of these substances are rare. It should be emphasized that a majority of oil spills have potentially devastating effects.

The number of deaths following an oil spill is not necessarily related to the amount of oil spilled; large spills may result in few deaths, whereas small spills may

cause large losses, particularly when substantial numbers of birds are concentrated in a small area (Croxall 1975, Salomonsen 1979).

In addition to the previously documented effects of oil drilling and oil spills on marine birds, North Carolina's offshore bird populations may be threatened in other ways. For example, some pelagic birds and migrant land birds are known to be attracted to offshore rigging as perches and are known to use established offshore roosting sites for resting. Certain gulls and terns, all species of boobies, and many migrant land-based birds, including Ospreys and Peregrine Falcons, regularly use offshore rigging for roosting or resting between foraging excursions. Oil-rigging artificially attracts birds to areas likely to contain spills and pollution, thereby increasing a bird's risk of contamination.

Petrels, storm-petrels, and other Procelliformes, as well as land-based birds that make nocturnal transoceanic flights are attracted to lights at night. [See Lee and Horner (1989) for a list of migrant land birds documented from the offshore waters of the Carolinas.] These birds are normally injured or killed when they fly into lighted structures. The petrels (Black-capped and Bermuda) are particularly threatened by lights. Permanent lighted structures, and possibly gas flares, would certainly exact a steady toll on their populations. Because the oil lease sites are located in a major, and possibly the foremost, foraging site for the world's population of the Black-capped Petrel, and possibly the Bermuda Petrel, the lights could quickly lead to the demise of either or both species.

Most seabirds are opportunists who converge on schools of feeding fish, oceanic upwellings, and other constantly changing marine conditions. Kills of marine organisms by oil pollution could attract large numbers of seabirds, whose consumption of these poisoned organisms could result in additional fatalities. Some seabirds (jaegers, Black-capped Petrels, storm-petrels, and some shearwaters) are attracted to, and hunt on, water surfaces covered with the natural oils of sounding whales and the activities of surface-feeding fishes. It is likely that these species would be curious about petroleum spills, which would look similar to natural oils. Storm-petrels feed on oily oceanic waxes, and it is known that they will ingest surface petroleum oils (presumably by chance and not by choice). Seabirds that hunt visually are often attracted by activities of other birds, often from considerable distances. It is likely that birds crippled by oil contamination would attract other birds, which, in turn, would attract still others.

Many species regularly hunt along oceanic fronts where currents of different speeds collect and transport sargassum and cause local, fertile upwellings (see Haney and McGillivary 1985). It is likely that even small amounts of oil would align along these fronts and be transported for miles. Many of these fronts form regularly between the 100 and 1,000 fathom contours at all seasons. Here, the oil could be concentrated into the narrow feeding corridors that attract sea birds.

Oil would also be ingested during routine feather maintenance. Seabirds, in particular, preen more frequently than most birds because they must maintain their buoyancy. Furthermore, preening, and hence, ingestion of toxins, becomes more frequent when feathers are contaminated.

Finally, the seabirds off the North Carolina coast are already under stress. Unusually high mercury loads have been documented in two species, Black-capped Petrel and Royal Tern (Whaling et al. 1980), and many species are ingesting large quantities of plastic, foam rubber, and styrofoam (NCSM unpublished data). The introduction of petroleum oils or dispersants to the digestive systems of seabirds would be an additional burden that they probably could not survive.

EFFECTS OF OIL ON MARINE MAMMALS

Oil spills do not affect marine mammals the same way they do birds. Engelhart (1985) listed the effects on marine mammals as follows: physical fouling, thermal imbalance, changes in enzymatic activity in the skin, interference with swimming, eye irritation and lesions, contamination of young, and occasional mortality. Most of Engelhart's work concerns fur-bearing marine mammals and not whales or dolphins. Whale specialists at the Smithsonian were not aware of any whale or porpoise mortality directly attributed to oil spills (Dr. James Mead, personal communication, April 1989). Of greater concern would be the possible long range contamination of foraging habitats and the corresponding loss of prey.

Appendix II lists the marine mammals known from North Carolina waters. Accounts on pages 24-25 provide further information on species of concern.

EFFECTS OF OIL ON MARINE TURTLES

All four species of marine turtles of the Atlantic occur off North Carolina. They are all federally Endangered or Threatened, but only Leatherbacks and Loggerheads occur with regularity in North Carolina. Little information on the effects of oil pollution on marine turtles is available; however, reports indicate that sea turtles may be very vulnerable to oil spills. Sea turtles do not avoid oil slicks, and physical contact with, and ingestion of, oil has been described as causing dermatological damage, detrimental respiratory changes, a decrease in digestive efficiency, hematological damage that elicits a profound immune reaction, and a decrease in the efficiency of the salt gland, which maintains

osmotic and ionic balances (Lutz 1985). In addition, although no published records exist, there are accounts of young sea turtles eating tar balls and dying as a result (D. Crouse, personal communication, May 1989). Contamination of nesting beaches would, of course, have major detrimental effects, but the beaches of northeastern North Carolina support only sporadic nesting attempts by Loggerheads.

Appendix II includes a list of marine turtles known from North Carolina. Their marine distributions have been discussed by Lee and Palmer (1981). Pertinent data on the four species appear on pages 26-28.

SIGNIFICANCE OF OIL SPILL MORTALITY

It is important to recognize, and to differentiate between, biologically significant mortality and the human emotional concerns associated with numerically large kills. Although it is reasonable to expect oil spills to produce highly visible mortalities along beaches, most of these dead birds would be the common, wide-ranging gulls, terns, and sea ducks. These fatalities would have little impact on local or global populations. Conversely, the death of only a few thousand individuals, particularly in offshore environments, would not be visible and, therefore, would not trigger the same emotional response. However, contamination of many of the offshore species, Procellariiformes and Pelecaniformes in particular, with small populations, long adolescent periods, low reproductive rates (usually one egg per year), and low survival rates of young, could cause catastrophic and irreversible depletion of their populations.

Furthermore, most of North Carolina's offshore birds occur in highly biased age and sex ratios (Lee 1988). For example, the Northern Fulmar occurs off the North Carolina coast in a 2:1 female-to-male ratio with 95% of the birds immature. Seasonal variation in age classes and sex ratios has also been recorded for most other transoceanic and transequatorial migrants (see Fig. 14) as well as for local coastal species (Lee 1988). A biased sex ratio leads to many unmated birds in the surviving portion of the population, which further inhibits population recovery; therefore, as mentioned previously, modest mortality among adults is more significant than a large mortality among young.

As noted in the species accounts, most of the taxa of concern are species with limited distributions and small populations, or local races and stocks with small populations. Sooty Shearwaters, for example, are extremely abundant throughout the Pacific; however, if the Atlantic stock were destroyed, it would not be replaced by Pacific birds. Thus, even when other populations exist, local stocks may be genetically separate and irreplaceable.

ZONATION

Locally, seabirds, marine mammals, and marine turtles occupy distinct zones. The dependence upon the zones varies from species to species and, in some cases, shifts seasonally. The general zone of each species is discussed in the species accounts. Although most species are not exclusively confined to a particular zone, clear preferences exist. (Examples are provided in Table 4 and in Figures 15, 17, and 19.)

Oil on the ocean surface would present different problems in different zones. In areas adjacent to the coast (<10 fathoms), the greatest danger would be to species that live on the coastal fringe and in shallow water. Here, loons, gannets, Piping Plovers, and nesting seabirds would be particularly threatened. In 1988, Parnell (personal communication) inventoried the waterbirds with nesting colonies on beaches and barrier islands in North Carolina. At that time there were 41,483 nesting pairs, an important portion of the total nesting seabirds of the western North Atlantic. Species composition was as follows: Brown Pelican (2,426 pairs; this species is regarded as one of Special Concern in North Carolina), Laughing Gull (18,974 pairs), Herring Gull (965 pairs), Gull-billed Tern (153 pairs; Special Concern), Royal Tern (11,794 pairs; regarded as Vulnerable in North Carolina), Sandwich Tern (1,465 pairs; Vulnerable), Common Tern (2,610 pairs; Vulnerable), Forster's Tern (933 pairs; Vulnerable), Least Tern (1,515 pairs; Vulnerable), and Black Skimmer (643 pairs; Special Concern). (The conservation status of these birds is based on Lee and Parnell [in press].) Although many of these birds do not nest on beach fronts, most forage regularly along beaches. Contamination of beaches by summer oil spill would have devastating effects on these birds.

The zone from 10 to 40 fathoms is broad and relatively devoid of seabirds and marine mammals. The only critical species found here regularly are marine turtles and Common Loons. The latter are present only from late October to early May. Oil spills and cleanups in this zone would have the fewest harmful effects on oceanic life.

The shelf-edge zone (40-100 fathoms) supports the largest number of species. Typical inhabitants include Northern Fulmars, Cory's Shearwaters, Greater Shearwaters, Manx Shearwaters, Audubon's Shearwaters, Wilson's Storm-Petrels, phalaropes, jaegers, Black-legged Kittiwakes, Bridled Terns, Spotted Dolphins, and Bottlenosed Dolphins. Because the edge of the Gulf Stream typically flows over this zone, large numbers of marine animals are likely to come into contact with spilled oil here.

The pelagic zone (100 fathoms and beyond) is dominated by the Gulf Stream. Most of the birds and

mammals listed in the shelf-edge zone also occur in this deeper zone. Species that are common here include Black-capped Petrels, Band-rumped Storm-Petrels, Sooty Terns, Short-finned Pilot Whales, and Sperm Whales. Oil spills here and in the shelf-edge zone would present the greatest danger to most of the species of primary concern.

PHENOLOGY

Different faunal assemblages and, in some cases, different age and sex ratios of the same species occur off North Carolina at different seasons. (Figures 21-31 show compositions of bird fauna between 20 and 1,000 fathoms. Figures 32 and 33 show seasonal distributions of marine birds and mammals.) The season in which an oil spill occurs would determine the species affected. Marine birds provide an excellent example of the seasonal variation in fauna. In general, December through March is dominated by species that nest in the northern hemisphere (e.g. Northern Fulmar, Manx Shearwater). The summer fauna is composed largely of tropical species with small, vulnerable populations (e.g. Bridled Tern, Audubon's Shearwater), plus spring and fall migrants (e.g. phalaropes, skuas, jaegers). Both the young and the adults of tropical nesting species normally vacate nesting areas once the breeding season is completed and move to areas having a higher productivity of marine organisms, such as the cooler waters farther north. A great abundance of food probably accounts for the number of tropical birds and the seemingly large concentrations of some relatively uncommon species observed off the North Carolina coast. Explosive migrants such as Sooty Shearwaters and Greater Shearwaters, which pass a given point in vast numbers during only a few days, would be quite vulnerable to an ill-timed oil spill, even though it might be cleaned promptly. Protracted migrants, such as jaegers and phalaropes, would not be highly vulnerable to promptly cleaned spills.

ENDANGERED AND VULNERABLE SPECIES

Endangered

The following species, considered Endangered or Threatened by the U.S. Fish and Wildlife Service or known to be Endangered on a global basis, occur in the oil lease area. All could be severely affected by oil spills off the North Carolina coast (see species accounts on pages that follow).

Black-capped Petrel
Bermuda Petrel
Peregrine Falcon
Roseate Tern

Highly Vulnerable

The six species listed below are considered to be highly vulnerable to local oil pollution. Though none is considered Endangered or Threatened, all are represented by populations that are either small and genetically isolated (most recognized as indigenous subspecies), or abundant with much of the global population seasonally concentrated off the North Carolina coast (see species accounts on pages that follow).

Greater Shearwater
Sooty Shearwater
Audubon's Shearwater
Band-rumped Storm-Petrel
Masked Booby
Bridled Tern

Vulnerable

The following four species could experience considerable population decline resulting from local oil spills, since a large percentage of their total populations seasonally occurs off North Carolina. In the case of the two tropicbirds, the small numbers that have been documented from local waters may, in fact, represent a significant portion of small and declining populations. Nevertheless, it does not seem likely that oil spills in coastal North Carolina waters could reduce populations of these species past the point of recovery (see species accounts on pages that follow).

Common Loon
White-tailed Tropicbird
Red-billed Tropicbird
Northern Gannet

General Concern

Of general concern are the locally nesting seabirds. None of these is considered Endangered on a global level, but eight of them are considered of Special Concern or Vulnerable by the state of North Carolina (Lee and Parnell [in press]): Brown Pelican, Gull-billed Tern, Royal Tern, Sandwich Tern, Common Tern, Forster's Tern, Least Tern, and Black Skimmer. The extent of oil-induced mortality on these nesting populations would depend on locations and seasons of spills and success of cleanup operations.

Species With Numerically High Mortality

The following species are expected to experience numerically high mortality from oil contamination. A spill would have little effect on total global populations and probably would have only short-term effects on local nesting species, unless it is associated with nesting areas or primary foraging areas of nesting birds. Species affected would vary based on seasons and locations of spills, as indicated after each of the birds listed below.

Sea ducks (winter, inshore)
Cory's Shearwater (summer, offshore)
Wilson's Storm-Petrel (summer, offshore)
Double-crested Cormorant (winter; inshore, particularly at inlets)

Brown Pelican (all seasons, inshore)
Red Phalarope (fall through spring, offshore)
Red-necked Phalarope (spring and fall, offshore)
Herring Gull (winter, all zones)
Ring-billed Gull (winter, inshore)
Great Black-backed Gull (winter, all zones)
Laughing Gull (summer, inshore; other seasons, all zones)
Royal Tern (summer; all zones, but mostly inshore)

PROBLEMS WITH INTERPRETATION

One problem with estimating the effects of oil spills on marine fauna is the difficulty of gathering the extensive biological information that is necessary to develop accurate mathematical models that can predict the responses of populations to spills. A recent attempt to do this by Ford et al. (1982) indicated that the following parameters are those most needed for such models:

1) the size of the nonbreeding population,
2) the movement patterns of foraging individuals,
3) the spatial and temporal distribution and availability of food near breeding colonies,
4) the relationship between breeding rates and the age of young in relation to growth rates and survival probabilities,
5) the degree of density dependence in various population parameters,
6) the probability that a given bird will die as a direct result of an oil spill,
7) the age-specific mortality schedules of local populations under normal conditions,
8) the rate at which populations respond to perturbations and regain an equilibrium distribution at sea, and
9) the effect of an oil spill on the availability of food.

Ford et al. (1982) thought that the last four parameters were the most important for developing a model. Clearly, none is easy to measure, and only further research on birds in the Southeast will allow effective models to be developed and used.

Another problem with estimating the effects of oil spills on local seabirds is that most studies of oil spills have occurred in northern seas along shorelines where currents washed affected birds onto the coast. The studies are biased toward large birds, possibly because small birds were overlooked or did not wash ashore. Clapp et al. (1982) noted that wind, offshore currents, and movements by the birds themselves may take most of the victims of an oil spill far from the original pollution site. In some parts of Europe and on the west coast of the United States, prevailing winds bring spill victims and oil to shore. In such areas, chronic oil pollution and the recorded mortality of marine birds are greater than elsewhere (Bourne 1976). In contrast, Atlantic seaboard winds take poisoned birds out to sea, onshore evidence of mortality is minimal and is found mostly around enclosed inlets. Consequently, comparisons of damage from oil pollution incidents between these areas are problematic. Nontheless, reports from Europe and the western United States suggest that damage to birds from oil pollution on the East Coast may be greatly underestimated.

Powers and Rumage (1978) documented one spill off Massachusetts well enough to demonstrate differences between onshore and offshore observations. Following the *Argo Merchant* spill, prevailing winds and tides made it unlikely that polluted birds would wash ashore. Those conditions led Powers and Rumage to suspect that the few birds (181) found on the beaches of Nantucket Island and Martha's Vineyard had made an active effort to get ashore and that onshore observations alone would underestimate the contamination of local seabird populations. Hundreds of oil-coated Great Black-backed and Herring Gulls were seen offshore during surveys at sea following this spill. Contaminated Northern Fulmars, a species not found along the beaches, were also seen. Most polluted birds were seen near the tanker or oil slick, but gulls and Black-legged Kittiwakes were widely dispersed. They may have followed fishing trawlers away from the site. Levy (1980) analyzed the oil found on dead or dying birds from Canada's east coast and suggested that Herring and Great Black-backed Gulls obtained near Sable Island, Nova Scotia, had been contaminated by oil from the *Argo Merchant* spill, which had occurred some 520 miles away.

Furthermore, biologists and others who are concerned with effects of oil on birds usually arrive on the scene of spills long after birds have dispersed (both live birds and ones carried by wind and current); thus, tallies of dead or injured birds do not adequately represent the contaminated populations. Many birds not immediately killed or crippled would be able to leave the area, and their death or injury would not be noticed. As mentioned previously, the number of birds contaminated by an oil spill may vary widely between species, depending on the habitats and the behavior of the birds. The probability of finding polluted birds that roost or rest onshore is greater than it is for finding birds that spend all or most of their time offshore and which, following contamination, sink unnoticed.

CONCLUSIONS

Although the current information on the biology, distribution, and season of occurrence of seabirds, marine mammals, and marine turtles in North Carolina is still incomplete, it is better than the comparable data available for most other areas of the world. The 14-

year study conducted by the N.C. State Museum is, so far as can be determined, the longest and most intensive oceanic study of seabirds and marine mammals conducted anywhere. A surprisingly diverse fauna has been documented off the North Carolina coast, and many of the regular species represent small populations that could be threatened by local oil spills and the subsequent use of dispersants.

The main problem at the present time is the lack of information on oil contamination of pelagic, tropical, and subtropical bird species. Satisfactory documentations of oil spills in the United States are almost nonexistent. Rarely is there any information on the number of birds, mammals, and turtles present in an area before, during, and after contamination. Although it may be impossible to do more than estimate the number of individuals of each species present before a spill, detailed observations made during and after the incident may allow better estimates of the number of birds affected and the relative severity of the spill.

Clapp et al. (1982) believe that attempted rehabilitation of oiled birds following a major oil spill is largely a waste of time, money, and other resources, although it does educate volunteers and the public about the hopeless plight of oiled birds. A group of marine bird experts (NERC 1977) stated that "since the results of attempts to rehabilitate oiled birds are so poor, it may be more profitable to expend efforts at preventing birds from becoming polluted." It is desirable, however, to salvage contaminated birds to find out what species were affected and to obtain information that will permit more prudent responses to future spills. Hence, the attention of any oil company should be focused on the prevention and the rapid and immediate cleanup of any oil spill.

It is apparent, even with scant knowledge of the effects of oil pollution on birds, that current plans for cleanup operations off North Carolina are inadequate. By the time attempts to control and remove the spilled oil could be made, most of the damage would have been done. Oil spilled off the North Carolina coast would spread too rapidly for containment procedures to be effective. No spills have been reported from any other area where so many species with such limited distributions and populations coexist, and it is imperative that adequate contingency plans be developed. At least 11 species could be heavily damaged by oil spills in North Carolina and its offshore waters.

At this time it appears that the best way to prevent large-scale damage to important elements of biota would be to develop technologies to quickly route spilled oil into shelf-edge areas. This would remove the oil from the areas frequented by pelagic and inshore species. It would also prevent the oil from being swept away by the Gulf Stream and potentially affecting the marine fauna of other states or countries. In the shelf-edge areas, the oil could be more easily contained and removed.

North Carolina is fortunate to have good documentation of the species composition and species densities for all seasons in the area presently being considered for oil exploration. This knowledge should prove useful in planning strategies regarding post-spill operations.

ACKNOWLEDGMENTS

Over the last 14 years, grants from the U.S. Fish and Wildlife Service (Slidell Louisiana Laboratory), the Department of the Navy, the U.S. Army Corps of Engineers, and the N.C. Sea Grant Program, plus contributions from many private citizens, have allowed us to conduct the offshore surveys on which this report is based. Laura Becker and Cathy Wood (both of the N.C. State Museum) each put in many long hours organizing data, preparing figures, and typing the text. A grant from the Department of Administration helped offset the overtime salaried expenses necessary to compile this information on rather short notice. The cooperation of all persons and agencies mentioned is greatly appreciated.

SPECIES ACCOUNTS

COMMON LOON

Gavia immer

Status: Common to very common migrant, common winter resident.

World Population: Indigenous to North America. Numbers unknown, but known to be declining.

Season of Occurrence: Maximum occurrence November through April.

Zone of Occurrence: Mostly inshore of the 20-fathom contour, but small numbers of birds winter far at sea (Lee 1987a).

Food Studies: None off coastal North Carolina.

Susceptibility to Oil Pollution: Loons are among the birds most vulnerable to oil pollution, because they sleep on the water and have a flightless molt period during late winter. There are at least three reasons why significant mortality of loons might have been unnoticed in previous oil accidents. First, on a worldwide basis, loons have much smaller populations and tend to be more widely dispersed than the auks and sea ducks that make up the bulk of reported oil pollution mortality. Second, contaminated loons may not seek shore as quickly as most other seabirds, thus becoming more likely to die in the water. Third, loons are less buoyant than other seabirds and do not have hollow bones. Heavily polluted loons are more likely to sink upon death than similarly contaminated ducks, auks, or other seabirds.

There have been several instances of notable loon mortality from petroleum in the southeastern United States and the Gulf of Mexico. Many beached Common Loons were reported from North Carolina (Pearson et al. 1942) and Florida (Longstreet 1953-1955) after oil spills. More recently, approximately 225 Common Loons were found dead or dying on beaches at St. Augustine, St. Johns County, Fla., between 12 and 20 January 1974 (Stevenson 1974). White et al. (1976) examined 124 of the dead loons found that winter at St. Augustine; 76 (61%) had been contaminated. The source of the oil was unknown.

In 1970, 10,000 gallons of Bunker C oil was spilled in Tampa Bay, Fla., and a slick of approximately 100 square miles quickly formed. Because the spill occurred in a sheltered bay, in fairly calm water, and in an urban area, a large volunteer rescue and cleaning force was mobilized the day after the spill. Contaminated birds were retrieved from the water by people wading from beaches and by reseuers in boats. Approximately 500 Common Loons, a major fraction of the winter population, passed through the cleaning stations. Most were released shortly after cleaning, but survival was probably low (as previously mentioned, cleaning birds may be a futile effort). It is important to note that the circumstances of the spill, and the quick response to it, allowed a much better assessment of the vulnerability of these birds than is usually possible. The seasonal reports in *American Birds* indicated lower than normal numbers of Common Loons in the Tampa Bay area in subsequent winters (Woolfenden 1973, Edscorn 1974, Stevenson 1974, 1977), presumably as a result of the 1970 mortality.

King and Sanger (1979) devised an Oil Vulnerability Index for marine birds of the northeast Pacific Ocean. On a scale of 1 to 100, with 1 being the most vulnerable, they gave the Common Loon a rating of 45, which indicates a species whose population might be adversely, but not catastrophically, affected by an oil spill.

Remarks: Acid rain, numerous chemical contaminants, and other industry-related factors have apparently caused a sharp decline in Common Loons. These birds have high public appeal because of their interesting vocalizations and high visibility on northern ponds and lakes. A significant portion of the total population winters in the coastal waters off the southeastern United States, and a large portion of this group occurs in, or migrates through, shelf waters off North Carolina.

BLACK-CAPPED PETREL

Pterodroma hasitata hasitata

Status: Rare, although regular and relatively common off North Carolina.

World Population: Indigenous to North Atlantic. Population size unknown, but estimates range from 2,000 to 25,000 pairs. Now extirpated, or believed so, on four of six Caribbean islands (Van Halewyn and Norton 1984). The race *P. hasitata caribbaea* of Jamaica has been extinct since 1879.

Season of Occurrence: Found during all seasons (Lee 1986), but most common in October, late April, and late December.

Zone of Occurrence: Restricted to relatively deep water (100-1,000 fathoms) and most common along the 500-fathom contour (Fig. 16 and 17).

Food Studies: Black-capped Petrels feed while in flight, snatching prey from the surface of the water. Stomach contents, which are currently being analyzed at the N.C. State Museum, include squid and small fish.

Susceptibility to Oil Pollution: Little information is available because of the apparent lack of encounters of tropical seabirds with oil spills. A Black-capped Petrel found on a Connecticut beach in 1938 was coated with oil (Holman 1952). Clapp et al. (1982) stated that, in general, *Pterodroma* seem relatively invulnerable to spilled oil. However, little information is available to prove or disprove their statement.

Off the North Carolina coast, the species occurs in a relatively narrow corridor. Because Black-capped Petrels are attracted to fish oil, they may be attracted to other surface-floating oils. When at rest, they collect in small rafts on the water and would be susceptible to oil contamination during such periods. Likewise, they are attracted to other individuals of the same species that are in distress. Thus, one polluted bird could attract large numbers to the area of pollution. Also, they are attracted to lights at night, especially on foggy nights. They fly at high speeds (70+ mph), and collisions with oil-rigging would certainly be fatal.

An oil spill off the North Carolina coast could jeopardize the global population of the Black-capped Petrel.

Remarks: Black-capped Petrels were long thought to be extinct. A breeding population was discovered in southeast Haiti in 1961 (Wingate 1964), and in 1977 a small population was found in eastern Cuba (Bond 1978). The species remains extirpated from a large portion of its former breeding range. Though probably within the estimate of 2,000 to 25,000 pairs, the actual population size of this species is unknown because of its secretive, nocturnal, cliff-nesting habits.

Large numbers of Black-capped Petrels are found off the Outer Banks of North Carolina, the only place concentrations of this bird are known to occur. Because of their mobility and high flight speeds, it is likely that birds nesting in Cuba and Haiti actually commute to North Carolina waters to feed. Here, it is not unusual

to see 100 birds a day and, once, more than 300 were sighted. If the conservative estimates of population size are correct, a majority of the world's population forages off the North Carolina coast. If the higher estimates are correct, a significant portion of the population occurs off North Carolina. In either case, the state's offshore waters are vital to the survival of the species.

BERMUDA PETREL (Cahow)
Pterodroma cahow

Status: Endangered (Federal Register 8495, 2 June 1970). This bird is extremely rare and virtually unknown away from its breeding areas. The only reports of Bermuda Petrels at sea are from North Carolina (Lee 1984, 1987b).

World Population: Indigenous to North Atlantic. Thirty-two pairs in 1982 (Van Halewyn and Norton 1984). The species is native only to Bermuda, although fossils are known from the Bahamas and the U.S. Virgin Islands (Wetmore 1918, 1938, Olson and Hilgartner 1982).

Season of Occurrence: Although as many as half a dozen sightings of possible Bermuda Petrels have been made in North Carolina waters (NCSM records), only two were seen well enough to be identified with reasonable certainty. They were seen in April and December (Lee 1984; 1987b).

Zone of Occurrence: All records are from deep water in the Gulf Stream.

Food Studies: None.

Susceptibility to Oil Pollution: The waters around Bermuda are heavily burdened with tar balls. However, despite regular examination of many of the Bermuda Petrels, no sign of contamination has been detected (Wingate 1978). The *Pterodroma* may be more susceptible to fresh spills than to the tar balls so abundant around Bermuda and elsewhere (Clapp et al. 1982). A specimen of the Bermuda Petrel's close relative, the Black-capped Petrel (*Pterodroma hasitata*), was found heavily polluted with oil on a Connecticut beach (Holman 1952).

Remarks: The close resemblance of this species to the Black-capped Petrel makes identifications at sea difficult. Black-capped Petrels off North Carolina include a small, dark form, of unknown origin, that is similar in appearance and size to the Bermuda Petrel. Internal structures, however, show the Bermuda Petrel and the Black-capped Petrel are separate species.

Because the world population of the Bermuda Petrel is so small, it is one of the most severely endangered species in the world. The fact that the only reports of Bermuda Petrels at sea have come from the area off Cape Hatteras requires that the needs of this species be analyzed before any decisions concerning North Carolina's offshore environment are made.

GREATER SHEARWATER
Puffinus gravis

Status: Abundant migrant, often common summer resident.

World Population: Indigenous to the Atlantic. The entire breeding population is confined to the small islands of the Tristan da Cunha group, Gough Island, and one island in the Falklands. Despite the limited breeding distribution, the species is abundant. Although no census has been taken, estimates suggest over five million birds.

Season of Occurrence: Mid-May through mid-November with isolated records from mid-April and late December (Lee 1986). Most common during spring and fall migration.

Zone of Occurrence: Greater Shearwaters typically occur along the inner edge of the Gulf Stream from 50 to 100 fathoms. This species may be found in other zones since they often follow schools of feeding tuna.

Food Studies: Numerous food samples have been taken but not yet analyzed (NCSM records). These birds feed mostly on small fish and pelagic squid. They often eat bait cast from offshore fishing boats.

Susceptibility to Oil Pollution: Because they are attracted to oil slicks, Greater Shearwaters may be highly susceptible to oil spills. In addition, they are gregarious and often feed while swimming or diving; therefore, large numbers could easily become contaminated.

Along the Atlantic coast, Greater Shearwaters may be extremely numerous in May and June, when, apparently, a large proportion of the global population migrates through North Carolina waters. Despite the abundance of this shearwater, an oil spill in late spring could have a significant effect on the total population of the species. During other seasons, local oil spills probably would not damage this bird's population.

Remarks: Most summering individuals found off North Carolina are subadults (Lee and Grant 1986).

After migrating over the tropics, where flocks are often stalled for days without favorable winds, the Greater Shearwaters arriving in North Carolina offshore waters are hungry and often weakened. Periodically, massive fatalities of immature shearwaters occur in late spring if food supplies off North Carolina are insufficient (NCSM records).

SOOTY SHEARWATER
Puffinus griseus

Status: Common spring migrant. Rare summer and fall transient.

World Population: Although the Pacific population of the Sooty Shearwater numbers in the millions, the Atlantic population is small. Atlantic birds are believed to be from nesting colonies in the Falkland Islands (Cramp and Simmons 1977). Maximum total population of the Falklands is estimated between 1,000 and 10,000 pairs (Croxall et al. 1984).

Season of Occurrence: Ninety percent of all North Carolina records are from the last week of May and the first week of June (although spring migration extends from the middle of May through the first two-thirds of June). Occasionally, individuals are seen in July, August, September, and October (Lee 1986). Nearly the entire Atlantic population migrates south through the eastern Atlantic, which makes fall records off North Carolina rare.

Zone of Occurrence: Many individuals migrate northward within a few miles of land (at least that is the case between Cape Hatteras and the Virginia line). Others are seen along the inner edge of the Gulf Stream.

Food Studies: Unavailable. The museum has only a few stomachs available for analysis at this time.

Susceptibility to Oil Pollution: The strongly gregarious nature of Sooty Shearwaters, their readiness to sit in flocks on the surface of the water, and the frequency with which they dive when feeding, all suggest that this species could be vulnerable in large numbers to oil spills.

King and Sanger (1979) devised an Oil Vulnerability Index for marine birds in the northeast Pacific, where the Pacific Sooty Shearwater "winters" (summer in the northern hemisphere). On a scale of 1 to 100 they rated the Sooty Shearwater at 51, which indicates a species that might be adversely, but not catastrophically, affected by oil pollution. They suggested that there would be time to develop conservation measures to protect Sooty Shearwaters in the event of an oil spill.

The population of the Sooty Shearwater that occurs in Southeastern waters is more likely to be threatened by an oil spill because of its smaller size. An oil spill in late May or early June could have a major adverse effect on the entire North Atlantic population since the species is seasonally and geographically concentrated along the North Carolina coast at that time.

Remarks: None.

AUDUBON'S SHEARWATER
Puffinus lherminieri lherminieri

Status: Common summer resident off the North Carolina coast.

World Population: This subspecies is indigenous to the North Atlantic. The Caribbean population (*P. l. lherminieri*) numbers about 5,000 pairs (Van Halewyn and Norton 1984). Other subspecies are widespread throughout tropical oceans.

Season of Occurrence: Commonly found from late April through early November, with large numbers (thousands) occurring from late August through early October. A few scattered records are available from winter months (Lee 1986).

Zone of Occurrence: Most frequently encountered along the inner edge of the Gulf Stream or over water 50 to 500 fathoms deep (see Fig. 15a).

Food Studies: The N.C. State Museum has data on a large number of individuals collected over the last 14 years. This information has not yet been analyzed. Nevertheless, superficial examination shows that Audubon's Shearwaters consume small fish associated with floating sargassum mats.

Susceptibility to Oil Pollution: There has been little opportunity to examine effects of oil on this and other pelagic species; therefore, the vulnerability of Audubon's Shearwater is not known. However, this shearwater's habit of feeding along current edges and in the sargassum that collects along these fronts would make the species very vulnerable to oil dispersing from local spills.

Because of the small population size and the high percentage of the population that occurs off North Carolina, this species may be especially threatened by local oil spills.

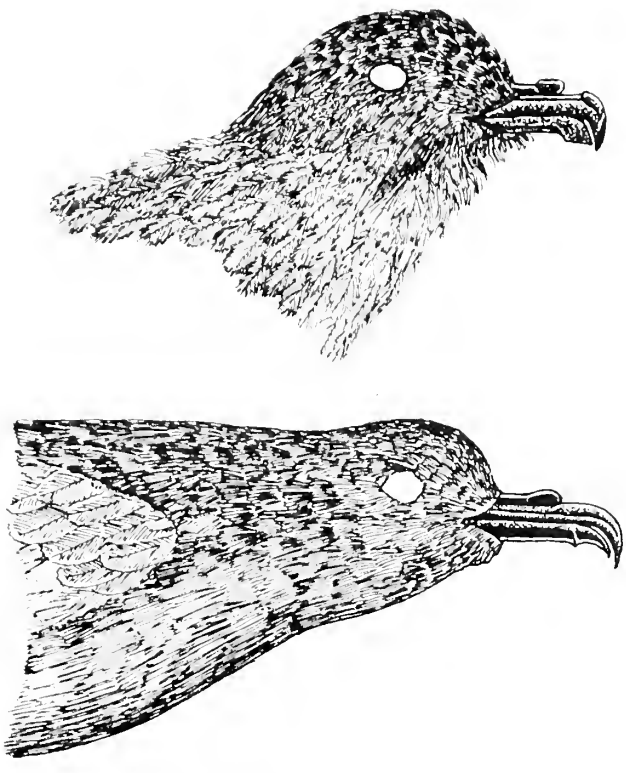
Remarks: All specimens collected off North Carolina are of the subspecies *lhlerminieri*. They appear in large numbers soon after their nesting season.

Based on the relatively small population known from the Caribbean and the large numbers regularly seen off the North Carolina coast in the late summer, it is apparent that up to 75% of the total population summers here. Local concentrations are quite variable.

BAND-RUMPED STORM-PETREL
Oceanodroma castro

Status: Common summer resident.

World Population: The North Atlantic population breeds on St. Helena (23 pairs), Ascension (1,500 pairs), the Azores (population size unknown), Madeira (rare), the Canary Islands (number unknown), and the Cape



Head profiles of storm-petrels:
Band-rumped (above) and Leach's (below).

Verde Islands (number unknown). The total Atlantic population is probably less than 5,000 pairs and possibly as small as 2,000 pairs. The species also occurs in the Pacific on the Galapagos Islands, the Hawaiian Islands, and some islands off Japan.

Season of Occurrence: Mid-June to mid-September.

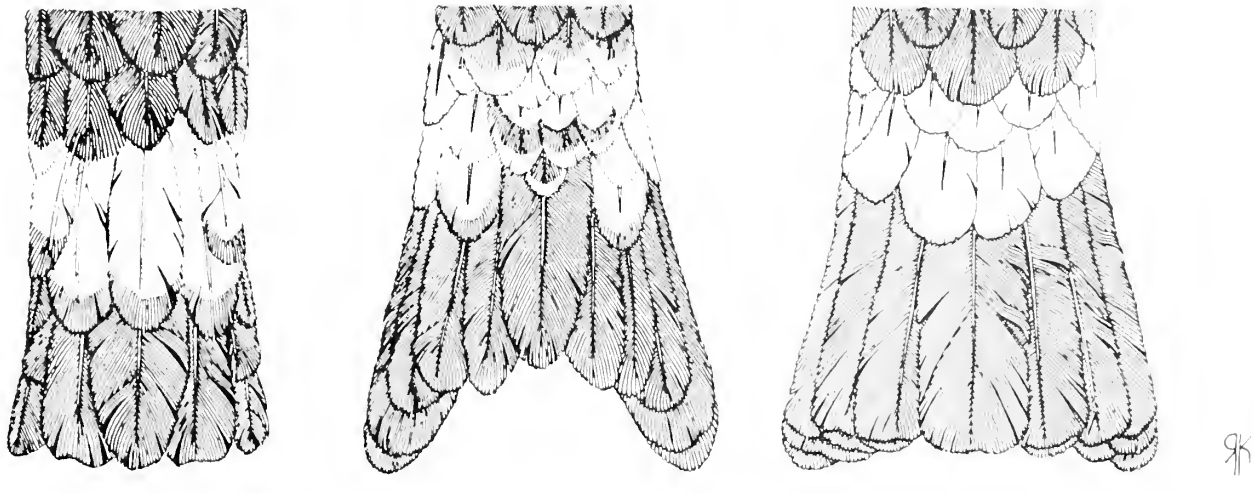
Zone of Occurrence: This species has only rarely been found away from the 500-fathom contour (Fig. 18 and 19). Haney (1985) found the species concentrated along oceanic currents off the Georgia coast.

Food Studies: Food habits and other biological information were presented by Lee (1984); small fishes and squid predominate in the diet.

Susceptibility to Oil Pollution: Band-rumped Storm-Petrels congregate along a narrow zone and feed along current edges; therefore, they may be highly susceptible to oil pollution. They may be more vulnerable to oil than other storm-petrels, because they feed while swimming and thus could be heavily exposed to contaminants. In addition, storm-petrels are often attracted to lighthouses and the lights of ships on foggy nights; they may be similarly attracted to oil drilling and production rigs. This attraction could result in injury when birds collide with lighted structures. The possibility of immolation in gas flares on production rigs should be investigated.

A major spill off North Carolina could injure a significant portion of the Atlantic population.

Remarks: This species was not known to occur regularly in North American waters until the 1980s (Lee 1984). However, the species is often common in North Carolina waters along the 500-fathom contour.



Tail shape and pattern of typical summer storm-petrels (left to right): Band-rumped, Leach's, and Wilson's.

Considering the limited numbers of Band-rumped Storm-Petrels known to be from Atlantic breeding colonies and the frequency and regularity of sightings in North Carolina (more than in any other nonbreeding area anywhere in the world), it is likely that deep waters off the Carolina coast are important (perhaps critical) to this species during the nonbreeding season.

WHITE-TAILED TROPICBIRD
Phaethon lepturus catesbyi

Status: Regular, but uncommon, summer visitor to North Carolina offshore waters.

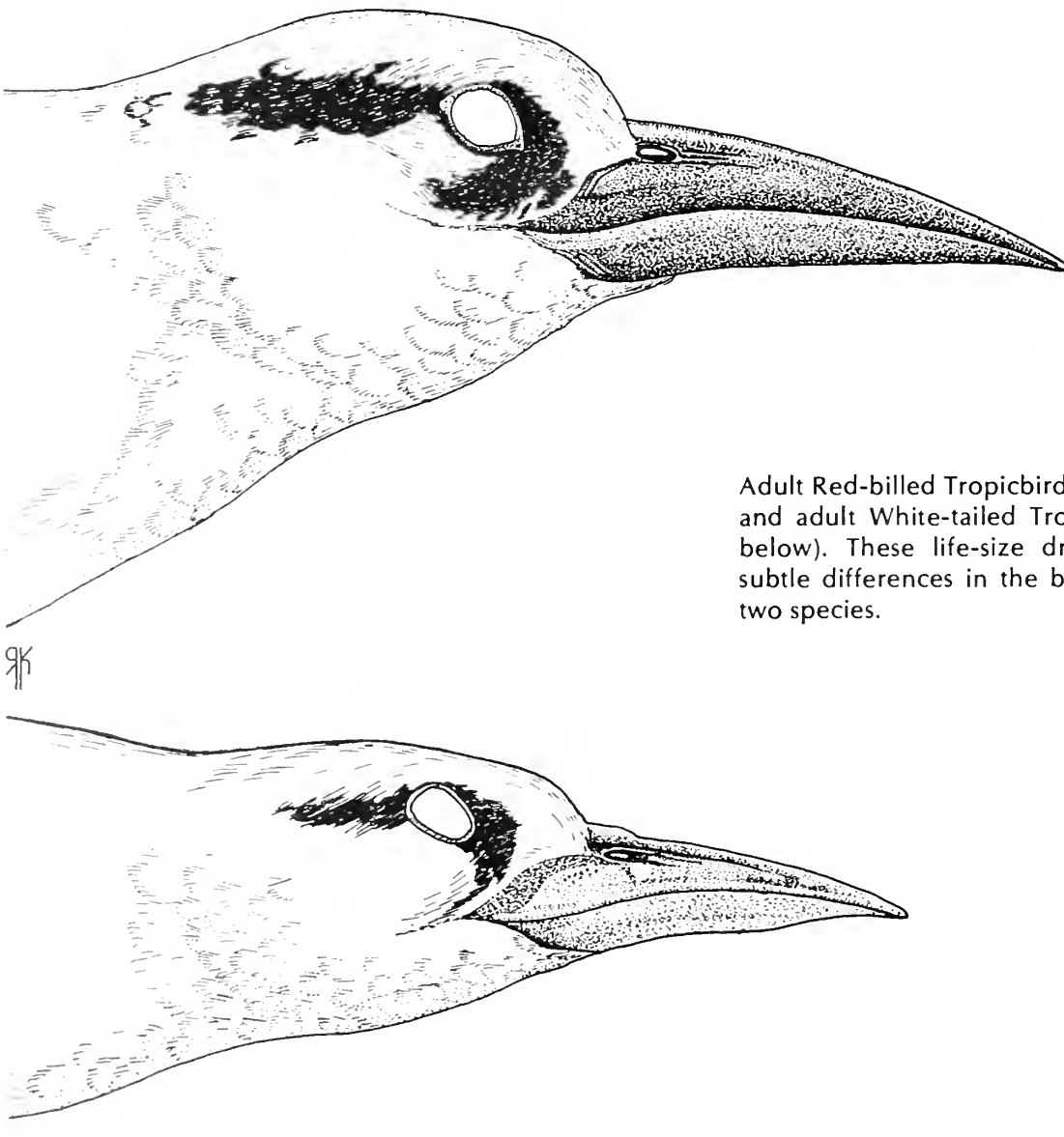
World Population: This subspecies is native to the North Atlantic. The Caribbean population (*P. l. catesbyi*) contains about 10,000+ pairs (Van Halewyn and Norton 1984). Other races occur in the tropical South Atlantic, Pacific, and Indian Oceans.

Season of Occurrence: Found off the North Carolina coast from mid-June through mid-September, with the largest number of records from July and August (Lee 1986, NCSM records).

Zone of Occurrence: South of Cape Hatteras, this species is widely dispersed over warm shelf and shelf-edge waters. North of Hatteras, this tropical bird is restricted to the Gulf Stream near the 100-fathom contour.

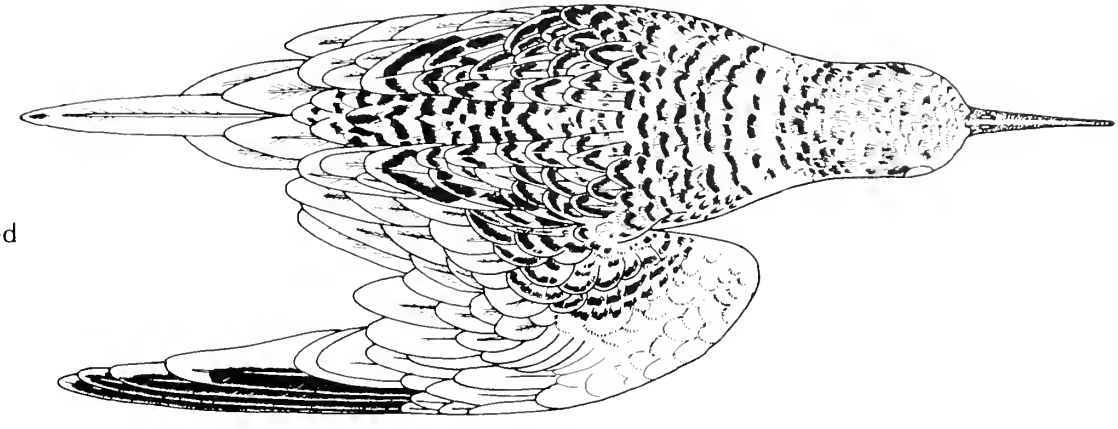
Food Studies: Lee and Irvin (1983) reported flying fish and squid in the stomachs of White-tailed Tropicbirds collected off North Carolina. Although the prey items were large, they were not identifiable to species because of partial digestion.

Susceptibility to Oil Pollution: Despite its pelagic and solitary feeding habits, the White-tailed Tropicbird

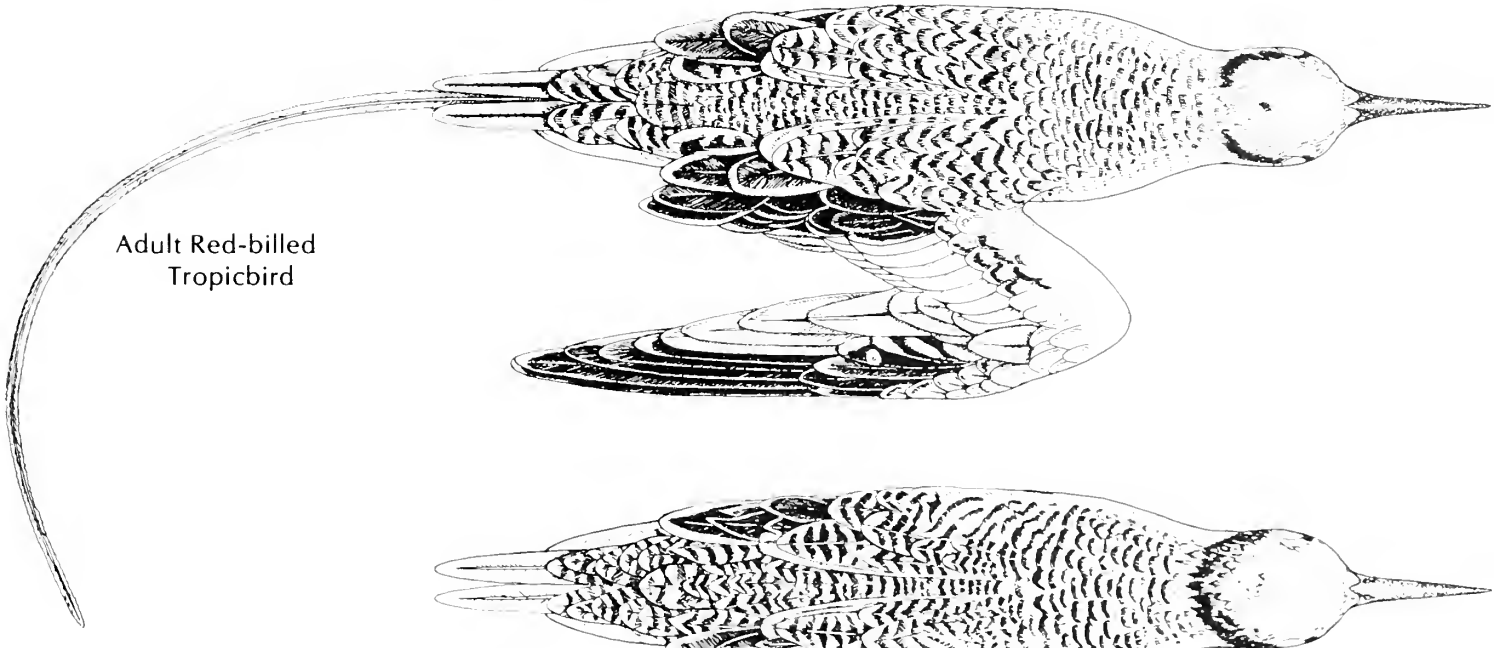


Adult Red-billed Tropicbird (NCSM 7-182, above) and adult White-tailed Tropicbird (NCSM 6828, below). These life-size drawings illustrate the subtle differences in the bill proportions of the two species.

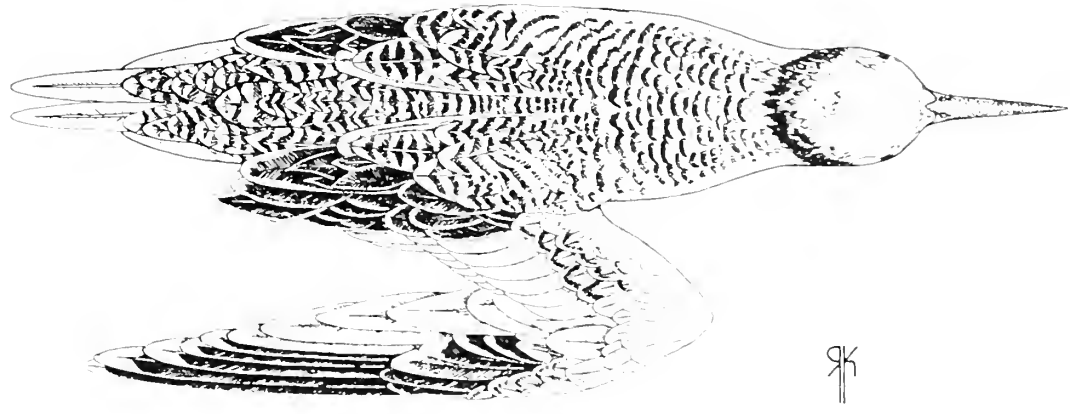
Adult White-tailed
Tropicbird



Immature White-tailed
Tropicbird



Adult Red-billed
Tropicbird



Immature Red-billed
Tropicbird

is one marine species that is known to have suffered major adverse effects from oil pollution. Wingate (1978) estimated that the White-tailed Tropicbird population on Bermuda has been reduced by as much as 40% in the last 25 years, owing primarily to oil pollution. Wingate's monitoring of over 200 nest-sites over the last 6 years "revealed a slow but steady decline [in the White-tailed Tropicbird breeding population] and a clear correlation between the amount of "young" or sticky tar on the beaches, the number of oiled birds seen in flight and the percentage of breeding success as a whole." The proportion of White-tailed Tropicbirds exhibiting oil on their underparts rose from about 1 in 100 in 1968 to about 1 in 15-20 in 1971 (Wingate 1978).

Because of the solitary nature and wide range of White-tailed Tropicbirds, it is possible that only a few individuals would be injured by local oil spills. As is the case with most tropical species, little information is available on tropicbirds' behavioral response to oil. If oil slicks attract birds (as some observations indicate), a local oil spill could have a significant adverse effect on the Caribbean population.

Remarks: The origin of the White-tailed Tropicbirds occurring in North Carolina is unknown, but the closest nesting population is in Bermuda.

All North Carolina records are of adults. With the exception of Florida, White-tailed Tropicbirds have been encountered more frequently and regularly off the North Carolina coast than in any other state or province in North America. Although the species is highly nomadic and ranges widely over warm tropical seas, it is reasonable to assume that an important percentage of the total population of *P. l. catesbyi* forages over North Carolina waters in the summer months.

RED-BILLED TROPICBIRD
Phaethon aethereus mesonauta

Status: Uncommon visitor.

World Population: The Caribbean population is 1,600+ pairs (Van Halewyn and Norton 1984). This same race occurs in the Cape Verde Islands, off the coast of Senegal, in the Gulf of California, and in the Galapagos. Other races occur elsewhere in the tropical Atlantic and western Indian Ocean.

Season of Occurrence: Early April through the first of August (Lee 1986).

Zone of Occurrence: Warm offshore waters. Typically associated with the Gulf Stream and its warm eddies.

Food Studies: The stomachs of birds collected off North Carolina contained squid beak fragments; one stomach contained the partial skeleton of a flying fish (Lee et al. 1981).

Susceptibility to Oil Pollution: The diving habits of Red-billed Tropicbirds might result in contamination by floating oil. However, their solitary or semi-solitary feeding habits and their pelagic foraging range should make Red-billed Tropicbirds less vulnerable to the direct effects of oil pollution than most other Pelecaniformes. In addition, it appears that the numbers found in U.S. waters are insignificant on a global scale; therefore, the populations would not suffer catastrophic losses as a result of oil spills in North Carolina waters.

Remarks: This species is included in this report because of the small number of pairs that breed in the Caribbean.

MASKED BOOBY
Sula dactylatra dactylatra

Status: Uncommon summer visitor.

World Population: This race is indigenous to the Atlantic Ocean. The Caribbean population is less than 2,500 pairs (Van Halewyn and Norton 1984). Also found in the South Atlantic on Ascension Island (1,200-1,300 pairs) and on Fernando de Noronha (number unknown). Other races live in the western Indian Ocean and throughout the tropical Pacific.

Season of Occurrence: Mid-June through the first of September. Several records from early June and October.

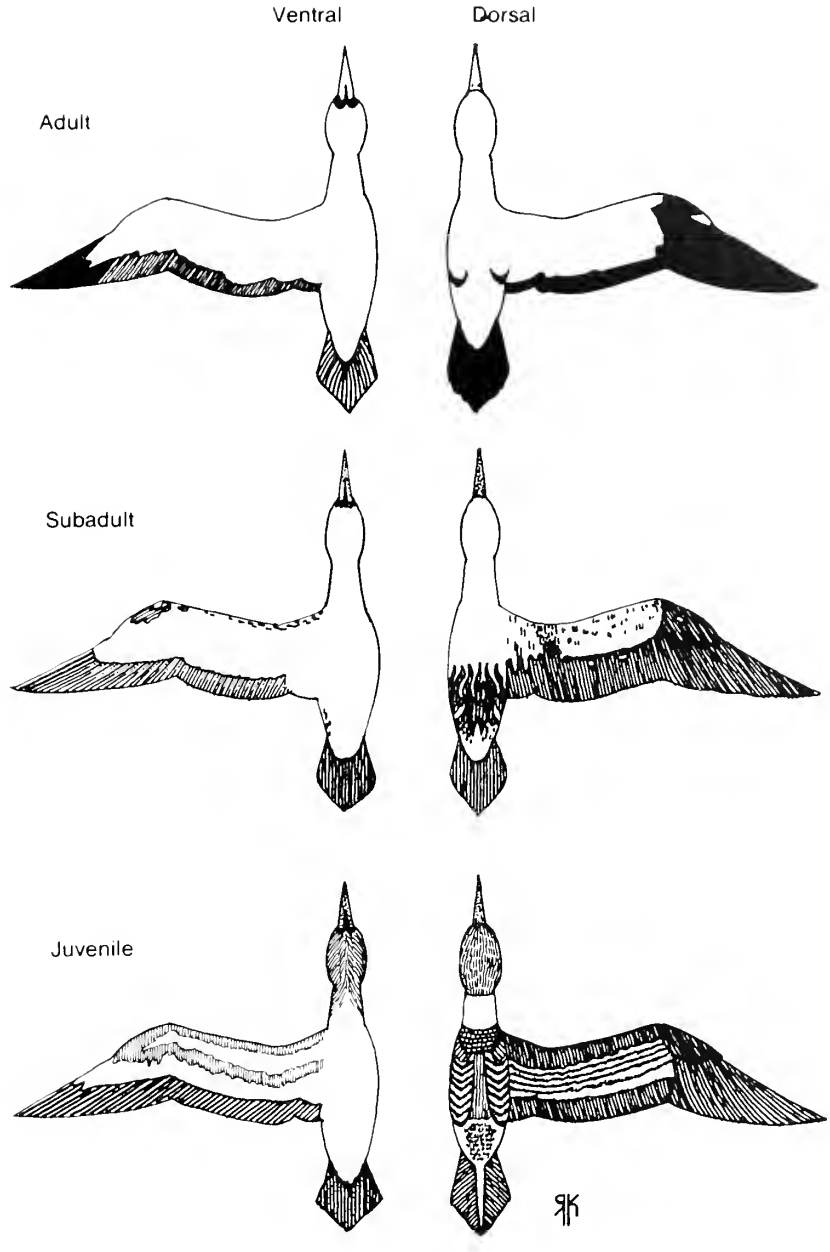
Zone of Occurrence: All records have been from the deep waters of the Gulf Stream.

Food Studies: The food items recovered from the stomachs of Masked Boobies off North Carolina agree with the basic diet of the species in other areas of the world. Portions of unworn squid beaks in two sizes (5 mm and 3 mm), partly digested dolphin (*Coryphaena hippurus*) and one well-digested, 60-mm fish (probably a flying fish) have been found in the stomachs of North Carolina Masked Boobies. Generally, Masked Boobies eat larger fish and fewer squid than do Red-footed Boobies (Lee and Haney 1984).

Susceptibility to Oil Pollution: Many oiled Masked Boobies have been recorded in the Gulf of Mexico, and contaminated birds have been seen in the northwestern Hawaiian Islands (Clapp et al. 1982). This species was the most frequent victim of the *Ixtoc I* oil spill in the Gulf of Mexico (Clapp et al. 1982). Duncan and Harvard (1980) estimated that as many as 800 birds may have been affected by the *Ixtoc I* accident. This number may represent a large proportion of the Gulf population.

The Masked Booby may also be attracted to ships and oil-production platforms.

In view of its small and declining populations and its known vulnerability to oil pollution, the Masked Booby is a species of concern.



Dorsal and ventral patterns of adult, subadult, and juvenile Masked Boobies. The subadult is from NCSM 9538; others are modified from Nelson (1978).

Remarks: Although Masked Boobies are rare in North Carolina waters, they are the most commonly seen of the three tropical Atlantic boobies because they travel farther from breeding areas than the other species. Nevertheless, Masked Boobies are the rarest and most local of the tropical boobies, and many populations are declining (Feare 1978, Nelson 1978). Consequently, every attempt should be made to monitor the remaining Caribbean population and to prevent its elimination.

NORTHERN GANNET
Sula bassana

Status: Common migrant, common to abundant winter resident.

World Population: Endemic to North Atlantic (no subspecies). Eastern North Atlantic: Britain (145,000 pairs), Iceland (10,000+ pairs), Channel Islands and Faeroes (9,000 pairs). Total eastern North Atlantic

population: approximately 165,000 pairs. Western North Atlantic: Newfoundland and Labrador (10,000 pairs), Gulf of St. Lawrence to Gulf of Maine (23,000 pairs). Total western North Atlantic population: 33,000 pairs.

Season of Occurrence: Resident from late November through early March. Migrants appear as early as the first of October and late northbound migrants are still found off the North Carolina coast in May. Scattered records of individuals in other months (Lee and Haney 1984).

Zone of Occurrence: Although gannets regularly occur in deep waters off the Maryland and Georgia coasts, they are usually found within a few miles of the beach along the Outer Banks (Lee and Haney 1984). Occasionally, individuals are seen over deep water.

Food Studies: Lee and Haney (1984) examined the stomachs of 10 individuals from North Carolina. Food included squid and small (100-200 mm) Atlantic Menhaden. Birds follow trawlers and feed on fish offal and other discarded material.

Susceptibility to Oil Pollution: Scattered references to oiled Northern Gannets in the southeastern United States are made in the literature dealing with the avifauna of this area (cf. Clapp et al. 1982). More detailed information on gannets and oil pollution may be found in European sources. Clapp et al. (1982) noted that 7% of birds lost to oil pollution along Dutch coasts were gannets. During the winter of 1976-1977, Northern Gannets composed 11% of the polluted birds found on Irish coasts (O'Keeffe 1978). Contaminated gannets also made up between 0.4% and 3.6% (mean + 1.8%) of the oiled seabirds found along British beaches for the seven winters from 1966 to 1973 (Croxall 1975). These reports clearly indicate that this species is often adversely affected by oil pollution.

Possible secondary effects of oil pollution on nesting Northern Gannets have also been suggested. Following the *Torrey Canyon* oil spill, (Nelson-Smith 1973) reported that gannets contaminated themselves and their eggs by bringing oily seaweed into the colony for nest-building. (The detrimental effects of oil on eggs and young birds were described previously in this report.)

Remarks: Collection of specimens off North Carolina shows a high percentage of adult males in midwinter. Apparently, adult females winter farther north. Because gannets are monogamous, any loss of male birds would remove the same number of females from the active breeding population.

The Outer Banks of North Carolina may represent the southernmost area of regularly occurring high concentrations of Northern Gannets. From January through March, a significant portion of the adult western North Atlantic stock appears off the Outer Banks. As much as 16% of the total western North Atlantic population has been seen on a single day from a single site off the North Carolina coast (Lee and Haney 1984).

Immatures and juveniles migrate ahead of adults in the fall, and they normally winter south of North Carolina. In the spring they move northward, usually after the adults have departed for their breeding grounds. Any oil spill in North Carolina would have a minimal effect on the young gannet population. However, seasonal distributions of adult gannets indicate that an oil spill in midwinter off the North Carolina coast could decimate the breeding population.

PEREGRINE FALCON
Falco peregrinus anatum

Status: Endangered (Federal Register: 6102, 17 February 1984). Regular migrant and rare winter resident in coastal areas of North Carolina.

World Population: Although there is no current world census, a good account of the populations and their decline is presented by Hickey (1969).

Season of Occurrence: September through April, with maximum numbers appearing along the Outer Banks from mid-September through October.

Zone of Occurrence: Along barrier islands, particularly around flats and other open areas near inlets. Migrates over the ocean. Numerous records from far out to sea (Lee and Horner 1989).

Food Studies: Feeds almost exclusively on smallto medium-sized birds, which it catches in flight.

Susceptibility to Oil Pollution: Peregine Falcons may be very vulnerable to oil pollution, because hungry birds would be attracted to, and could easily catch, prey weakened by oil contamination. Falcons migrating over the open ocean often reach land exhausted, and in this condition they would readily accept prey weakened by pollution. At sea and on land, oiled seabirds would probably be irresistible targets for migrating Peregrines.

Remarks: Most of the Peregrines that use migratory routes in the eastern United States are from nesting populations originating in western Greenland. The N.C. State Museum has an extensive file on coastal migration records and areas of occurrence in North Carolina.

ROSEATE TERN
Sterna dougallii dougallii

Status: Endangered (see Remarks). Uncommon migrant (see Fig. 20 for distribution of Roseate Terns in North Carolina).

World Population: Race indigenous to Atlantic Ocean. Caribbean population, 4,000 total pairs (Van

Halewyn and Norton 1984); U.S. population, 2,500-3,300 pairs (Nisbet 1980); British Isles, ca. 800 pairs; France, ca. 120 pairs. The total Atlantic population is probably less than 8,000 pairs. Other races occur in the Indian Ocean and in the western tropical Pacific; an apparently disjunct population of the nominate race occurs in southern and eastern Africa.

Season of Occurrence: Roseate Terns appear in North Carolina in May, when they are migrating north to their New England nesting grounds, and from August through October (peak occurrence in early September), when they are returning south. There is one record of a bird picked up after a storm on 20 January 1937 at Cape Hatteras (Pearson et al. 1942).

Zone of Occurrence: Migratory individuals are found primarily along the coast of North Carolina, but in the spring they are also seen far out to sea (Fig. 20). Although there are only two confirmed nesting records for the state (Oregon Inlet 1939, NCSM records; Lighthouse Bay, Carteret Co., 23 May 1973, Soots and Parnell [1974]), there are numerous North Carolina records of birds in breeding plumage in June, July, and August (birds in spring migration are also in full breeding plumage). These birds are typically associated with mixed tern colonies. The increasing interest in the protection of tern colonies and the vigilance of bird watchers, make it likely that additional nesting will be documented in the near future. Expanding populations of Atlantic Coast terns are currently extending their range, and it is likely that major Roseate Tern colonies could develop in North Carolina within the next several decades.

Food Studies: None has been undertaken in North Carolina. Roseate Terns specialize in feeding on small, schooling marine fishes, which the birds capture by diving from the air into the water. The specific prey for the Roseate Terns in North Carolina is unknown.

Susceptibility to Oil Pollution: There is little available information on the effect of oil on Roseate Terns or on how often they are contaminated. Gochfeld (1979) saw one lightly oiled bird among 76 he checked on western Long Island. Because Roseate Terns rarely occur in most Southeastern States, and usually only as offshore migrants, it is unlikely that development of oil resources in this area will affect this species. However, because Roseate Terns are Endangered and declining in numbers in many parts of their range, including the United States, obtaining more information on the Roseate Tern's susceptibility to oil spills is imperative.

Remarks: The U.S. Fish and Wildlife Service determined that the Northeastern population of Roseate Terns is Endangered and the Florida and Caribbean population is Threatened. Although North Carolina birds probably represent both western Atlantic populations, it is assumed most local records are of birds of northern origin. The number of suitable nesting islands for this species has been greatly reduced by human activities. At the same time, populations of large gulls (and perhaps other predators) have greatly expanded. Former nesting areas, such as Bermuda, have been abandoned for decades, and recent surveys show that the number of breeding birds in the northeastern United States, eastern Canada, and Europe has declined sharply (Buckley and Buckley 1984, Kirkham and Nettleship 1985, Cramp 1985). Thus, every effort should be made to protect suitable nesting areas for Roseate Terns in North Carolina.

BRIDLED TERN
Sterna anaethetus melanoptera

Status: Common summer resident, frequent in fall.

World Population: Race indigenous to Atlantic Ocean. The Caribbean population is believed to be 7,000+ pairs (Van Halewyn and Norton 1984). This subspecies also occurs off Africa in the Gulf of Guinea (population size unknown but believed to be small). Other races occur off the west coast of Central America and in the Indian Ocean.

Season of Occurrence: Mid-May through early October, with peak concentrations from mid-August through mid-September (Lee 1986). One December record (Lee 1987b).

Zone of Occurrence: Along current edges and in association with mats of drifting sargassum. Occasionally within 20 miles of shore, but typically along the 50- to 100-fathom contour.

Food Studies: Feeds primarily on small fish in mats of sargassum. Stomachs of individuals collected off North Carolina have not yet been analyzed (NCSM records).

Susceptibility to Oil Pollution: LeCroy (1976) mentioned two birds at Los Rocques Island that had been contaminated by oil. One had only a spot on the bill, but the other had "its face and vent well fouled by crude oil." The N.C. State Museum has collected oiled Bridled Terns at sea off North Carolina.

Strongly pelagic during the nonbreeding season, Bridled Terns are apparently reluctant to settle on the surface of the sea and will instead choose to perch on any drifting object (Smith 1951, Warham 1958). Although Bridled Terns may not experience direct oiling, the floating debris on which they rest and the sargassum rows over which they feed may be sources of contamination.

The Bridled Tern's unwillingness to land on open water, its widespread pelagic distribution, and its

apparent tendency toward little or no diving may make this species less vulnerable to oiling than many other terns. However, the relatively small total population of this subspecies and the high numbers encountered off North Carolina suggest that a major portion of the global population moves into waters off the southeastern coast of the United States after the breeding season. Therefore, a major oil spill could adversely affect this species.

Remarks: Although no satisfactory estimates of pelagic populations exist, recent observations have shown that Bridled Terns are considerably more abundant off the Atlantic coast than previously thought. Birds may leave breeding grounds and move north as family groups after young have fledged. During the summer, adult Bridled Terns have been seen feeding begging young off North Carolina.

SEI WHALE
Balaenoptera borealis

Status: Endangered (Federal Register: 8495, 2 June 1970). Boreal species migrating and wintering off the southeastern United States.

World Population: Unknown. The North Atlantic stock is believed to number around 2,200-2,600 (Mitchell 1974).

Season of Occurrence: Few records for North Carolina waters (5 and 14 April 1975).

Zone of Occurrence: Unknown.

Food Studies: These large baleen whales probably do not feed while wintering. Instead, they fast for several months and live off their fat reserves (Mackintosh 1965).

Susceptibility to Oil Pollution: Unknown.

Remarks: Schmidly (1981) speculates that a Gulf of Mexico/Caribbean stock exists, but this is questionable.

The few records of this large whale probably reflect misidentification resulting from confusion with other large baleen whales. The species is probably a relatively common migrant off the North Carolina coast.

ATLANTIC RIGHT WHALE
Eubalaena glacialis glacialis

Status: Endangered (Federal Register: 8495, 2 June 1970). Migrant boreal species occasionally wintering as far north as North Carolina.

World Population: Originally, may have numbered 100,000 to 300,000. Current populations believed to be only 3,000 to 4,000. Only a few hundred are currently known to exist in the North Atlantic (Braham and Rice 1984).

Season of Occurrence: Occasionally off the North Carolina coast from January to March. Migration dates recorded for off the North Carolina coast are spring (9 March to 1 May) and fall (one record, 6 October). There are also records for 3 June and 3 July, both assumed to be aberrant migrants.

Zone of Occurrence: During spring migration, Right Whales usually occur immediately adjacent to the coast (Fig. 34). The southward fall migration appears to occur far out to sea and could account for the paucity of fall records for the Southeast.

Food Studies: Right Whales probably do not feed while wintering or migrating.

Susceptibility to Oil Pollution: Unknown; however, in the spring, female Right Whales and their calves migrate northward along the coast, often in sight of land. A large oil spill at this time could delay northward migration or be harmful to mother whales and calves that swim through oiled waters.

Remarks: The North Atlantic population, which is morphologically distinguishable from other stocks, is extremely small. Because of their small populations, habit of using coastal waters, and low reproductive rates, Right Whales are the most vulnerable of all the great whales to human activities. Even though it has been fully protected for more than 50 years, its populations have not recovered noticeably.

FINBACK WHALE or FIN WHALE
Balaenoptera physalus

Status: Endangered (Federal Register: 8495, 2 June 1970). Boreal species migrating and wintering off the southeastern United States. Commonly seen off the North Carolina coast.

World Population: Although the original stock size is unknown, it was certainly decimated by commercial whaling. Current estimates for the western North Atlantic range from 3,590 to 6,300 individuals (Mitchell 1974). Schmidly (1981) speculated that there may be an isolated stock in the northern Gulf of Mexico. The species also occurs in the South Atlantic and Pacific Oceans.

Season of Occurrence: Most records are from winter. All North Carolina records are from 15 January to 10 April.

Zone of Occurrence: Most observations at sea have been in deep water (>300 fathoms) but there are a number of records of wintering Finback Whales seem near the coast in 15 to 20 fathoms of water (Fig. 35).

Food Studies: Like other baleen whales, Fin Whales fast for several months and do not appear to feed while migrating or wintering.

Susceptibility to Oil Pollution: Unknown.

Remarks: Several stocks occur in the North Atlantic. There is no evidence of mixing among these stocks, but there have been no studies that have examined genetic differences between groups (Arnason 1981).

On 4 April 1978 hundreds of migrating Finback Whales were sighted in deep water off the North Carolina coast. Although it was not possible to get an accurate count of the whales, this group certainly represented a large percentage of the western North Atlantic population.

The closely related Blue Whale, an Endangered species has been regarded by some authors as part of North Carolina's fauna, but there are no actual records from the state (Lee et al. 1982).

HUMPBACK WHALE
Megaptera novaeangliae

Status: Endangered (Federal Register: 8495, 2 June 1970). Migrant.

World Population: A population that once may have numbered 120,000 has been reduced to approximately 10,000, but many stocks are showing signs of recovery. The current estimate of the eastern North Atlantic population is a few hundred individuals; the separate western North Atlantic stock numbers between 5,000 and 6,000 (Johnson and Wolman 1984). The species also occurs in the South Atlantic, Indian, and Pacific Oceans.

Season of Occurrence: Spring (early April to 16 May) and fall (2 September to late December) migrant. One July record.

Zone of Occurrence: Kenney et al. (1981) analyzed sightings of Humpback Whales by water depth. They found that the majority of Humpback Whales are seen in 11-40 fathoms of water. The limited records of the N.C. State Museum indicate a similar distribution.

Food Studiess: This species feeds only in its summer grounds.

Susceptibility to Oil: Unknown; however, because Humpback Whales inhabit, and migrate in, shallow coastal areas, they appear to be more susceptible to petroleum pollution than some other whale species.

Remarks: Humpbacks winter in the waters off Puerto Rico, Bermuda, and the Windward and Leeward Islands. They summer primarily off Newfoundland. Unlike the other great whales, Humpbacks give no indication that they even occasionally winter off the Carolinas.

SPERM WHALE
Physeter catodon

Status: Endangered (Federal Register: 8495, 2 June 1970). Year-round resident of shelf-edge and deep water.

World Population: Sperm Whales inhabit all oceans of the world. There are no reliable estimates of the current or the former size of the world population. The North Atlantic stock is regarded as separate from others, and Hain et al. (1985) give the minimum population for the shelf-edge region of northeastern North America as 215 individuals.

Season of Occurrence: Throughout the year but perhaps more common in warmer months. The species is known to be migratory, though some stocks may be sedentary.

Zone of Occurrence: Found along the edge of the continental shelf (100-1,000 fathoms) where warm and cold water currents interface (Fig. 36).

Food Studies: No local studies have been done, but the species is known to feed mostly on medium to large mesopelagic squids. Males also eat large pelagic sharks, skates, and fishes (Berzin 1971, Clark 1980).

Susceptibility to Oil Pollution: Unknown.

Remarks: Sperm Whale hunting began on the New England Coast around 1712. When New England whalers later expanded their activities, the waters off Cape Hatteras became an important whaling area.

In summer, small herds of Sperm Whales are seen regularly east of Oregon Inlet by offshore fisherman.

SEA COW or MANATEE
Trichechus manatus

Status: Endangered (Federal Register: 4001, 11 March 1967; 8495, 2 June 1970). Uncommon but regular visitor.

World Population: Unknown but small. The total United States population is about 1,000 individuals. The North Carolina population is now probably never more than a dozen individuals, but at one time the manatee may have been more numerous and a regular summer resident.

Season of Occurrence: Visitor from midsummer (29 June) into fall (2 November).

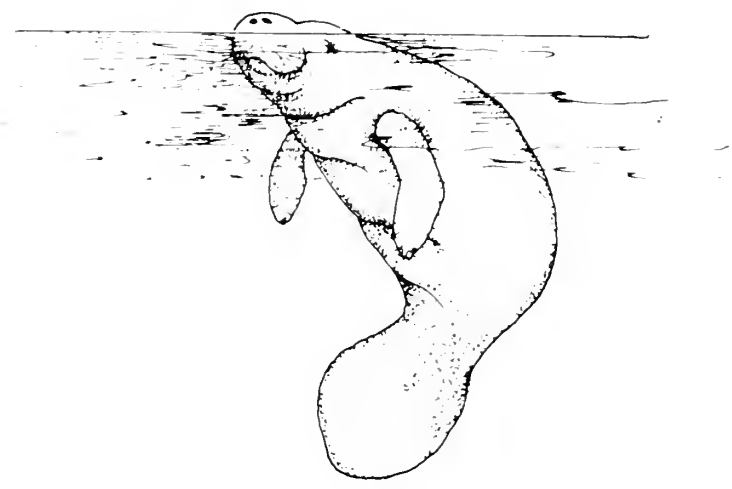
Zone of Occurrence: Beach fronts (during migration), sounds, and estuaries. Manatees may travel considerable distances up the rivers of the Coastal Plain.

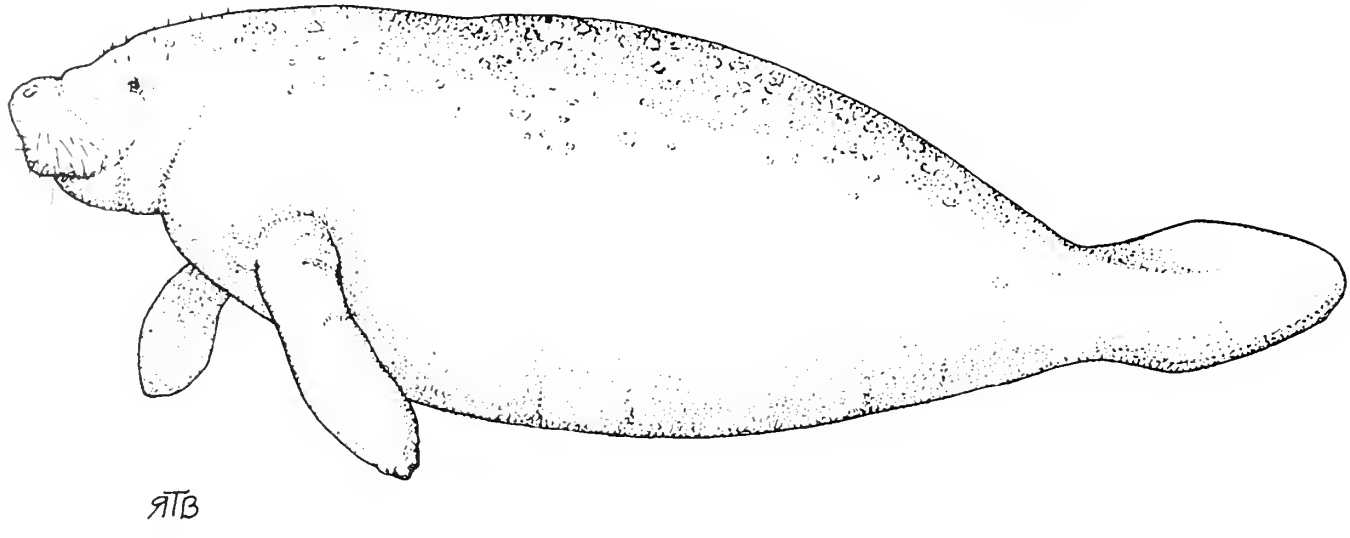
Food Studies: The manatee, a herbivorous species, feeds on submerged, floating, and aquatic vegetation.

Susceptibility to Oil Pollution: Unknown.

Remarks: Surveys by the N.C. State Museum show this mammal to be an uncommon but regular visitor to the state. Fewer than 20 manatees have been documented in North Carolina (NCSM records), but there are many unconfirmed reports.

Although the species has occasionally been found as far north as Tidewater Virginia, North Carolina has historically been regarded as the northern limit of the manatee's range. Manatees winter in Florida's coastal rivers and freshwater springs.





The whole body of the manatee may be visible in clear water; but in the dark and muddy waters of coastal North Carolina, one normally sees only a small part of the head when the manatee raises its nose to breathe.

ATLANTIC LEATHERBACK
Dermochelys coracea coracea

Status: Endangered (Federal Register: 8495, 2 June 1970).

World Population: Widely distributed in tropical and subtropical seas, seasonally migrating into temperate waters. Global population size unknown but estimated to be about 120,000 nesting females (Pritchard 1983).

Season of Occurrence: Lee and Palmer (1981) indicate most records are from April to October with the maximum number in the summer.

Zone of Occurrence: Shallow coastal waters but seldom near shore. Rarely in deep waters beyond the continental shelf (Lee and Palmer 1981). Hoffman and Fritz (1982) noted that Atlantic Leatherbacks were distributed along the boundary of the Gulf Stream current off eastern Florida (Fig. 37).

Food Studies: No local studies. Lazell (1980) and others have suggested that the Arctic jellyfish *Cyanea capillata* is a major food of this turtle.

Susceptibility to Oil Pollution: Unknown.

Remarks: Except for information on nesting behavior, little is known about this species. These turtles are so different from other sea turtles they have been placed in a family by themselves; some consider them a distinct suborder.

This species does not nest regularly north of the tropics; however, there is a report of a single, apparently accidental, nesting at Cape Lookout in 1966 (Schwartz 1977).

ATLANTIC HAWKSBILL
Eretomochelys imbricata imbricata

Status: Endangered (Federal Register: 8495, 2 June 1970).

World Population: A rare species whose global population is unknown because of its widely scattered, solitary nesting.

Zone of Occurrence: This is a tropical species, and individuals in North Carolina are best regarded as vagrants.

Season of Occurrence: Known from only a few confirmed records in July, October, and November.

Food Studies: No local studies. Known to eat fish but seem to prefer invertebrates (jellyfish, coral, sponges, mollusks, and barnacles and other crustaceans) (Schwartz 1977).

Susceptibility to Oil Pollution: Unknown.

Remarks: Hawksbills are not known to nest north of the Florida coast, and most records are more tropical. However, True (1887) described a commercial fishery for this turtle in the sounds of North Carolina. That suggests the species was once common here.

Although this species is regarded as Endangered, the isolated individuals found in North Carolina are vagrants and the main population of the Atlantic Hawksbill would not be threatened by local oil spills.

ATLANTIC RIDLEY
Lepidochelys kempi

Status: Endangered (Federal Register: 18320, 2 December 1970).

World Population: Endemic to North Atlantic Ocean. The size of the global population is small, but exact numbers are not known. Most nesting occurs in a small area in Tampico, Mexico, where between 600 and 700 females nest each year (Mager 1985).

Season of Occurrence: Unclear. The few records available for North Carolina are from April, June, July, August, and November (Lee and Palmer 1981).

Zone of Occurrence: Most North Carolina records are from inshore areas or from sounds and estuaries (see Remarks).

Food Studies: No local studies. Known to eat crabs, jellyfish, snails, clams, fish, and, occasionally, plants (Schwartz 1977).

Susceptibility to Oil Pollution: Unknown.

Remarks: Lazell (1980) noted that juveniles of the species are common in New England in the fall. Because nesting takes place in Mexico, many of the young turtles must migrate through North Carolina waters. At the present time, the seasons and zones of such movements are unclear.

This species looks similar to the Loggerhead sea turtle; thus, a small percentage of sightings of Loggerheads may, in fact, be Atlantic Ridleys. This makes mapping the local occurrence of Atlantic Ridleys difficult.

ATLANTIC LOGGERHEAD
Caretta caretta caretta

Status: The loggerhead is regarded as Threatened by the U.S. Fish and Wildlife Service (Federal Register 40685, 11 August 1977). This is the most common species of marine turtle in North Carolina waters.

World Population: Unknown. Annual estimates of the number of nesting females in the Southeast range from 14,000 to 29,000 (Powers 1981, Murphy and Hopkins 1984). This race occurs throughout the Atlantic, but the species is circumglobal in tropical and temperate seas.

Season of Occurrence: Present throughout the year but most common in the warmer months.

Zone of Occurrence: Variable. From June through September, most sightings are made within a few miles of the beach. In cooler months, most Loggerheads are seen in shelf waters and the Gulf Stream. However, individuals may occur in any zone at any season (Fig. 38).

Food Studies: No specific studies off the North Carolina coast. Other studies show that the Loggerhead's diet includes fish, mollusks, sponges, crabs and other crustaceans, jellyfish, and squid as well as other animals (Schwartz 1977).

Susceptibility to Oil Pollution: Unknown; however, polluted beaches would undoubtedly affect nesting activities and the hatchlings.

Because of the small number of loggerhead nests on the Outer Banks, local oil spills would have little impact on nests or hatchlings. Fair numbers of adults and subadults, however, live off the coast of the Outer Banks in the summer. It is not known what effect oil pollution would have on these turtles.

Remarks: Nesting occurs mainly south of Cape Lookout. Crouse (1984) indicates that the area north of Cape Lookout National Seashore (Carteret Co.) had 0.0-0.9 nesting attempts per kilometer of beach in 1980-1981, the lowest rate recorded for the North Carolina coast. In the last century, this species supported a commercial fishery in North Carolina (True 1887).

ATLANTIC GREEN TURTLE
Chelonia mydas mydas

Status: Endangered (Federal Register: 40685, 11 August 1977).

World Population: Unknown; however, in the 1970s, the global population was estimated to be between 100,000 to 400,000 individuals (Ehrenfield 1974). The current U.S. population is believed to include fewer than 200 adult nesting females (Mager 1985).

Season of Occurrence: Recorded from May through August (Lee and Palmer 1981), but may be present throughout September and October as well.

Zone of Occurrence: All oceanic zones, also in sounds and estuaries. There are too few records to indicate habitat preference.

Food Studies: No local studies. Adults eat submerged marine vegetation.

Susceptibility to Oil Pollution: Unknown; however, the species occurs with such irregularity in North Carolina that it would not be jeoparidized by local oil pollution.

Remarks: At one time the Atlantic Green Turtle must have been quite abundant locally. Carr (1952) noted that in the 1880s one man could catch a hundred Green Turtles off Cape Hatteras in a day. Now, these turtles are only occasionally found in North Carolina. The several recent confirmed nestings in North Carolina (1980-1988) and the small numbers of juveniles found throughout coastal waters may be a result of a stocking program for Atlantic Green Turtles in Florida several decades ago.

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TABLES 1-4

Table 1. Number of one-day surveys off North Carolina (1975-1989) and average number of birds per hour by month.

	No. 1-day surveys	Average birds/hour
January	8	130
February	7	174
March	6	717
April	20	43
May	15	29
June	29	25
July	21	22
August	46	40
September	19	34
October	13	24
November	8	48
December	12	75
Total	194 days	

Table 2. Susceptibility to local oil pollution of seabirds occurring off North Carolina.

Species	Local abundance	Large portion of world population	Large portion of North Atlantic population	Locally vulnerable seasonal or geographical concentration	Established susceptibility to oiling
Common Loon	common	no	no	yes	yes.
Black-capped Petrel	common	yes	yes	yes	unknown
Bermuda Petrel	very rare	unknown	unknown	unknown	unknown
Greater Shearwater	common	yes	yes	yes	unknown
Sooty Shearwater	common	no	yes	yes	unknown
Audubon's Shearwater	abundant	no	yes	yes	unknown
Band-rumped Storm-Petrel	rather common	no	yes	yes	unknown
Masked Booby	rare	no	no	no	yes
Northern Gannet	abundant	yes	yes	yes	unknown
White-tailed Tropicbird	rare	no	unknown	no	yes
Red-billed Tropicbird	rare	no	no	no	unknown
Peregrine Falcon	uncommon	no	no	no	unknown
Roseate Tern	uncommon	no	yes	no	unknown
Bridled Tern	common	no	yes	yes	yes

Table 3. Species of major concern by month (x = periods when maximum concentrations of rare or highly vulnerable species occur).

Species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Common Loon			x	x								
Black-capped Petrel										x	x	
Bermuda Petrel					(unknown)							
Greater Shearwater					x	x						
Sooty Shearwater					x	x						
Audubon's Shearwater												
Band-rumped Storm-Petrel						x	x	x				
Masked Booby												
Northern Gannet	x	x	x									
White-tailed Tropicbird												
Red-billed Tropicbird												
Peregrine Falcon									x	x		
Roseate Tern												
Bridled Tern							x	x	x	x		

Table 4. Summer zonal distribution (individuals hour) of six species selected to show deep-water, shelf-edge, and inshore distributions and zones of overlap. (See also Fig. 15a and 15b.)

Depth (fathoms)	Total survey hours in zone	Shelf-edge			Deep-water		Inshore	All species[a]
		Wilson's Storm-Petrel	Cory's Shearwater	Audubon's Shearwater	Black-capped Petrel	Band-rumped Storm-Petrel	Royal Tern	
≤10	10.42	.38	0	0	0	0	4.41	11.13
11-19	7.25	1.38	3.17	0	0	0	2.48	12.41
20-30	35.42	2.32	4.71	0.62	0	0	0.28	10.42
31-50	12.42	14.75	6.04	.72	0	0	1.13	43.32
51-99	4.17	20.86	5.52	16.07	0.24	0	0.96	50.07
100-400	18.50	25.08	6.97	4.49	1.14	0.16	0.54	78.38
401-799	18.17	24.49	7.15	4.62	2.92	1.32	0.17	71.44
≥800	19.75	14.23	17.92	15.34	3.39	1.11	0.10	61.62

[a] Includes birds not listed in this table.

FIGURES 1-38

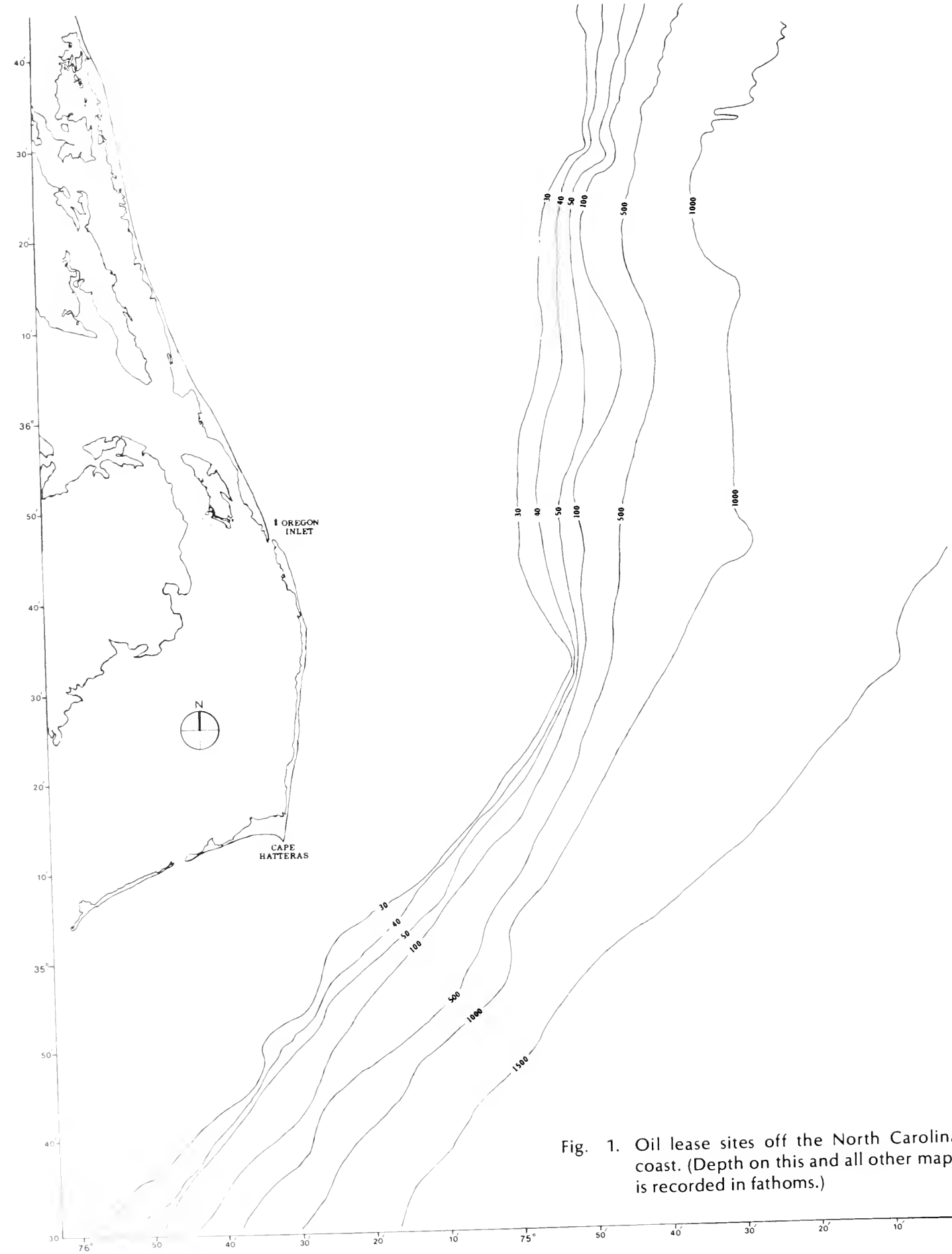


Fig. 1. Oil lease sites off the North Carolina coast. (Depth on this and all other maps is recorded in fathoms.)

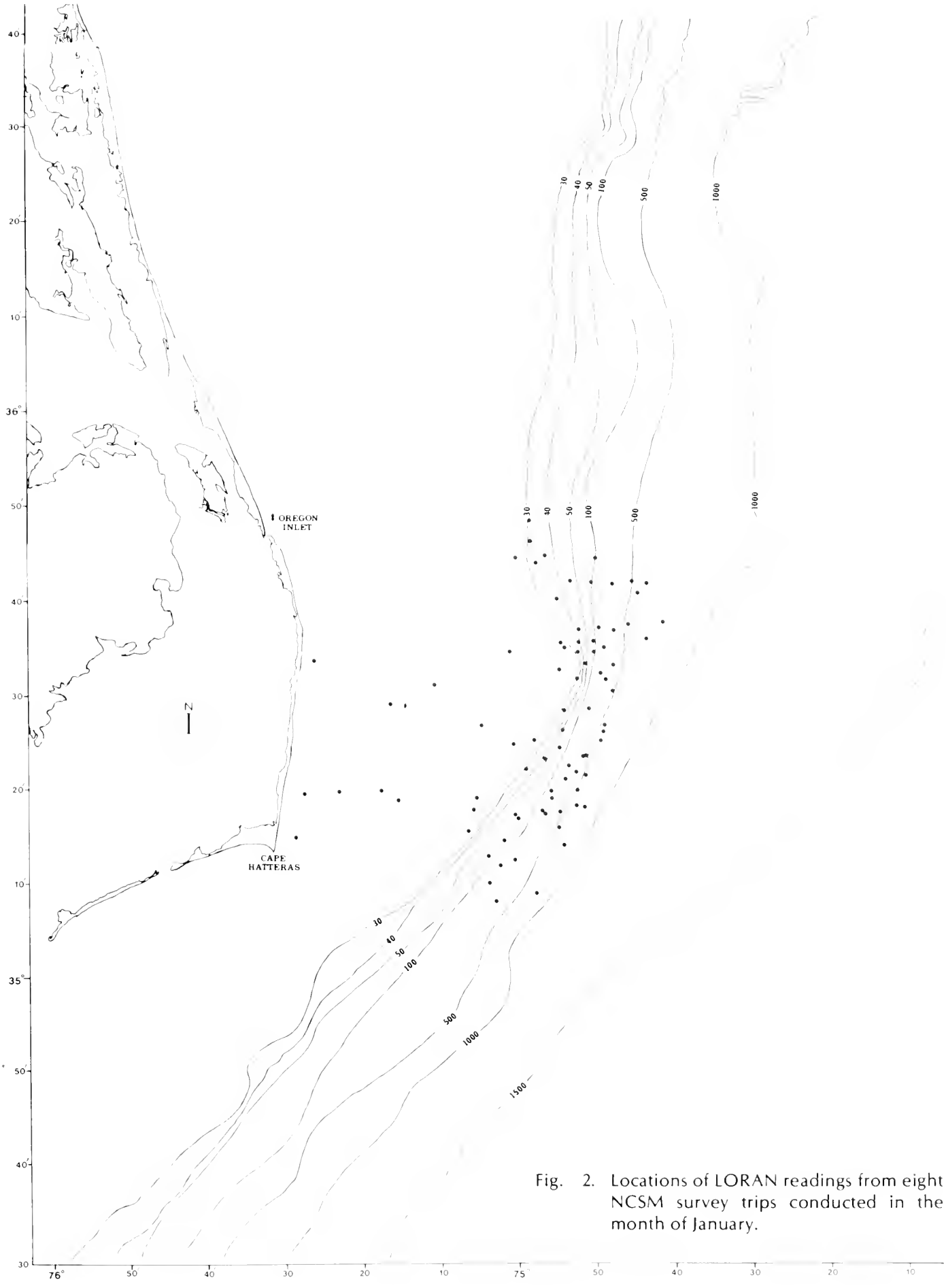


Fig. 2. Locations of LORAN readings from eight NCSM survey trips conducted in the month of January.

Fig. 3. Locations of LORAN readings from seven NCSM survey trips conducted in the month of February.

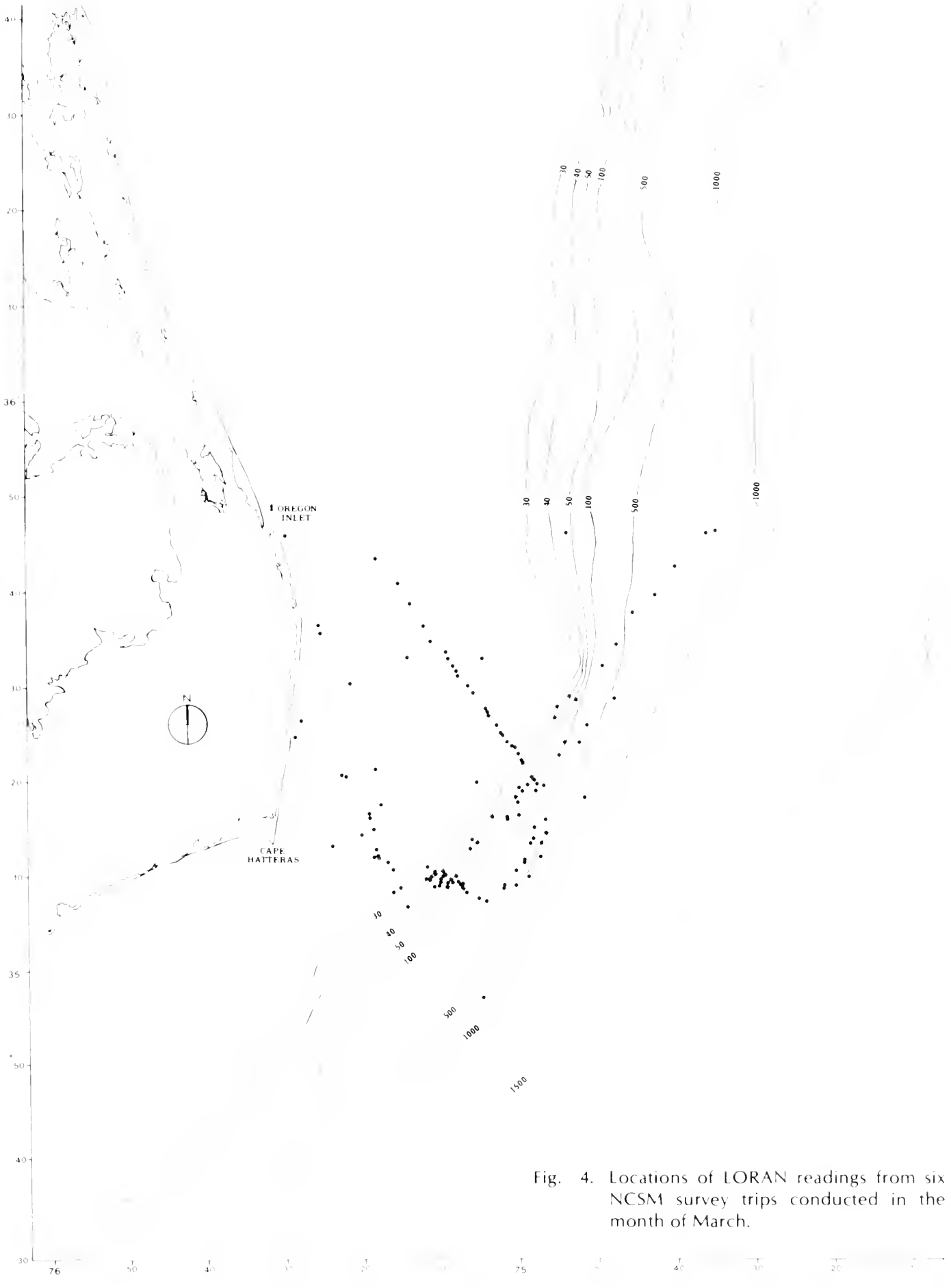


Fig. 4. Locations of LORAN readings from six NCSM survey trips conducted in the month of March.

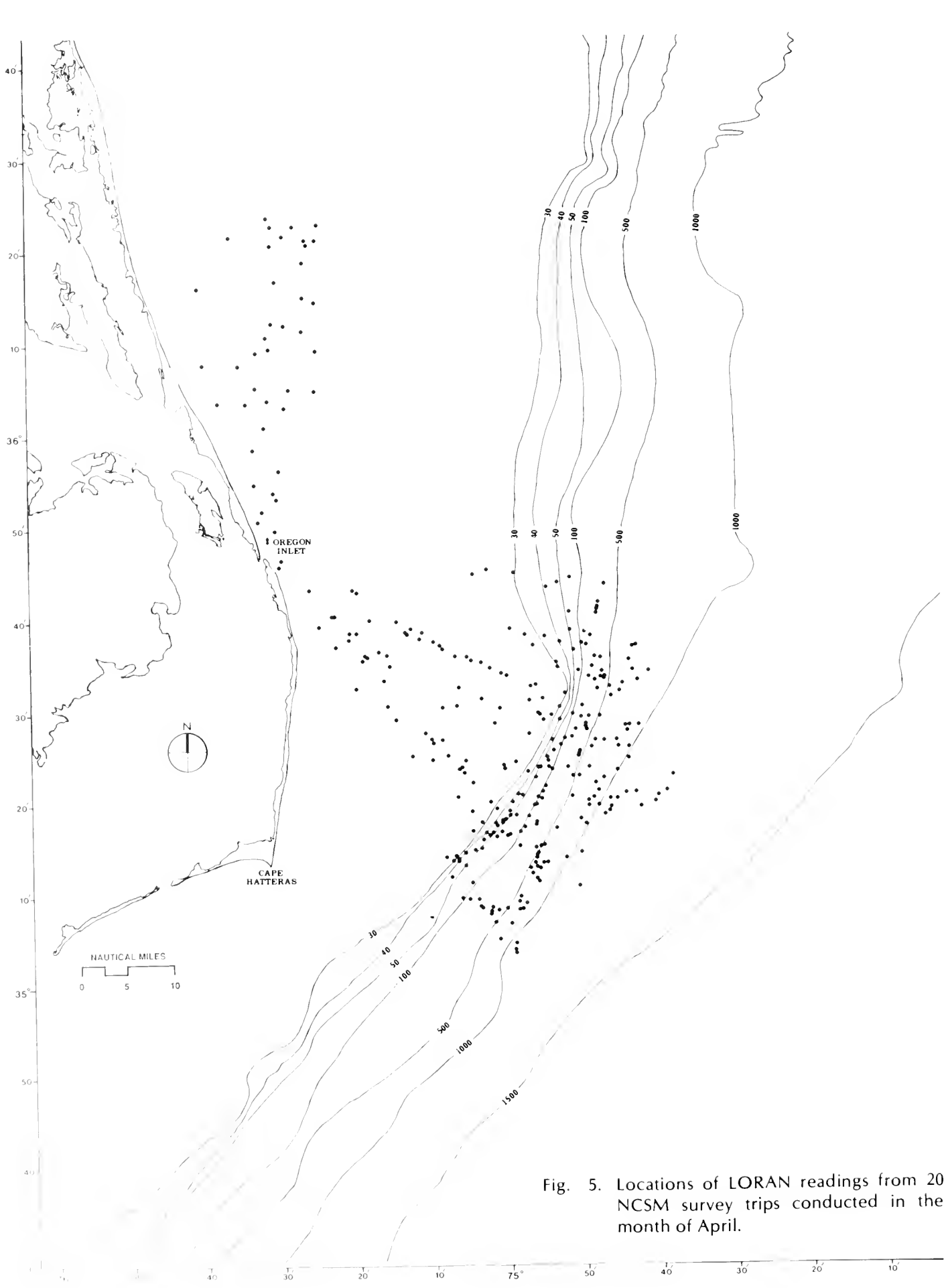


Fig. 5. Locations of LORAN readings from 20 NCSM survey trips conducted in the month of April.

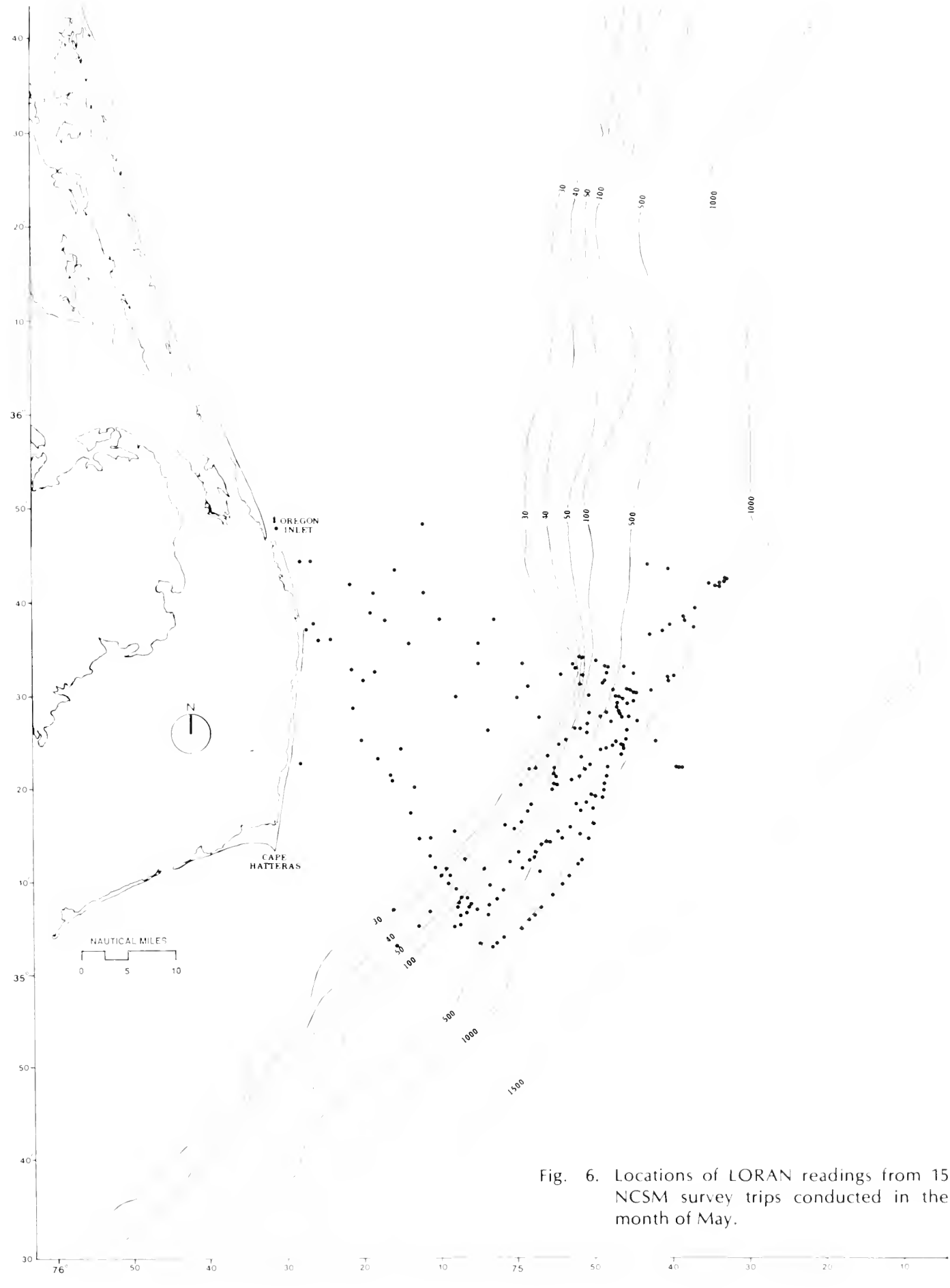


Fig. 6. Locations of LORAN readings from 15 NCSM survey trips conducted in the month of May.

Fig. 7. Locations of LORAN readings from 29 NCSM survey trips conducted in the month of June.

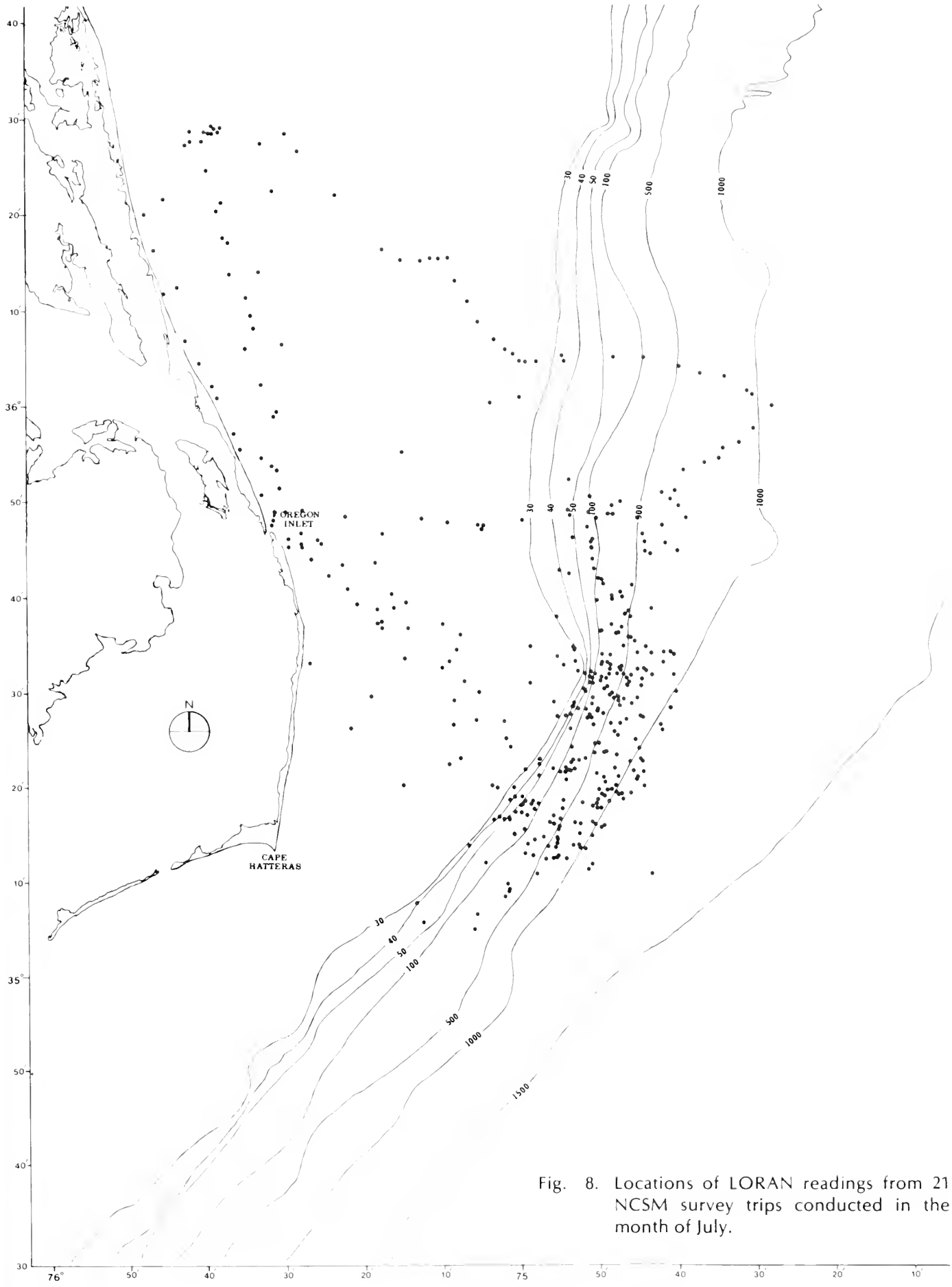


Fig. 8. Locations of LORAN readings from 21 NCSM survey trips conducted in the month of July.

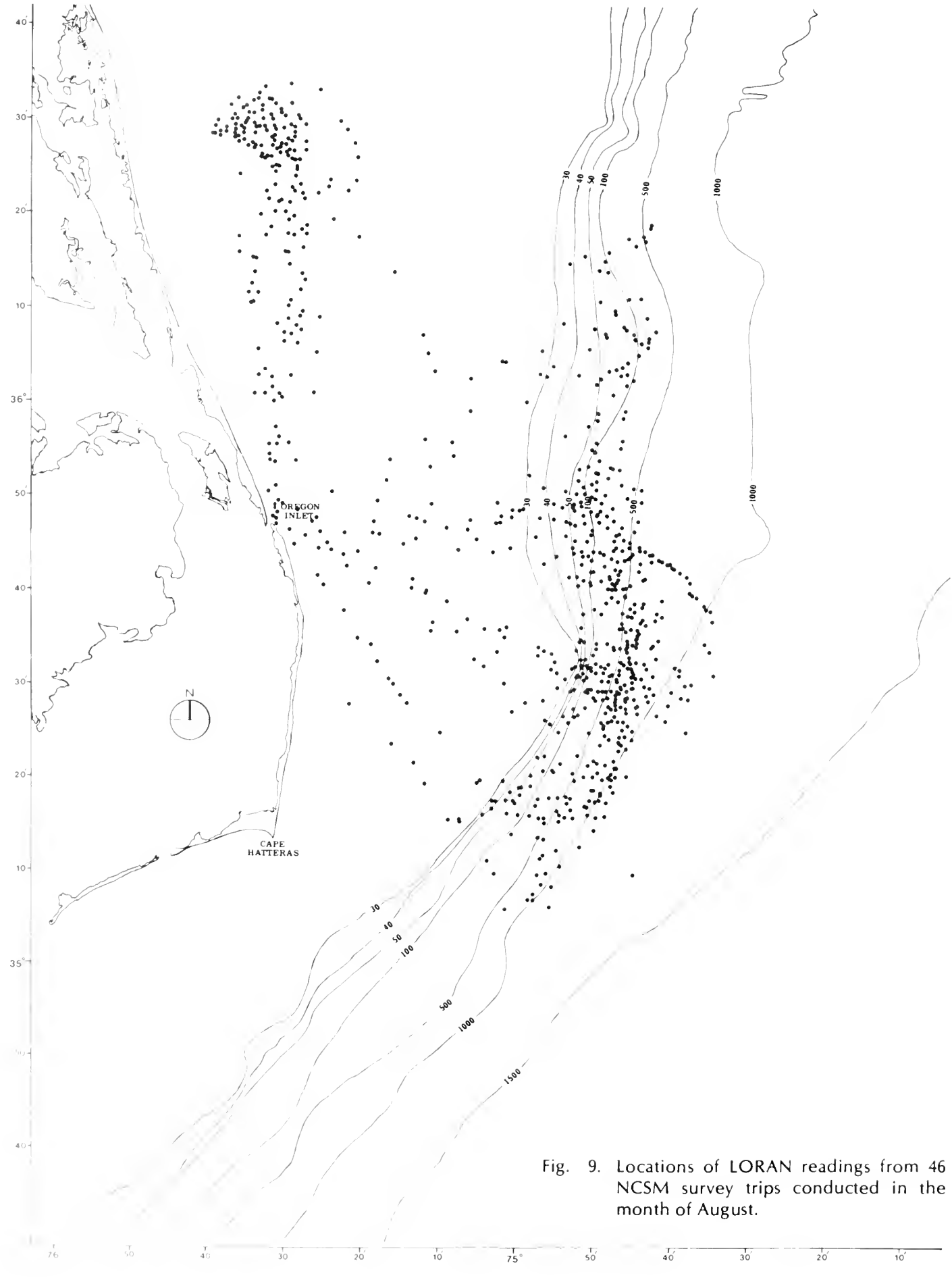


Fig. 9. Locations of LORAN readings from 46 NCSM survey trips conducted in the month of August.

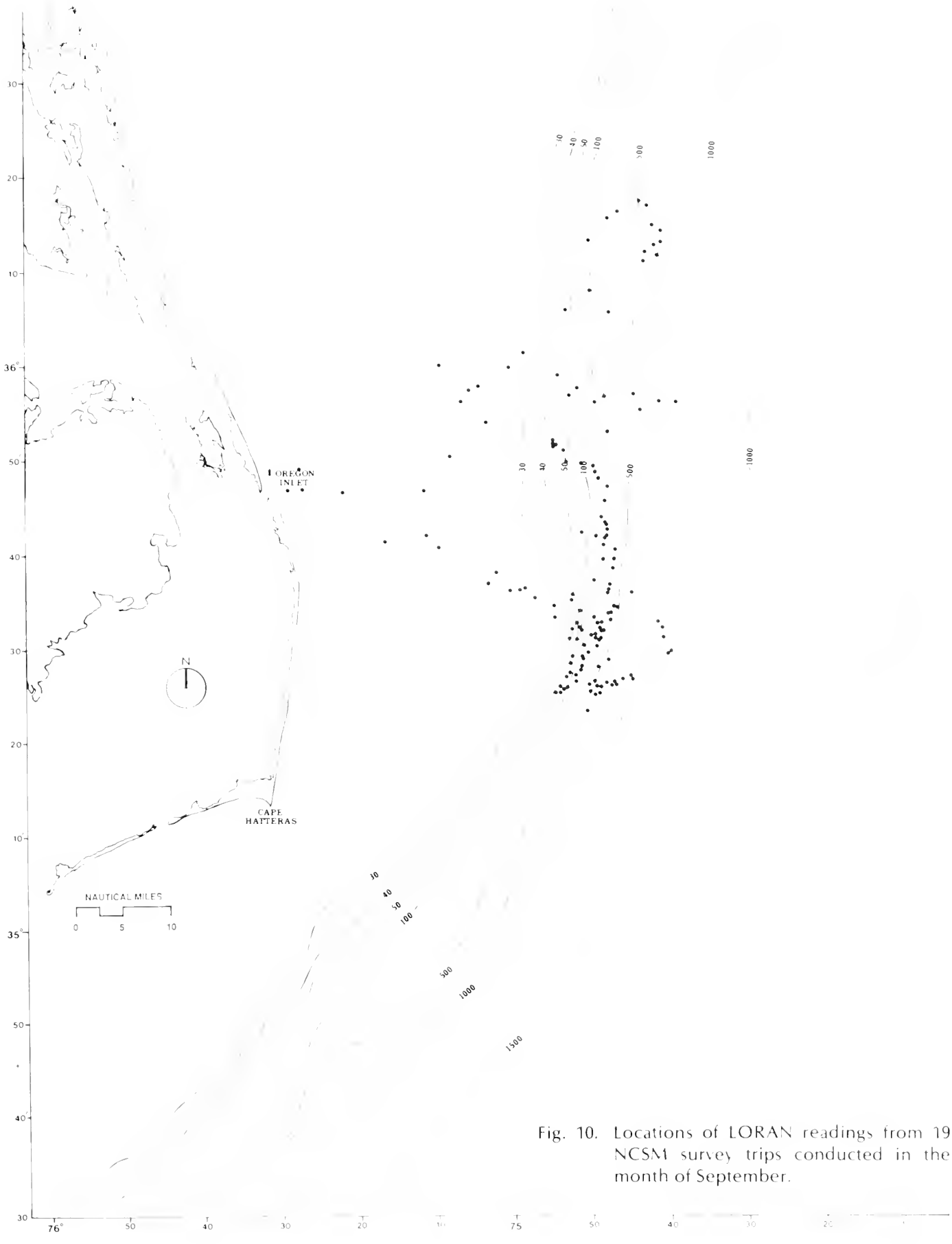


Fig. 10. Locations of LORAN readings from 19 NCSM survey trips conducted in the month of September.

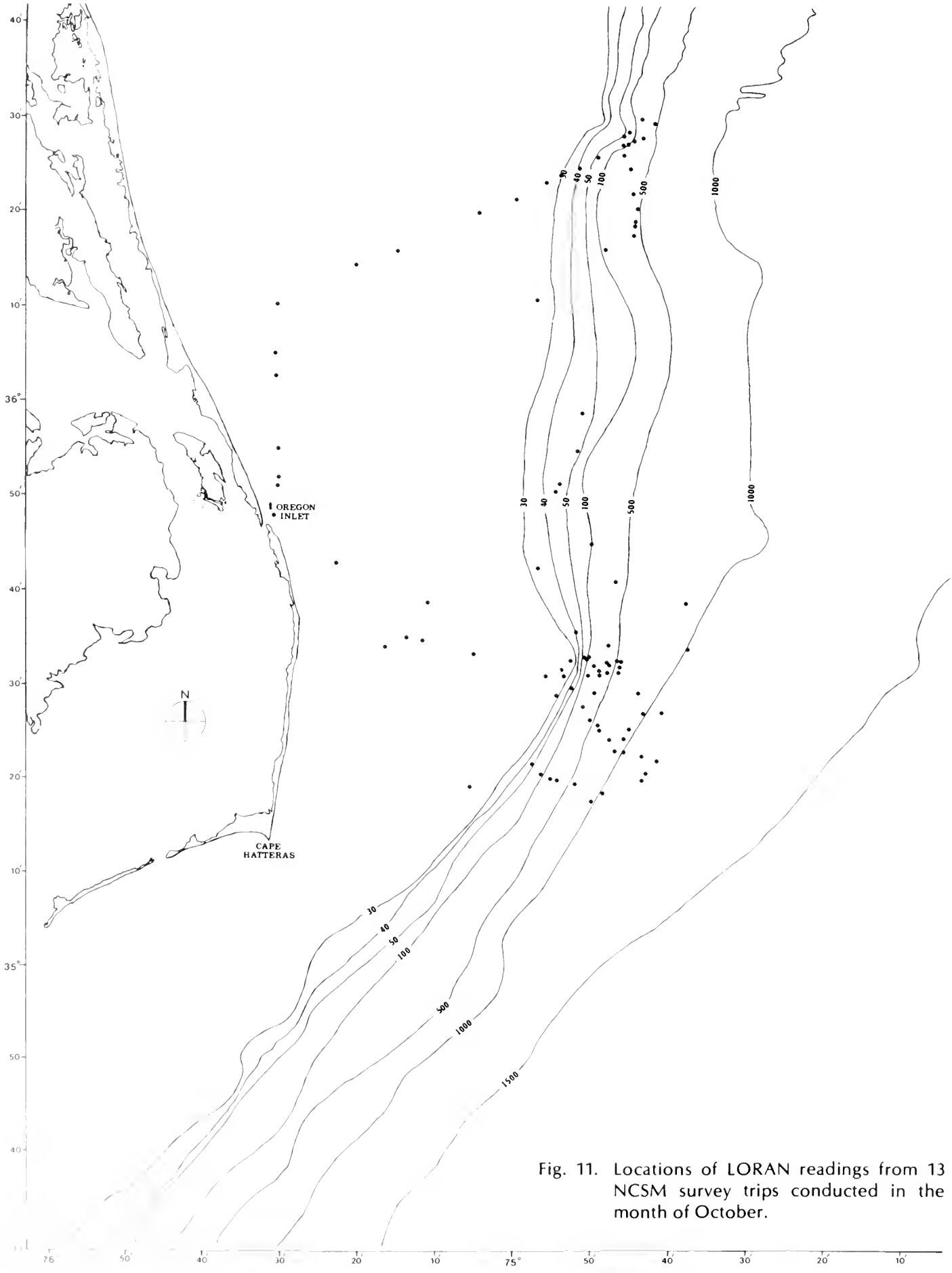


Fig. 11. Locations of LORAN readings from 13 NCSM survey trips conducted in the month of October.

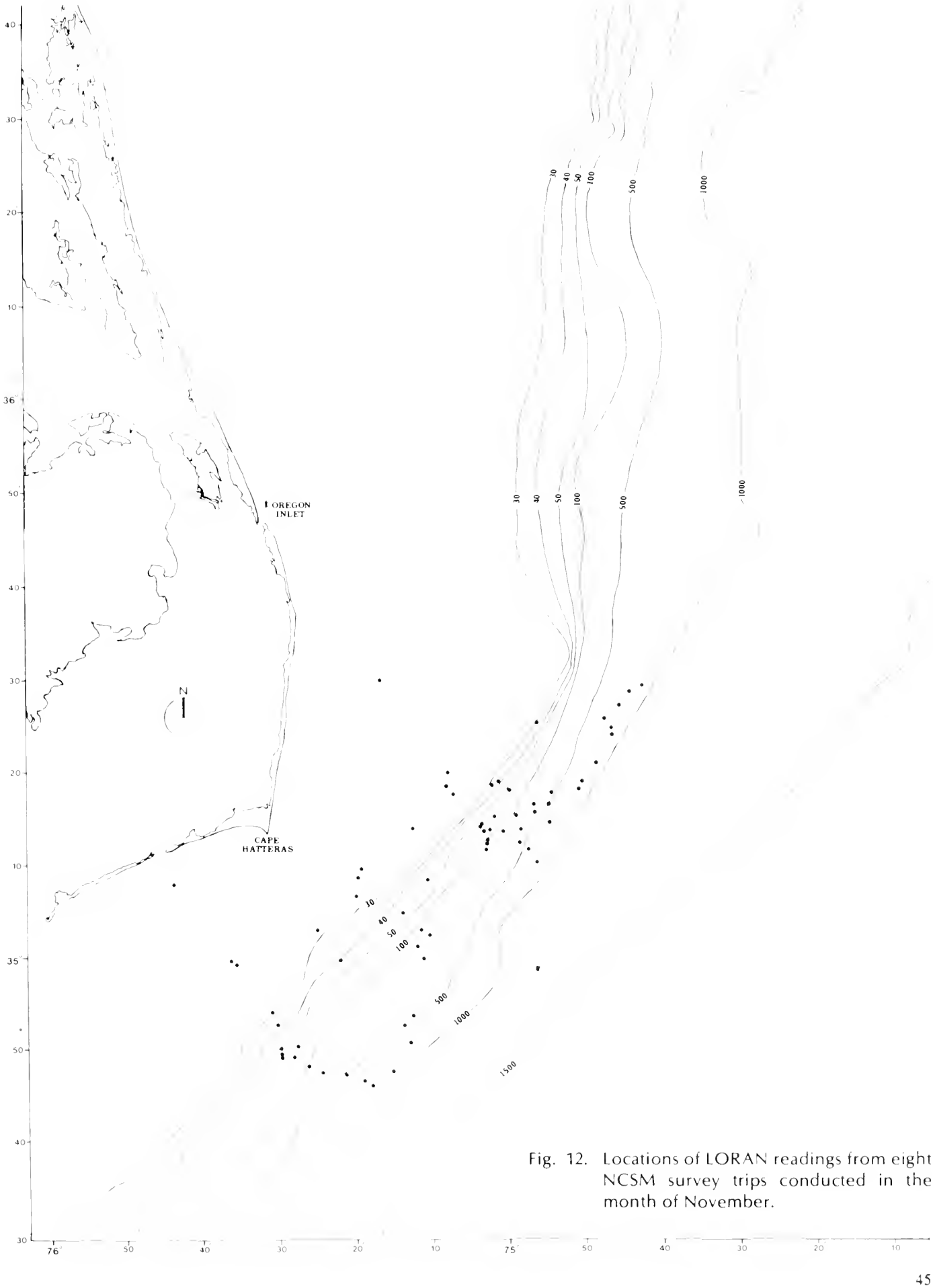
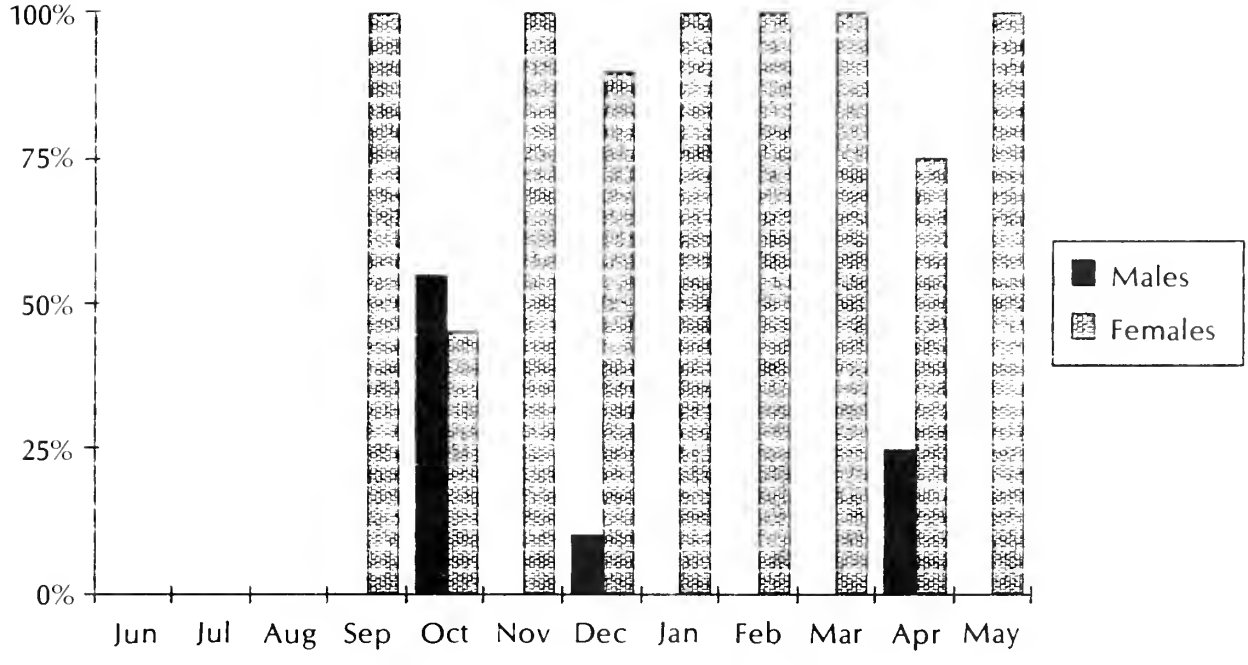
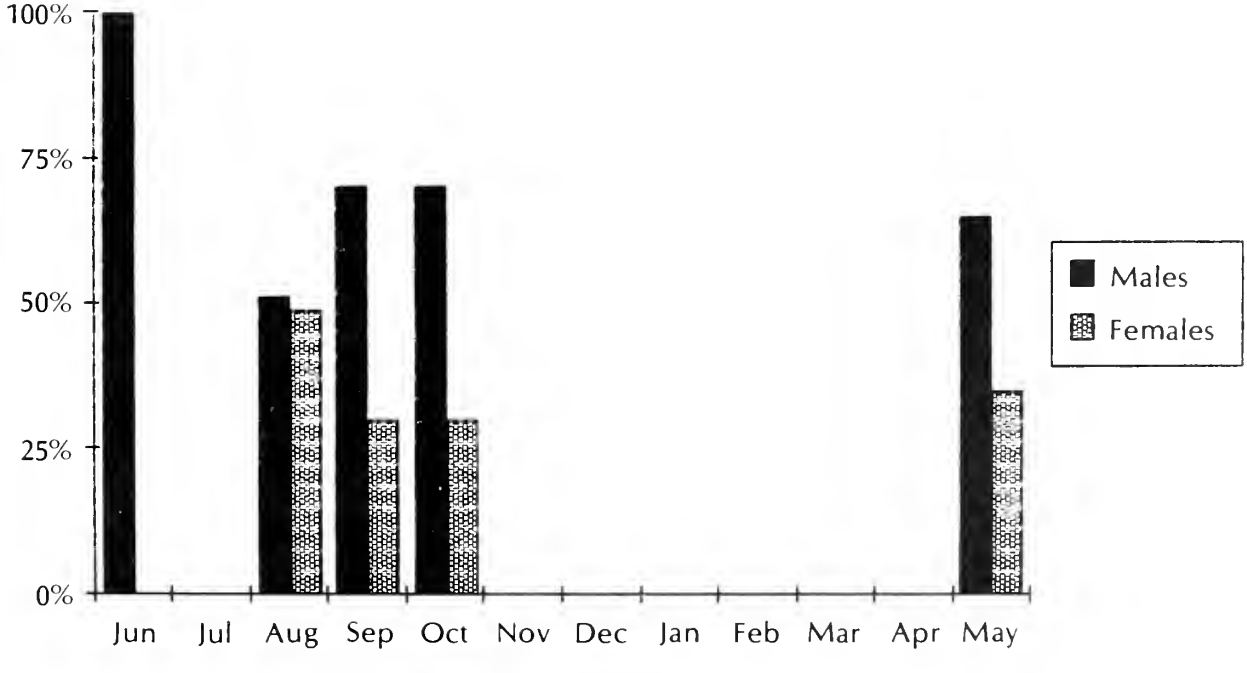


Fig. 12. Locations of LORAN readings from eight NCSM survey trips conducted in the month of November.

Fig. 13. Locations of LORAN readings from 12 NCSM survey trips conducted in the month of December.

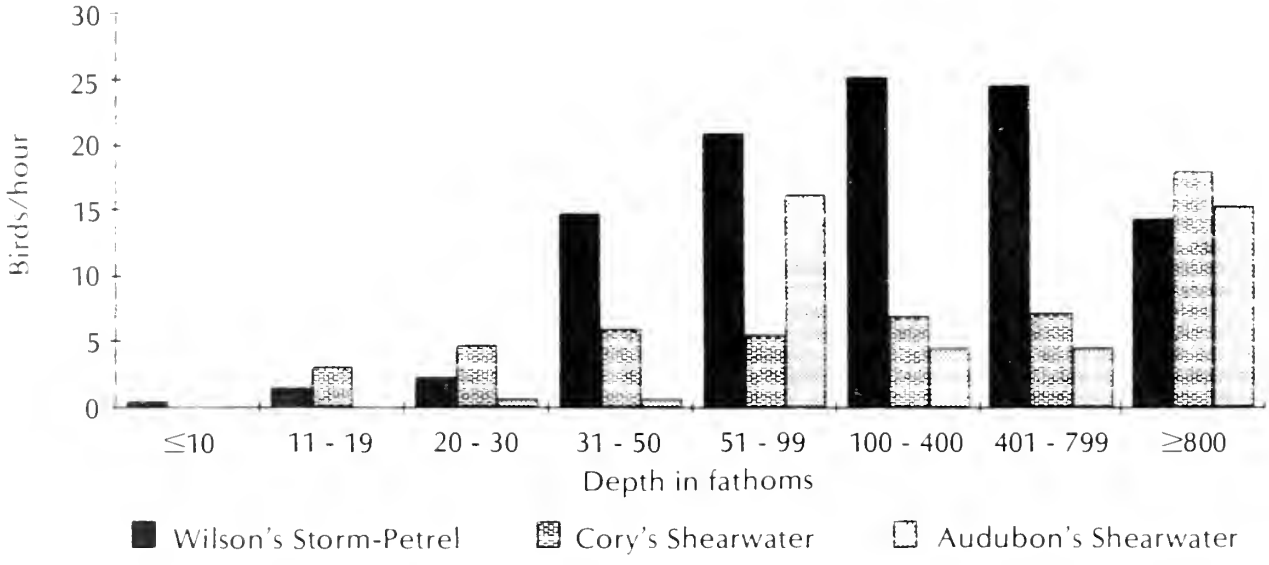


Red Phalarope, *Phalaropus fulicaria* (N = 125)

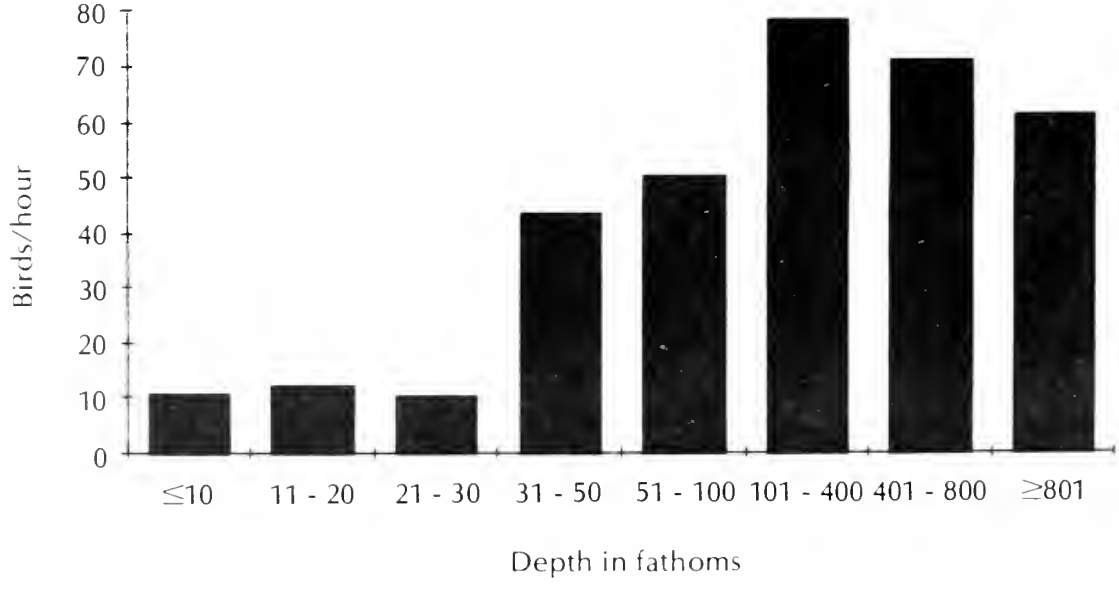


Red-necked Phalarope, *Phalaropus lobatus* (N = 103)

Fig. 14. Seasonal distribution by sex of two phalarope species that occur off the North Carolina coast.



a. Zonation of three species in summer.



b. Zonation of all species in summer.

Fig. 15(a-b). Zonation of marine birds off North Carolina.

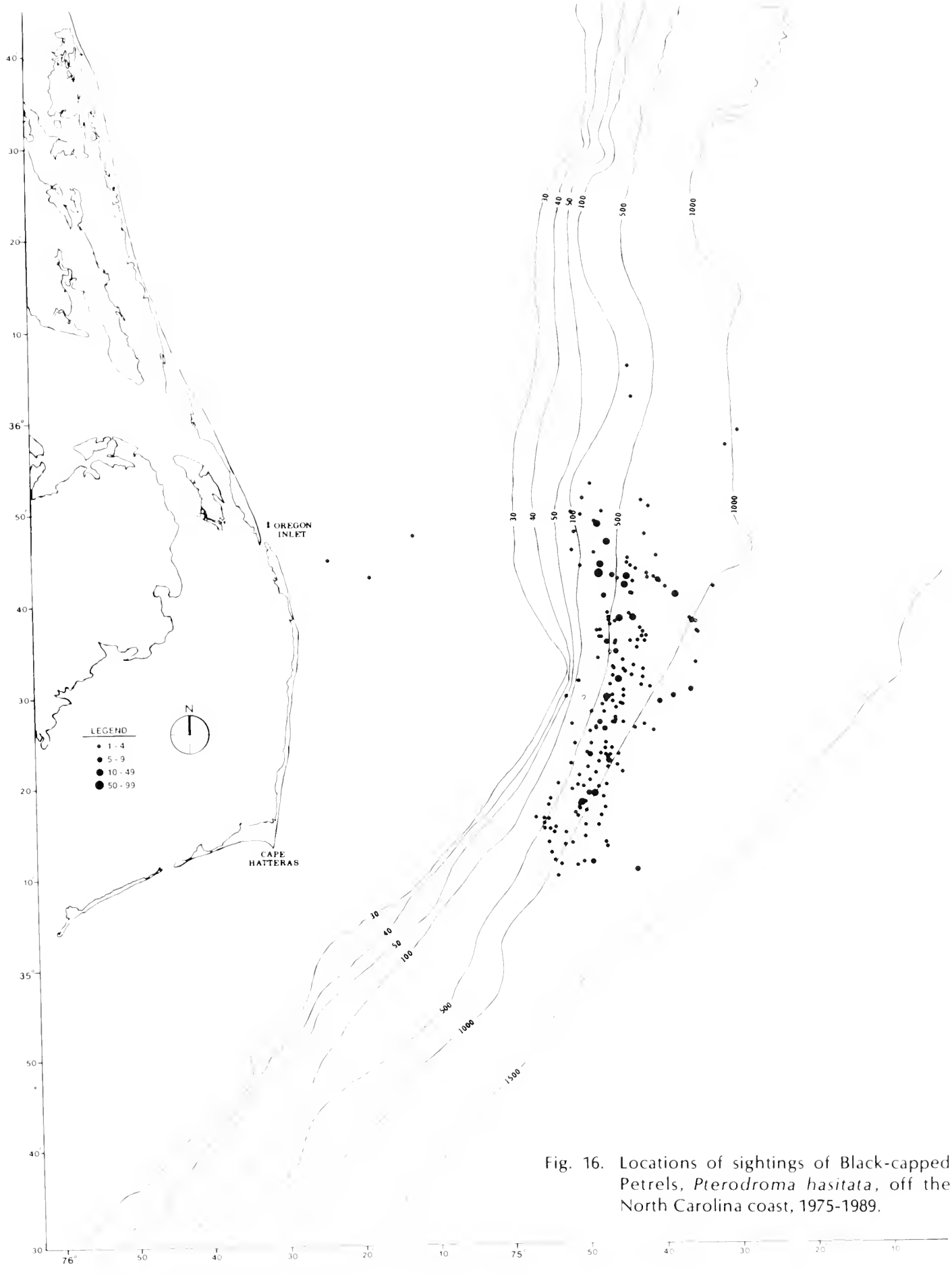


Fig. 16. Locations of sightings of Black-capped Petrels, *Pterodroma hasitata*, off the North Carolina coast, 1975-1989.

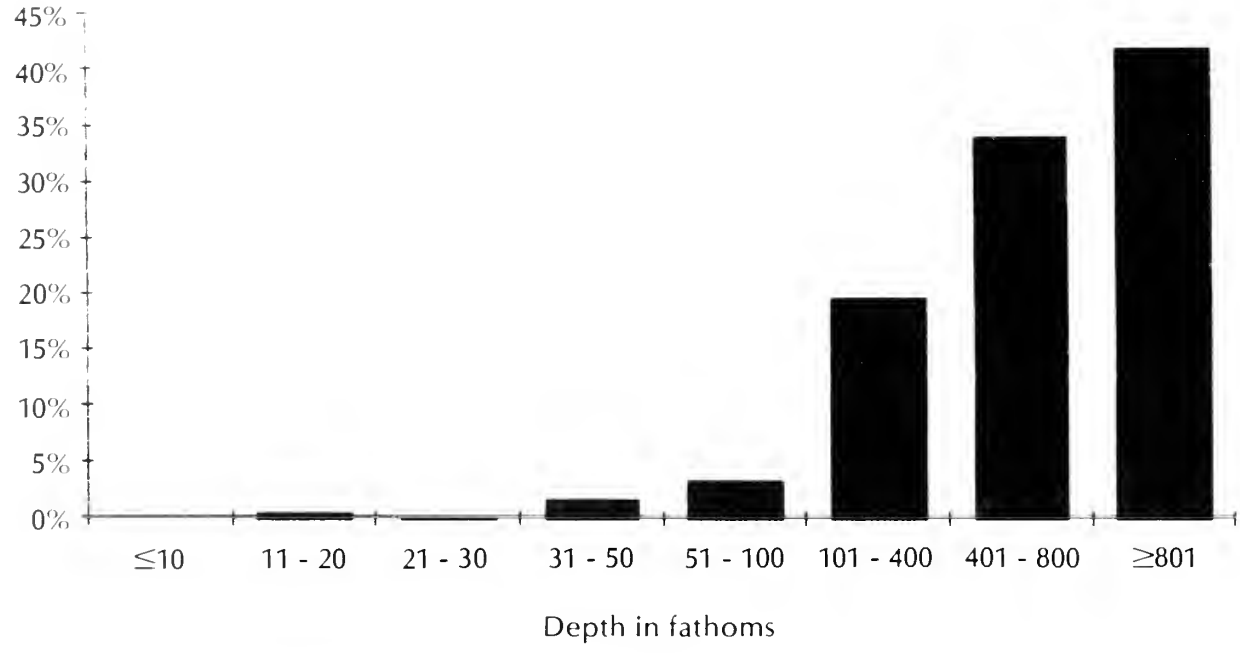


Fig. 17. Zonal distribution of 1,824 Black-capped Petrels, *Pterodroma hasitata*, recorded off the North Carolina coast, 1975-1989.

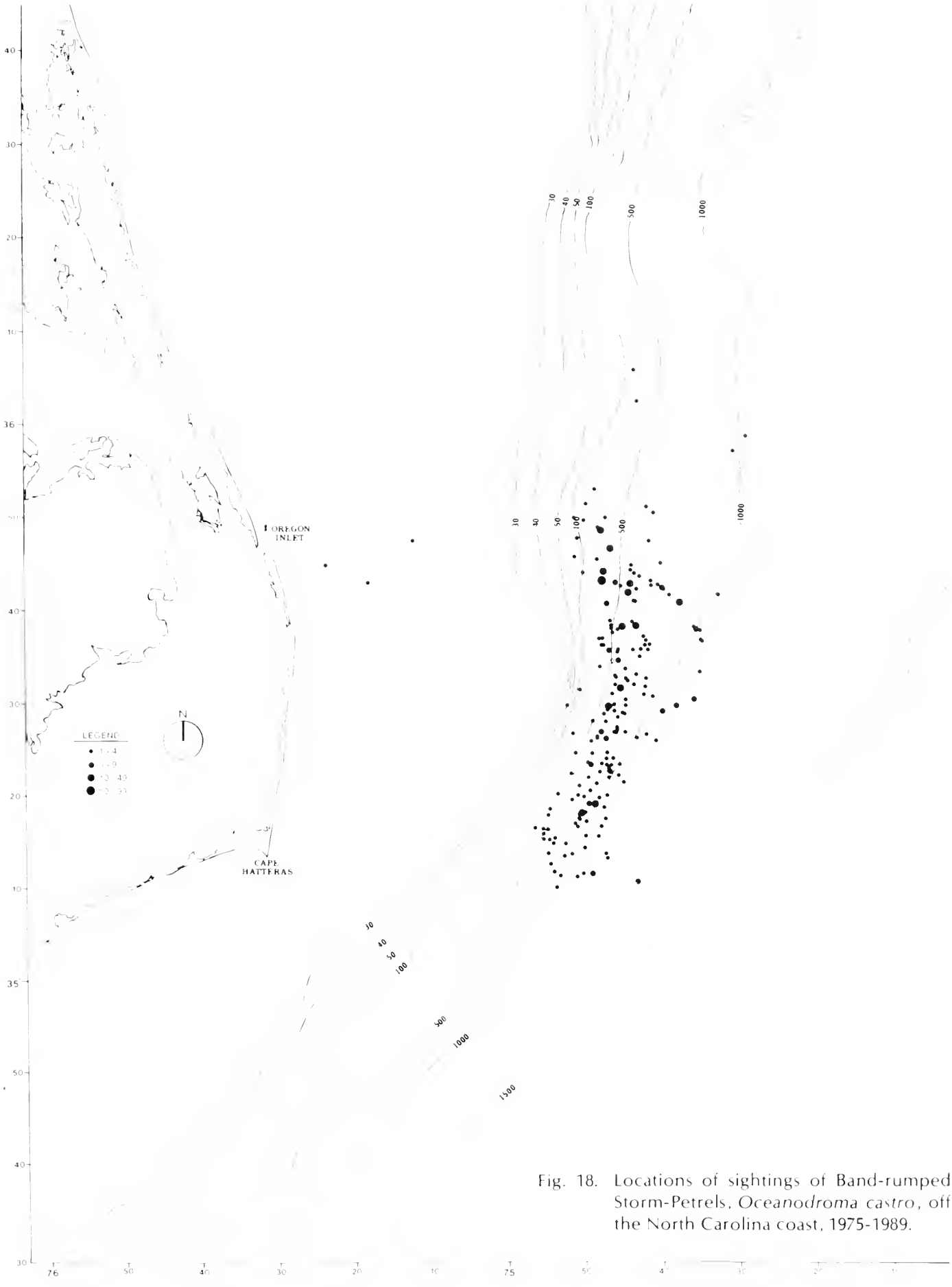


Fig. 18. Locations of sightings of Band-rumped Storm-Petrels, *Oceanodroma castro*, off the North Carolina coast, 1975-1989.

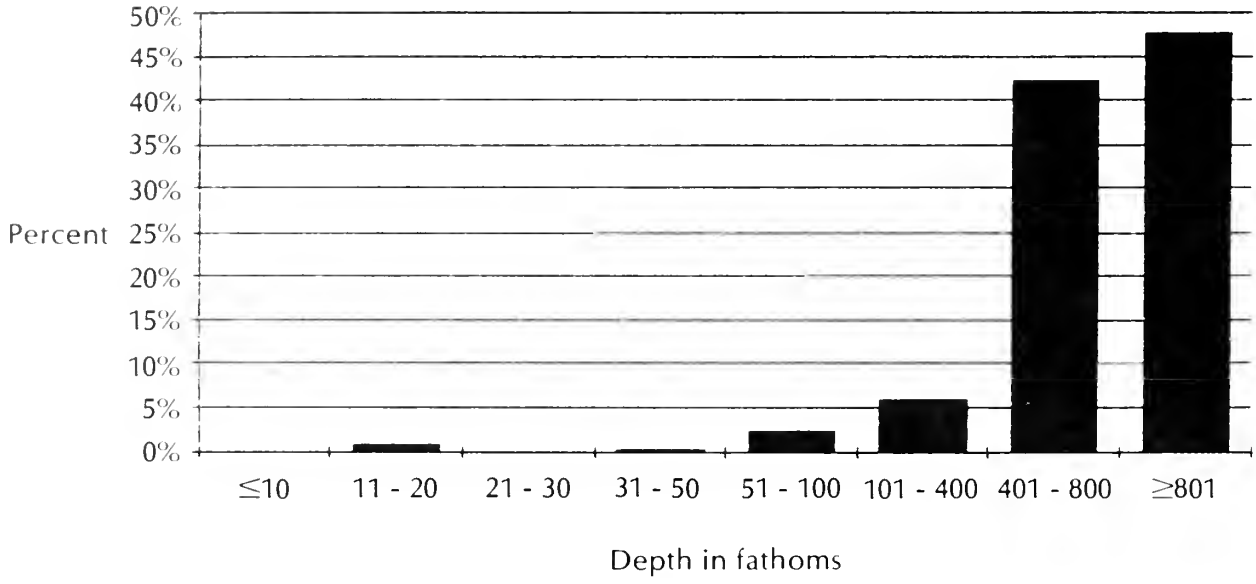


Fig. 19. Zonal distribution of Band-rumped Storm-Petrels, *Oceanodroma castro*, off the North Carolina coast, 1975-1989.

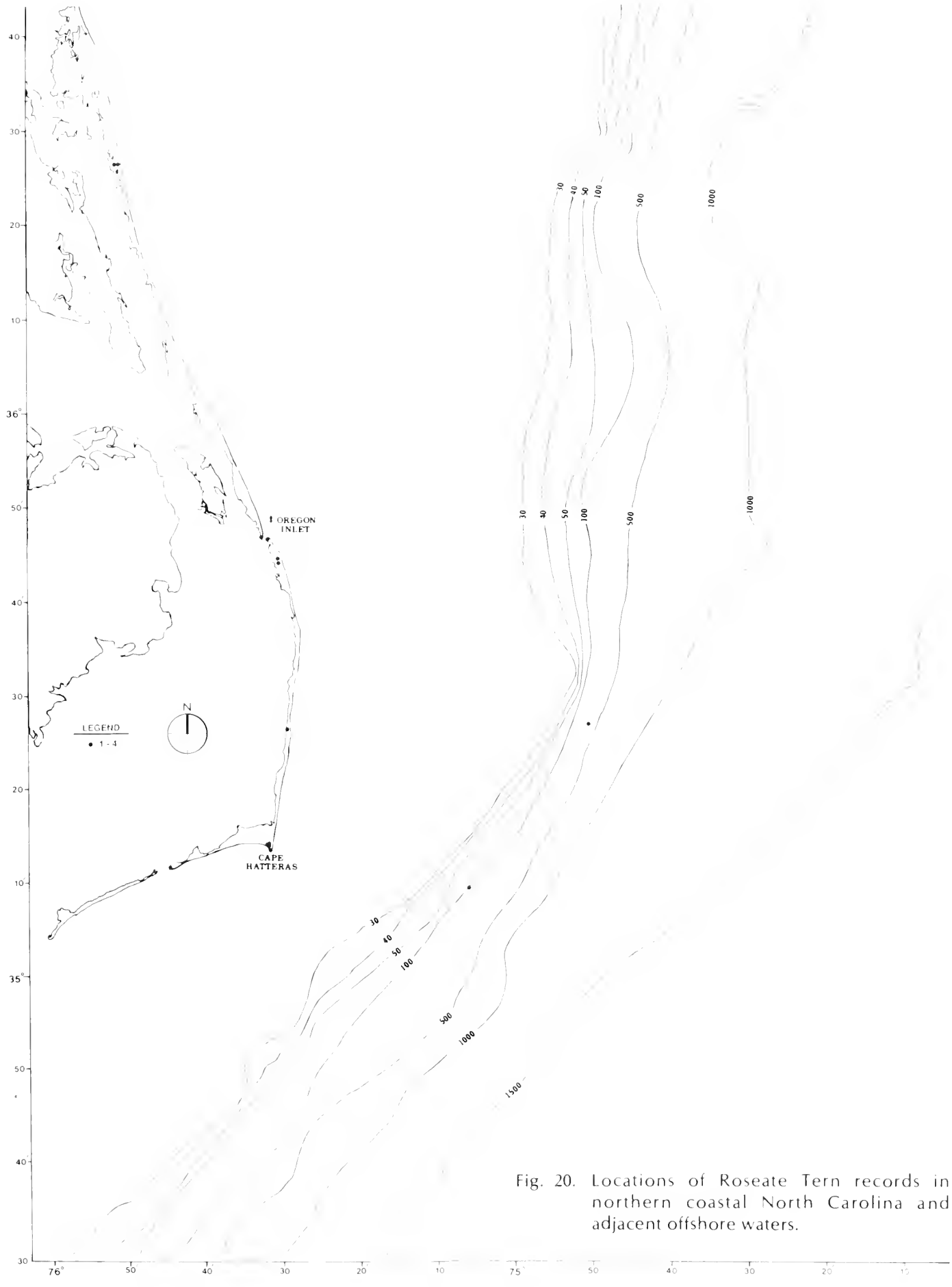


Fig. 20. Locations of Roseate Tern records in northern coastal North Carolina and adjacent offshore waters.

January/February

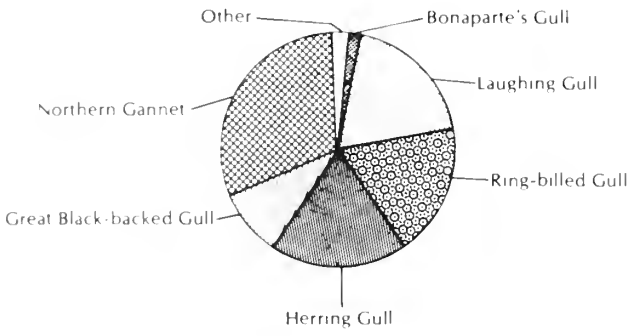


Fig. 21. Major composition of bird fauna between 20 and 1,000 fathoms off the northern North Carolina coast in January and February (from Lee 1986).

March

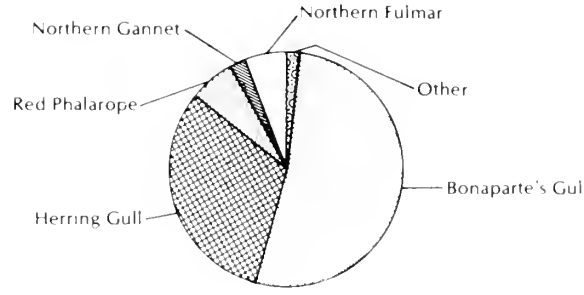


Fig. 22. Major composition of bird fauna between 20 and 1,000 fathoms off the northern North Carolina coast in March (from Lee 1986).

April

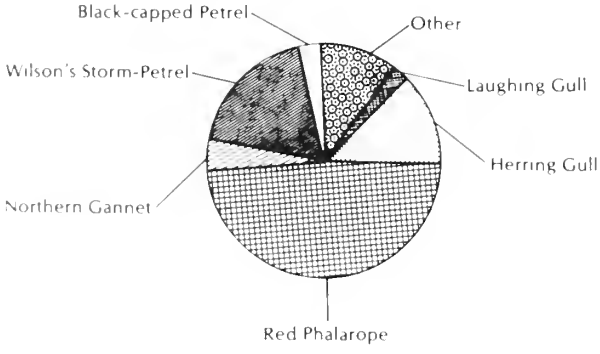


Fig. 23. Major composition of bird fauna between 20 and 1,000 fathoms off the northern North Carolina coast in April (from Lee 1986).

May

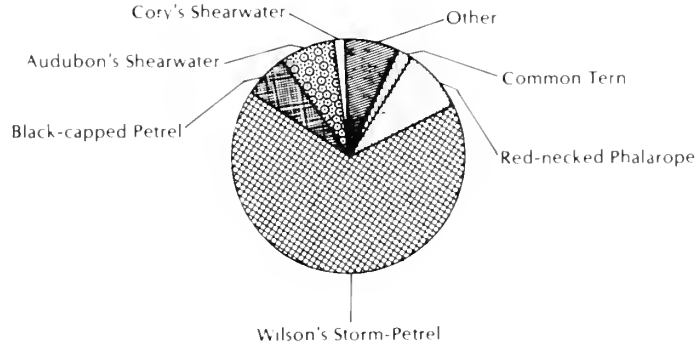


Fig. 24. Major composition of bird fauna between 20 and 1,000 fathoms off the northern North Carolina coast in May (from Lee 1986).

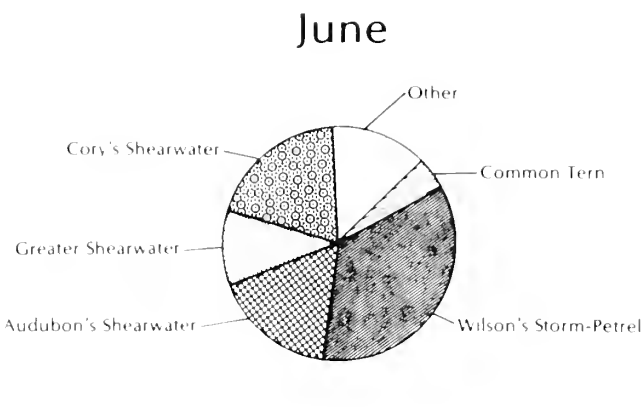


Fig. 25. Major composition of bird fauna between 20 and 1,000 fathoms off the northern North Carolina coast in June (from Lee 1986).

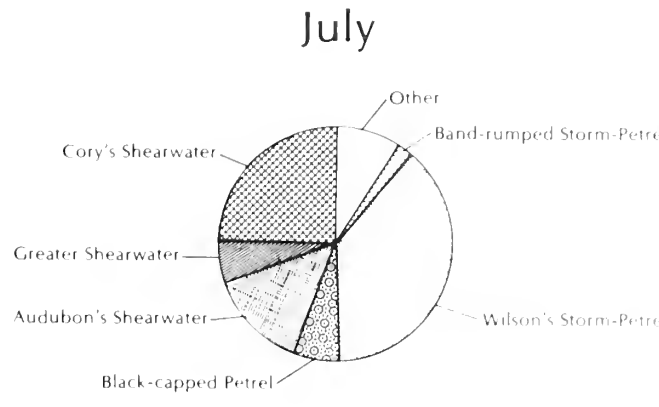


Fig. 26. Major composition of bird fauna between 20 and 1,000 fathoms off the northern North Carolina coast in July (from Lee 1986).

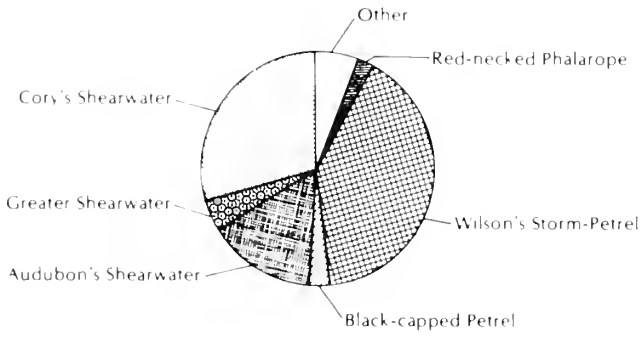


Fig. 27. Major composition of bird fauna between 20 and 1,000 fathoms off the northern North Carolina coast in August (from Lee 1986).

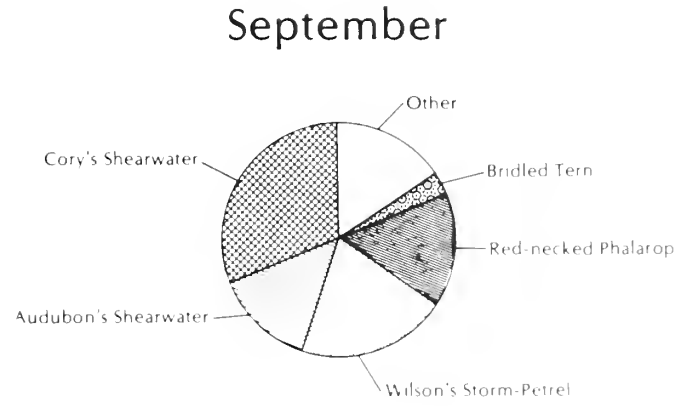


Fig. 28. Major composition of bird fauna between 20 and 1,000 fathoms off the northern North Carolina coast in September (from Lee 1986).

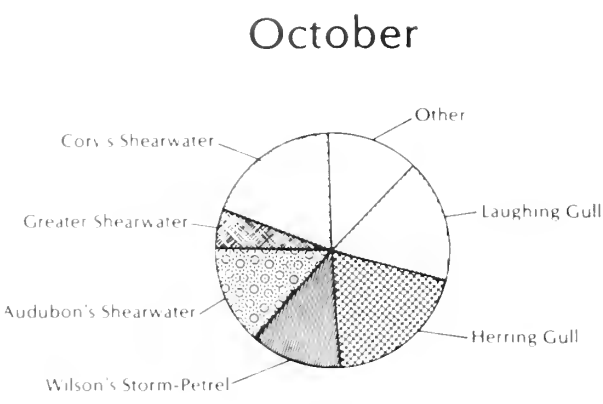


Fig. 29. Major composition of bird fauna between 20 and 1,000 fathoms off the northern North Carolina coast in October (from Lee 1986).

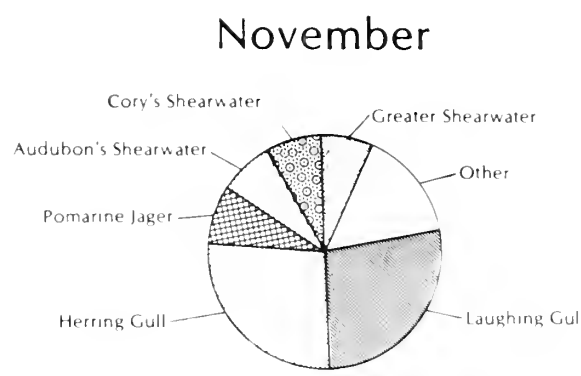


Fig. 30. Major composition of bird fauna between 20 and 1,000 fathoms off the northern North Carolina coast in November (from Lee 1986).

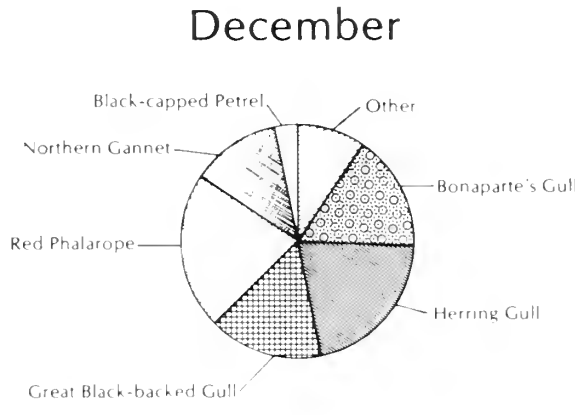


Fig. 31. Major composition of bird fauna between 20 and 1,000 fathoms off the northern North Carolina coast in December (from Lee 1986).

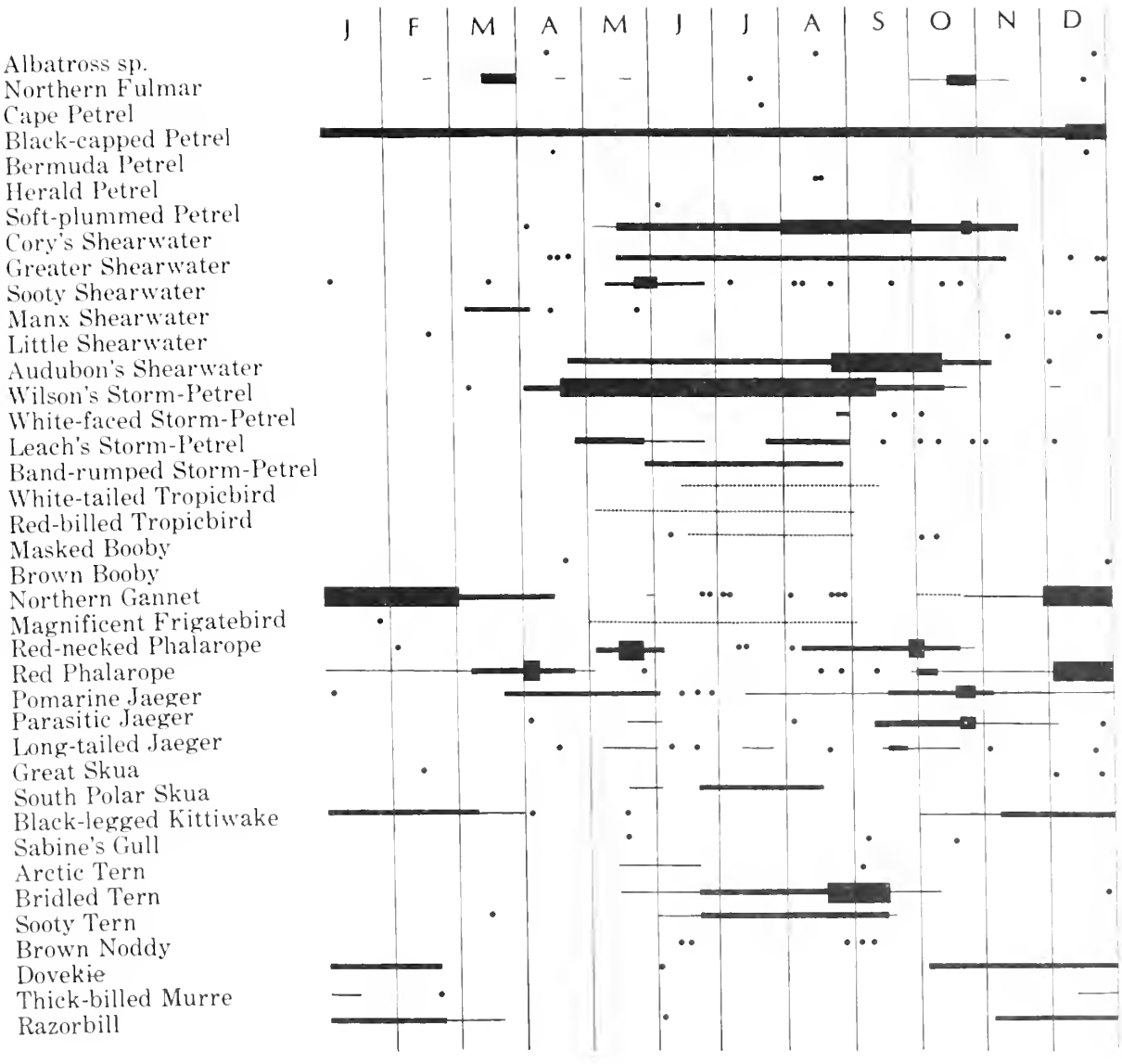


Fig. 32. Seasonal distribution of North Carolina's offshore and pelagic birds. Thickness of lines indicates relative abundance.

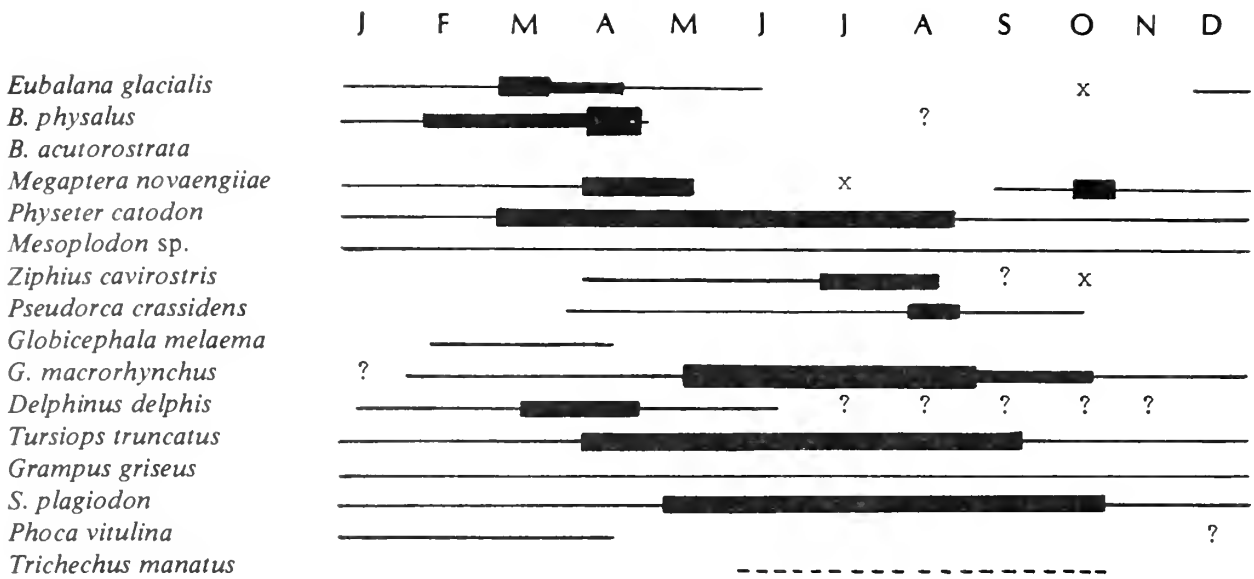


Fig. 33. Seasonal distribution of North Carolina's offshore and pelagic mammals. Thickness of lines indicates relative abundance. x = isolated records. ? = expected occurrence.

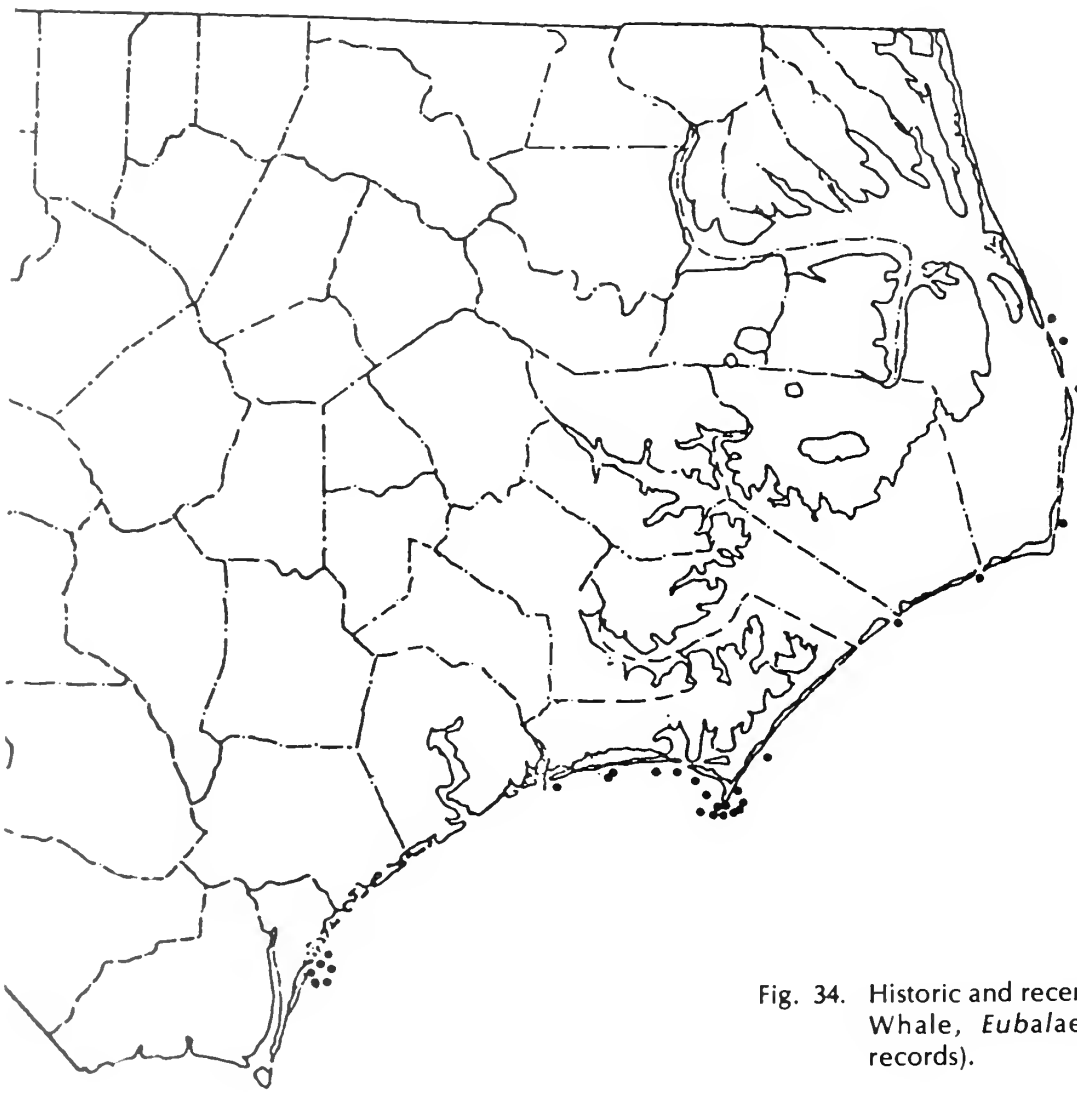


Fig. 34. Historic and recent sightings of the Right Whale, *Eubalaena glacialis* (NCSM records).

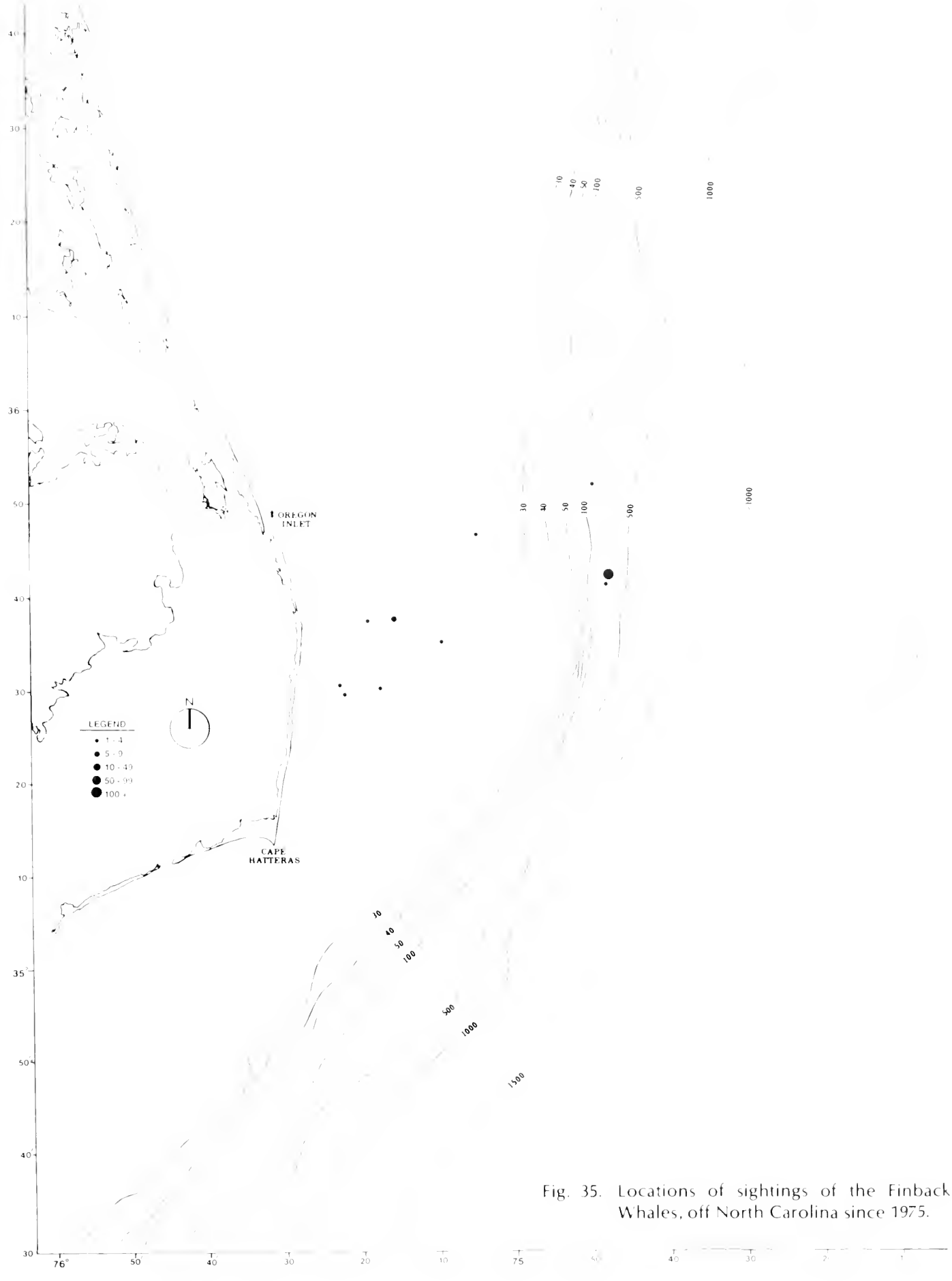


Fig. 35. Locations of sightings of the Finback Whales, off North Carolina since 1975.

Fig. 36. Locations of sightings of the Sperm Whale, off North Carolina since 1975.

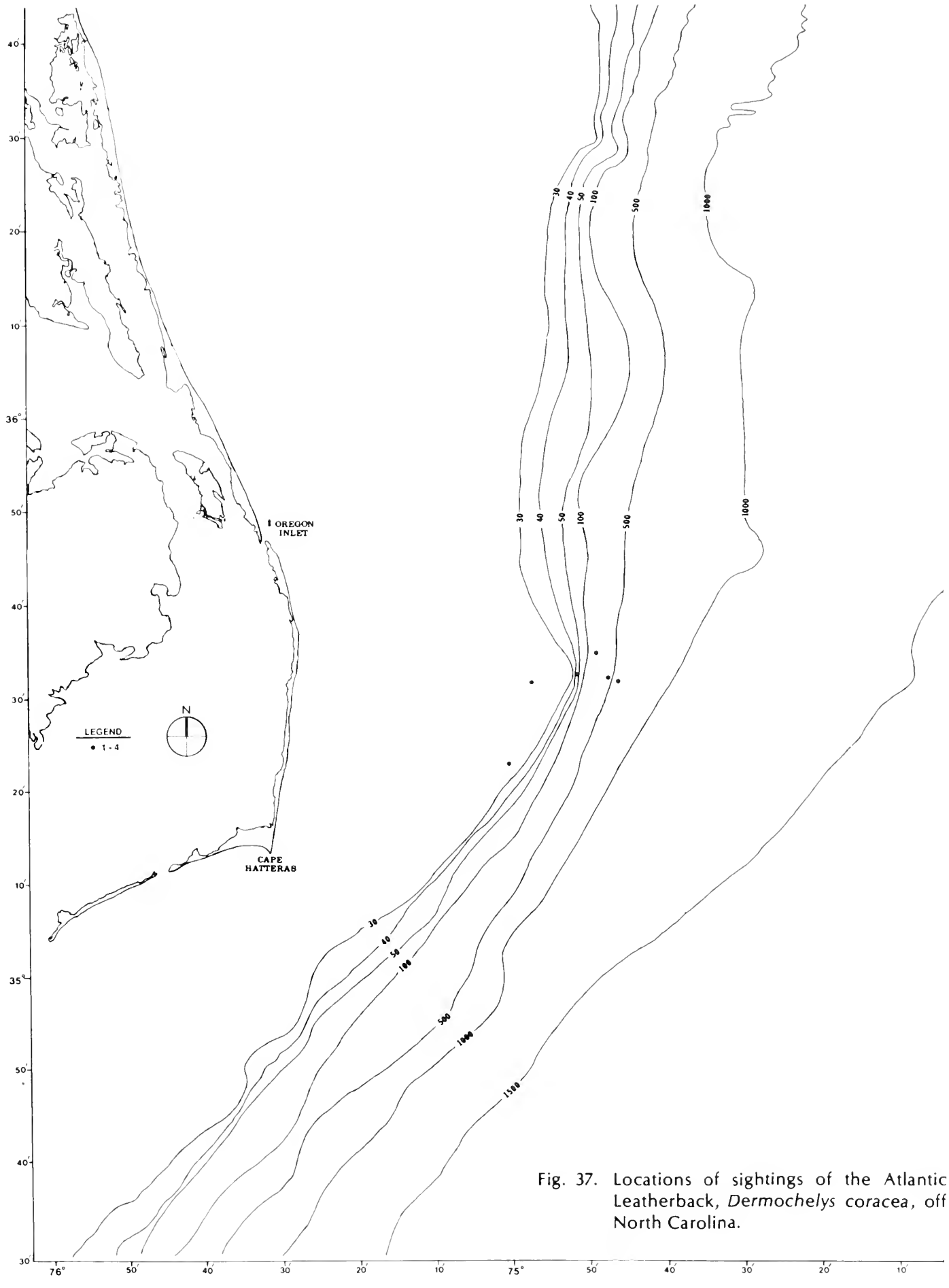


Fig. 37. Locations of sightings of the Atlantic Leatherback, *Dermochelys coracea*, off North Carolina.

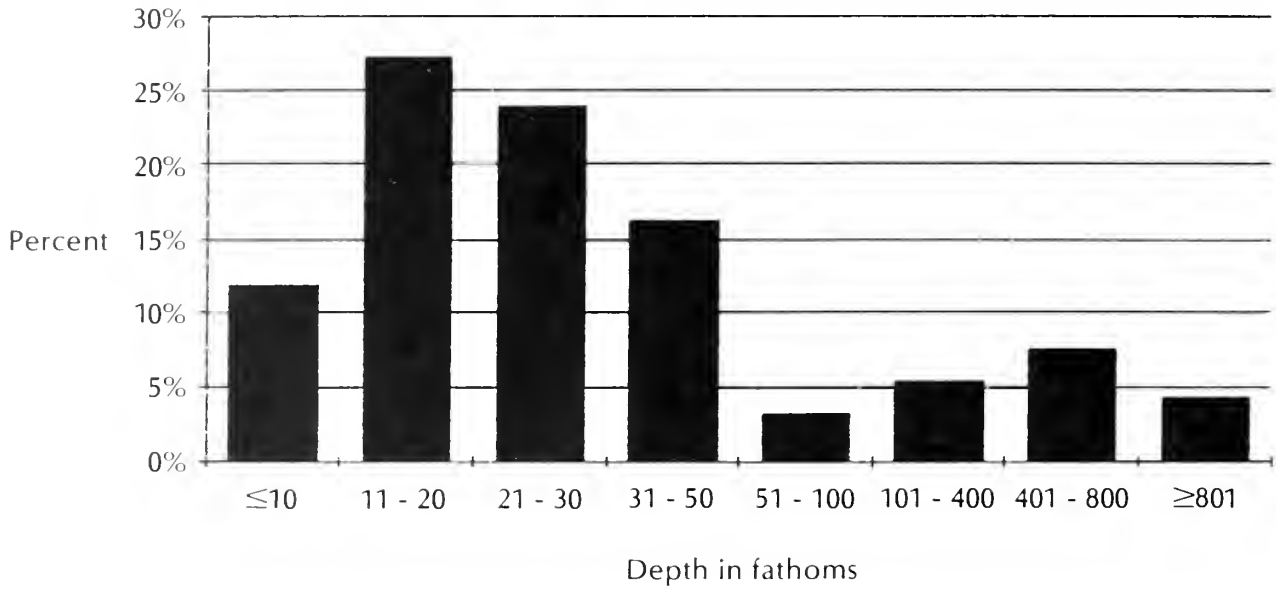


Fig. 38. Zonal distribution of 92 sightings of the Loggerhead Sea Turtle, *Caretta caretta*, off the northern North Carolina coast, 1975-1989 (NCSM records).

APPENDIX I
Species of Seabirds Occurring in North Carolina Waters

COMMON NAME	SCIENTIFIC NAME
Common Loon	*Gavia immer*
Black-browed Albatross	*Diamedea chlorohynchus*
Northern Fulmar	*Fulmarus glacialis*
Black-capped Petrel	*Pterodroma hasitata*
Bermuda Petrel	*Pterodroma cahow*
Soft-plumaged Petrel	*Pterodroma mollis*
Herald Petrel	*Pterodroma arminjoniana*
Cory's Shearwater	*Calonectris diomedea*
Greater Shearwater	*Puffinus gravis*
Sooty Shearwater	*Puffinus griseus*
Manx Shearwater	*Puffinus puffinus*
Little Shearwater	*Puffinus assimilis*
Audubon's Shearwater	*Puffinus lherminieri*
Wilson's Storm-Petrel	*Oceanites oceanicus*
White-faced Storm-Petrel	*Pelagodroma marina*
Leach's Storm-Petrel	*Oceanodroma leucorhoa*
Band-rumped Storm-Petrel	*Oceanodroma castro*
White-tailed Tropicbird	*Phaethon lepturus*
Red-billed Tropicbird	*Phaethon aethereus*
Masked Booby	*Sula dactylatra*
Brown Booby	*Sula leucogaster*
Northern Gannet	*Sula bassanus*
Double-crested Cormorant	*Phalacrocorax auritus*
Red-necked Phalarope	*Phalaropus (Lobipes) lobatus*
Red Phalarope	*Phalaropus fulicaris*
Pomarine Jaeger	*Stercorarius pomarinus*
Parasitic Jaeger	*Stercorarius parasiticus*
Long-tailed Jaeger	*Stercorarius longicaudus*
Great Skua	*Catharacta skua*
South Polar Skua	*Catharacta maccormicki*
Laughing Gull	*Larus atricilla*
Little Gull	*Larus minutus*
Bonaparte's Gull	*Larus philadelphia*
Ring-billed Gull	*Larus delawarensis*
Herring Gull	*Larus argentatus*
Great Black-backed Gull	*Larus marinus*
Black-legged Kittiwake	*Rissa tridactyla*
Sabine's Gull	*Xema sabini*
Gull-billed Tern	*Sterna nilotica*
Royal Tern	*Sterna maxima*
Sandwich Tern	*Sterna sandvicensis*
Roseate Tern	*Sterna dougalli*
Common Tern	*Sterna hirundo*
Arctic Tern	*Sterna paradisaea*
Forster's Tern	*Sterna forsteri*
Least Tern	*Sterna antillarum*
Bridled Tern	*Sterna anaethetus*
Sooty Tern	*Sterna fuscata*
Black Tern	*Chlidonias niger*
Brown Noddy	*Anous stolidus*
Dovekie	*Alle alle*
Thick-billed Murre	*Uria lomvia*
Razorbill	*Alca torda*

APPENDIX II
Species of Cetaceans and Marine Turtles Occurring in North Carolina

CETACEA

Family Balaenopteridae
- *Balaenoptera acutorostrata* Lacepede
  Minke Whale
- *Balaenoptera borealis* Lesson
  Sei Whale
- *Balaenoptera physalus* (Linnaeus)
  Fin Whale
- *Megaptera novaeangliae* (Borowski)
  Humpback Whale

Family Balaenidae
- *Balaena glacialis* Muller
  Black Right Whale

Family Delphinidae
- *Steno bredanensis* (Lesson)
  Rough-toothed Dolphin
- *Tursips truncatus* (Montagu)
  Atlantic Bottlenosed Dolphin
- *Grampus griseus* (G. Cuvier)
  Risso's Dolphin or Grampus
- *Stenella longirostris* (Gray)
  Spinner Dolphin
- *Stenella frontalis* (G. Cuvier)
  Bridled Spotted Dolphin
- *Stenella coeruleoalba* (Meyen)
  Striped Dolphin
- *Delphinus delphis* Linnaeus
  Saddleback Dolphin
- *Pseudorca crassidens* (Owens)
  False Killer Whale
- *Globicephala melas* (Traill)
  Long-finned Pilot Whale
- *Globicephala macrorhynchus* Gray
  Short-finned Pilot Whale
- *Orcinus orca* (Linnaeus)
  Killer Whale

Family Phocoenidae
- *Phocoena phocoena* (Linnaeus)
  Harbor Porpoise

Family Ziphiidae
- *Ziphius cavirostris* G. Cuvier
  Goosebeaked Whale
- *Mesoplodon europaeus* (Gervais)
  Gervais' Beaked Whale
- *Mesoplodon densirostris* (Blainville)
  Dense-beaked Whale
- *Mesoplodon mirus* True
  True's Beaked Whale

Family Koglidae
- *Kogia breviceps* (Blainville)
  Pygmy Sperm Whale
- *Kogia simus* (Owen)
  Dwarf Sperm Whale

Family Physeteridae
- *Physeter macrocephalus* Linnaeus
  Sperm Whale

MARINE TURTLES

Family Dermochelyidae
- *Dermochelys coriacea* (Linnaeus)
  Leatherback

Family Cheloniidae
- *Eretmochelys imbricata* (Linnaeus)
  Hawksbill
- *Lepidochely kempi* (Garman)
  Atlantic Ridley
- *Caretta caretta* (Linnaeus)
  Loggerhead
- *Chelonia mydas* (Linnaeus)
  Green Turtle

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