AN OILSPILL RISK ANALYSIS FOR THE MID-ATLANTIC (PROPOSED SALE 49) OUTER CONTINENTAL SHELF LEASE AREA

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AN OILSPILL RISK ANALYSIS FOR THE MID-ATLANTIC (Proposed Sale 49)

OUTER CONTINENTAL SHELF LEASE AREA

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ABSTRACT

An oilspill risk analysis was conducted to determine the relative environmental hazards of developing oil in different regions of the Mid-Atlantic Outer Continental Shelf lease area. The study analyzed the probability of spill occurrence, likely paths of the spilled oil, and locations in space and time of such objects as recreational and biological resources likely to be vulnerable. These results are combined to yield estimates of the overall oilspill risks associated with development of the proposed lease area. The analysis implicitly includes estimates of weathering rates and slick dispersion and an indication of the possible mitigating effects of cleanups. Assuming that economically recoverable amounts of oil are found in the area, the leasing of the tracts proposed for Sale 49 will increase the expected number of spills by about 20-25% over the number expected from the existing (Sale 40) leases. The probability that an object, such as land, will be contacted by a spill is increased by at most five percentage points.

INTRODUCTION

The Federal Government has proposed to offer about 775 thousand acres of Outer Continental Shelf (OCS) lands off the Mid-Atlantic coast for oil and gas leasing. If there is an economically recoverable amount of oil to be found in the area, then the estimated recoverable petroleum resources for the 136 tracts proposed for sale are about 150 million barrels of crude oil. Contingent upon actual discovery of this quantity of oil, production is expected to span a period of about 25 years. There are already 93 existing tracts (resulting from OCS Sale 40) in this area which, it is estimated, may yield about 800 million barrels of oil, if the area is petroleum prone.

Oilspills are one of the major concerns associated with offshore oil production in the Mid-Atlantic area. An important fact that stands out when one attempts to evaluate the significance of accidental oil spillage for this, or any proposed lease area, is that the problem is fundamentally probabilistic. A great deal of uncertainty exists, for example, about the number and size of spills that might occur during the life of production, as well as the wind and current conditions that would exist and give direction to the oil slick at the specific times spills do occur. While some of the uncertainty reflects incomplete and imperfect data, considerable uncertainty is simply inherent in the problem of decribing future events over which complete control cannot be exercised.

In view of this inability to predict with certainty future oilspill effects, it is important to consider the range of possible effects that could accompany oil and gas production. It is equally important, however, in attempting to maintain perspective on the problem, to associate these potential effects with quantitative estimates of the probability of their occurrence.

This report summarizes results of an oilspill risk analysis conducted for the proposed Mid-Atlantic (Sale 49) OCS lease sale. The study had the objective of determining relative risks associated with additional oil and gas production in different regions of the proposed lease area and was undertaken for consideration in the draft Environmental Impact Statement (EIS) and to facilitate final selection of tracts to be offered for sale. The analysis was conducted in three more or less independent parts corresponding to different aspects of the overall problem. The first part dealt with the probability of spill occurrence, the second with likely spill trajectories for the times and places oilspills might occur, and the third part with the spatial and temporal location of specific objects, such as biological and recreation resources thought to be vulnerable to spilled oil. Results of the individual parts of the analysis were then combined to give estimates of the overall oilspill risk associated with oil and gas production in the lease area. This analysis was done separately for the proposed leases and the existing leases and the results combined to determine the cumulative or incremental risk due to the proposed sale.

An extremely important point to bear in mind is that this report assumes that petroleum, in economically recoverable amounts, exists in the area. As of the end of this study (February, 1978), there had been no drilling for oil in the Mid-Atlantic area. There is insufficient data available to say for certain that the area does contain significant amounts of petroleum. It is estimated that the probability is 0.6 that economically recoverable oil exists in the area. In simple terms, there is a 40% chance that no oil will be produced in this area and therefore what follows would be moot. The numbers in this report for occurrences of oilspills assume (the odds are 3 to 2 in favor of the assumption) that oil will in fact be discovered and produced in the area.

Much of the data and information used in the analysis was compiled by the U.S. Bureau of Land Management (BLM) in the course of preparing the EIS for the proposed lease sale. These results thus represent synthesis and analysis of existing information rather than presentation of new material.

We would like to express special appreciation to David Amstutz and Ralph Ainger of the BLM for their assistance in gathering the necessary data and information for the study; and to the Conservation Division of the Geological Survey for providing the estimates of petroleum quantities and probability of their occurrence

METHODS

Spill Frequency Estimates

Statistical distributions for estimating probabilities of oilspill occurrence were taken from Devanney and Stewart (1974) and Stewart (1975, 1976). In addition to the fundamental assumption that realistic estimates of future spill frequency can be based on past OCS experience, use of these distributions requires the further specific assumptions that spills occur independently of each other (as a Poisson process), and that spill rate is dependent on volume of oil produced and handled. Each of these assumptions is open to dispute. The first assumption - that past spill rates are indicative of future spill rates - might be modified either by assuming a decrease in future spill rate because of experience and improved standards or by assuming an increase in future spill rate because of unknown conditions in new territory. The second assumption - that spills occur independently of each other - might be modified either by assuming a positive correlation (if a spill occurs, conditions are such that more will follow shortly) or by assuming a negative correlation (if a spill occurs, extra precautions are immediately thereafter taken). The third assumption - that the spill rate is solely a function of the volume of oil handled - might be modified on the basis of size, extent, frequency, and duration of the handling. This analysis takes the middle ground through these assumptions. Any changes in the results due to variations of the assumptions apply uniformly to all parameters so that relative merits are not altered.

Spill frequency estimates were calculated separately for each of the 5 subdivisions of the proposed lease area (figure 1A) and the 3 subdivisions of the existing leases (figure 1B) based on estimated oil resources for the areas [Conservation Division, U.S. Geological

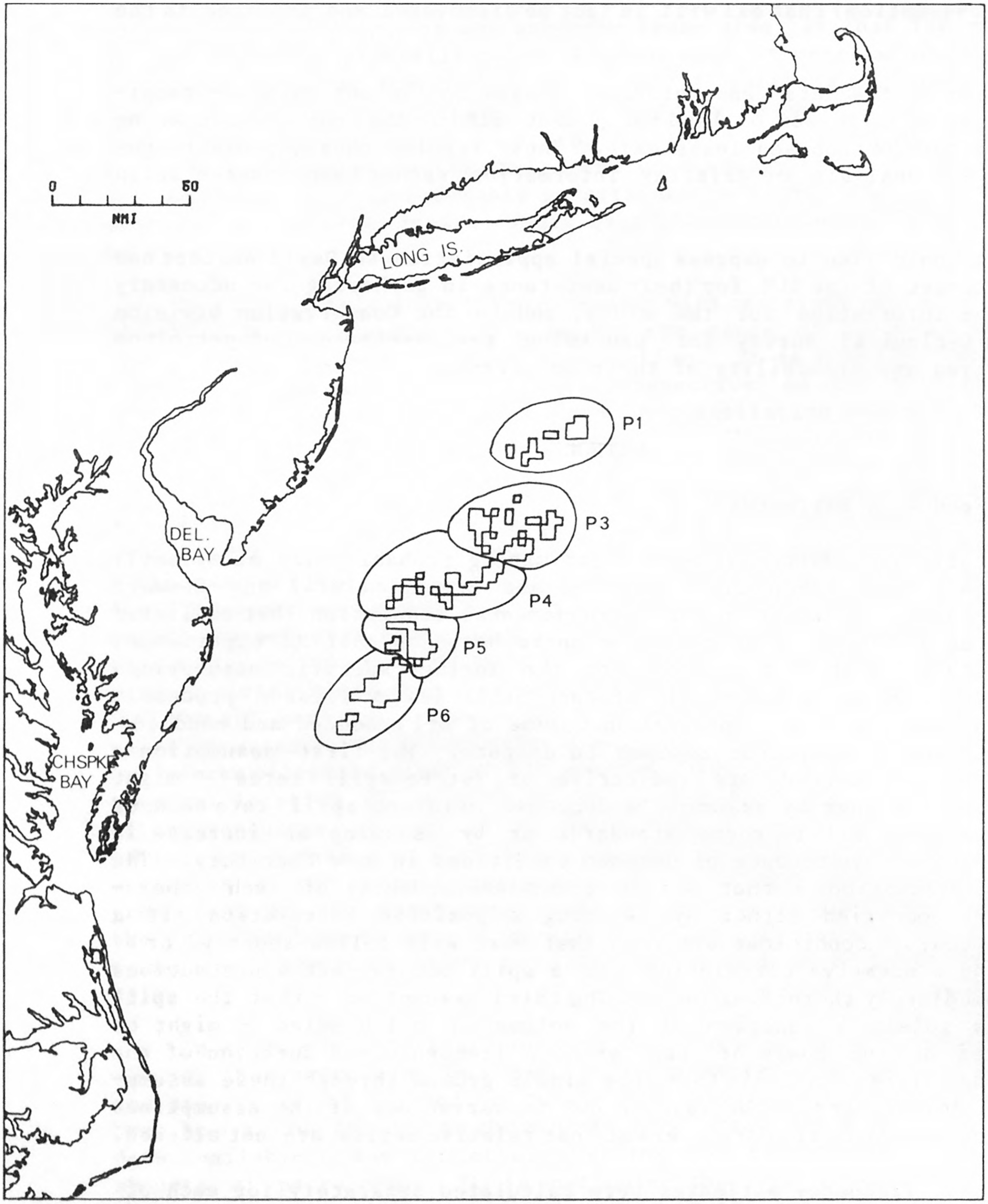

Figure 1A.--Map showing the subdivisions of the proposed leases.

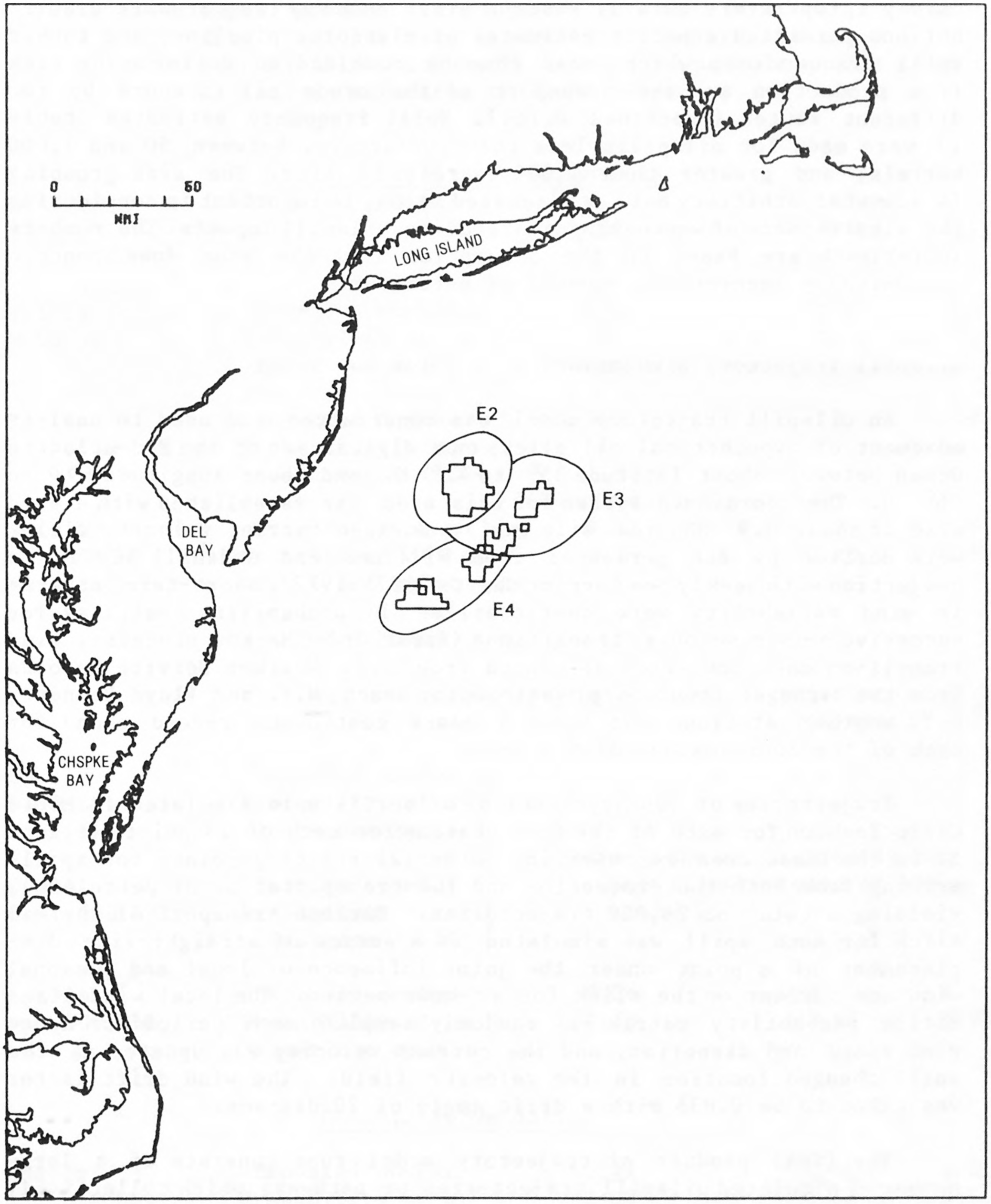

Figure 1B.--Map showing the subdivisions of the existing leases.

Survey (proprietary data)]. Use of the Devanney and Stewart distributions permitted separate estimates of platform, pipeline, and tanker spill frequencies; which could then be combined to estimate the risk from production and the transport of the crude oil to shore by two different routes (described below). Spill frequency estimates (table 1) were made for oilspills less than 50 barrels, between 50 and 1,000 barrels, and greater than 1,000 barrels in size. The size grouping is somewhat arbitrary but, as discussed below, is important in considering the significance of weathering in reducing oilspill impacts. The numbers in table 1 are based on the assumption that the area does contain economically recoverable amounts of petroleum.

Oilspill Trajectory Simulations

An oilspill trajectory model was constructed and used to analyze movement of hypothetical oil slicks on a digital map of the Mid-Atlantic Ocean between about latitude 35° to 42° N. and about longitude 69° to 76° W. The coordinate system for this area was established with a grid size of about 0.9 nautical mile (nmi). Surface current velocity fields were derived by BLM personnel from Williams and Godshall (1977) in conjuction with Weekly Sea Current Charts (1975-1977). Short-term patterns in wind variability were characterized by probability matrices for succesive 6-hour velocity transitions (first order Markov process). Wind transition matrices were calculated from U.S. Weather Service records from the Barnegat Light Ship, Westhampton Beach, N.Y. and Floyd Bennett, N.Y. weather stations (at least 5 years continuous record each) for each of the four seasons of the year.

Trajectories of 500 hypothetical oilspills were simulated in Monte Carlo fashion for each of the four seasons for each of 13 points (figure 2) in the lease area (representing potential starting points for spills arising from both the production and the transportation of petroleum), yielding a total of 26,000 trajectories. Surface transport of the oil slick for each spill was simulated as a series of straight-line displacement of a point under the joint influence of local and seasonal wind and current on the slick for a 6-hour period. The local wind transition probability matrix was randomly sampled each period for a new wind speed and direction, and the current velocity was updated as the spill changed location in the velocity field. The wind drift factor was taken to be 0.035 with a drift angle of 20 degrees.

The final product of trajectory model runs consists of a large number of simulated oilspill trajectories or pathways which collectively reflect both the general trend and variability of winds and currents, and which can be summarized in statistical terms. It should be emphasized that these trajectories represent only hypothetical pathways of oil-

Table 1.--Oilspill probability estimates for the mid-Atlantic lease area. All estimates assume that the area contains economically recoverable amounts of petroleum (The chance of this is estimated to be 60 percent.).

A. Pipeline transportation

		Proposed leases	Existing leases	Both
Spills 0-50 bbl	Expected number	530	2810	3340
	Probability of at least one spill	*	*	*
Spills 50-1,000 bbl	Expected number	9.3	49	58
	Probability of at least one spill	*	*	*
Spills > 1,000 bbl	Expected number	0.62	3.3	3.9
	Probability of at least one spill	0.46	0.95	0.98

B. Mixed transportation

		Proposed leases	Existing leases	Both
Spills 0-50 bbl	Expected number	Available statistics do not permit estimation of these numbers.		
	Probability of at least one spill			
Spills 50-1,000 bbl	Expected number			
	Probability of at least one spill			
Spills > 1,000 bbl	Expected number	0.86	3.3	4.1
	Probability of at least one spill	0.58	0.95	0.98

C. Platforms only

		Proposed leases	Existing leases	Both
Spills > 1,000 bbl	Expected number	0.27	1.44	1.71
	Probability of at least one spill	0.24	0.75	0.81

* - greater than 0.995

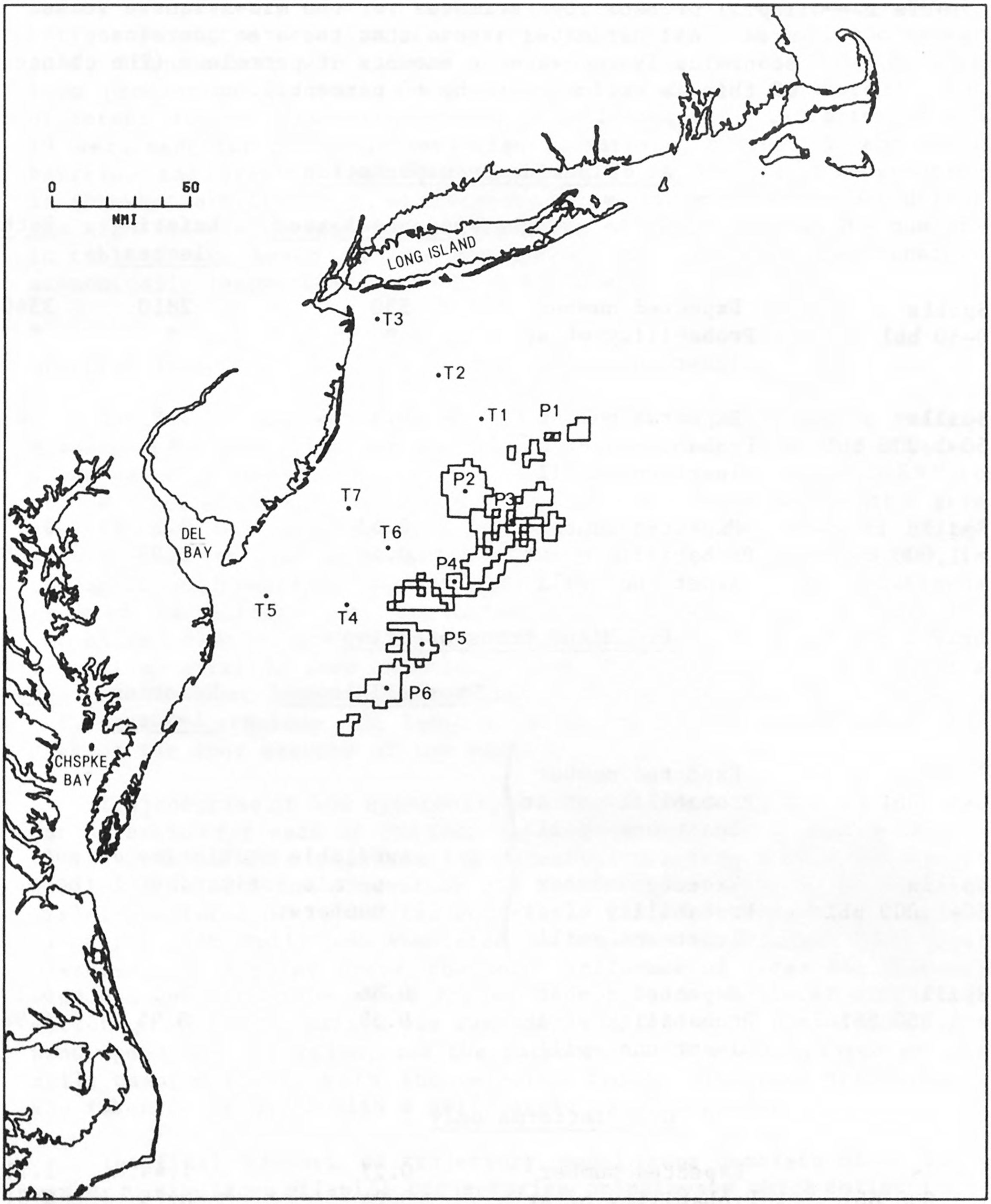

Figure 2.--Map showing the potential starting points from the proposed and existing leases (P1-P6) and transportation (T1-T7).

slicks and do not involve any direct consideration of cleanup, dispersion, or weathering processes which would determine the quantity and quality of oil that may eventually come in contact with biological populations or other important resources. The significance of dispersion and weathering in mitigating oilspill effects is discussed in more detail below.

Locations of Biological and Recreational Resources

The locations of 28 categories of biological, recreational, and other resources were digitized in the same coordinate system as that used in trajectory simulations (see Appendix A, figures A1-28). The monthly sensitivity of these resources (for example spawning period or migration period) was also recorded. Resource groups were as follows:

1 Wading bird colonies
2 Sea duck wintering areas
3 Osprey nesting areas
4 Bald eagle nesting areas
5 Peregrine falcon nesting areas
6 Peregrine falcon migratory stopover areas
7 Sea turtle nesting areas
8 Grey seal area
9 Hard clam grounds
10 Soft clam grounds
11 Bay scallop areas
12 Oyster grounds
13 Blue crab grounds
14 Lobster grounds
15 Sandy beaches
16 Coastal marshes
17 National parks, seashores, and recreation areas
18 Local and state parks and seashores
19 National wildlife refuges
20 State wildlife and natural areas
21 State marine sanctuaries
22 Non-government wildlife and natural areas
23 Narragansett Bay
24 Long Island Sound
25 Delaware Bay
26 Chesapeake Bay
27 Raritan Bay
28 Sewage dumping site

Objects 23 through 27 are entrances to enclosed bodies of water. Because the trajectory model does not operate satisfactorily in such areas, simulated trajectories were stopped on encountering these entrances and a "hit" scored on the body of water and on land. "Hits" were not scored on other objects within the bodies of water even though the presence of such objects is depicted in the figures in the Appendix.

Because the trajectory model simulates a spill essentially as a point, most land-based objects have been given an areal extent greater than they actually occupy. Object 15 (sandy beaches) for example extends a short distance offshore. This allows the model to simulate a spill that approaches land, makes partial contact, withdraws, and continues on its way. That this happens in the model operation will be seen in the tables which follow - where, for example, contact with sandy beaches may occur more frequently than contact with land.

RESULTS AND DISCUSSION

Spill Frequency Estimates

The probability distributions on the frequency of oilspills greater than 1,000 barrels in size during the production life of the proposed leases and the existing leases are given in figure 3. If there are economically recoverable amounts of petroleum in the existing leases, it is expected that crude oil from those areas (areas E2, E3, and E4; starting points P2, P3, and P4, respectively) will be transported to shore by pipeline along a line through starting points T6 and T7 (see figure 2) to a land-fall near Atlantic City, N.J. If there are economically recoverable amounts of petroleum in the proposed leases, it is expected that crude oil from these areas will be transported to shore either a) by the pipeline just described for the existing leases or b) by tanker with the petroleum from areas P1 and P3 going along a route through points T1, T2, and T3 to lower New York harbor and the petroleum from areas P4, P5, and P6 going along a route through points T4 and T5 to Delaware Bay. Statistics are presented for these two combinations under the labels "pipeline" and "mixed" respectively. Estimates of the number of spills of different size for the existing and proposed leases for the two transportation scenarios are given in Table 1.

Of course, if petroleum is eventually produced in this area, its actual transportation may differ from these hypothetical scenarios. Table 1C gives transportation-independent estimates of the number of large spills which might occur from production platforms alone. Estimates are not given for the number of small spills from platforms alone or from platforms with any tanker transport, because past data has not adequately differentiated between small spills which originated from platforms and small spills which originated from pipeline gathering nets. Thus, while the sum of small spills from pipeline and platforms

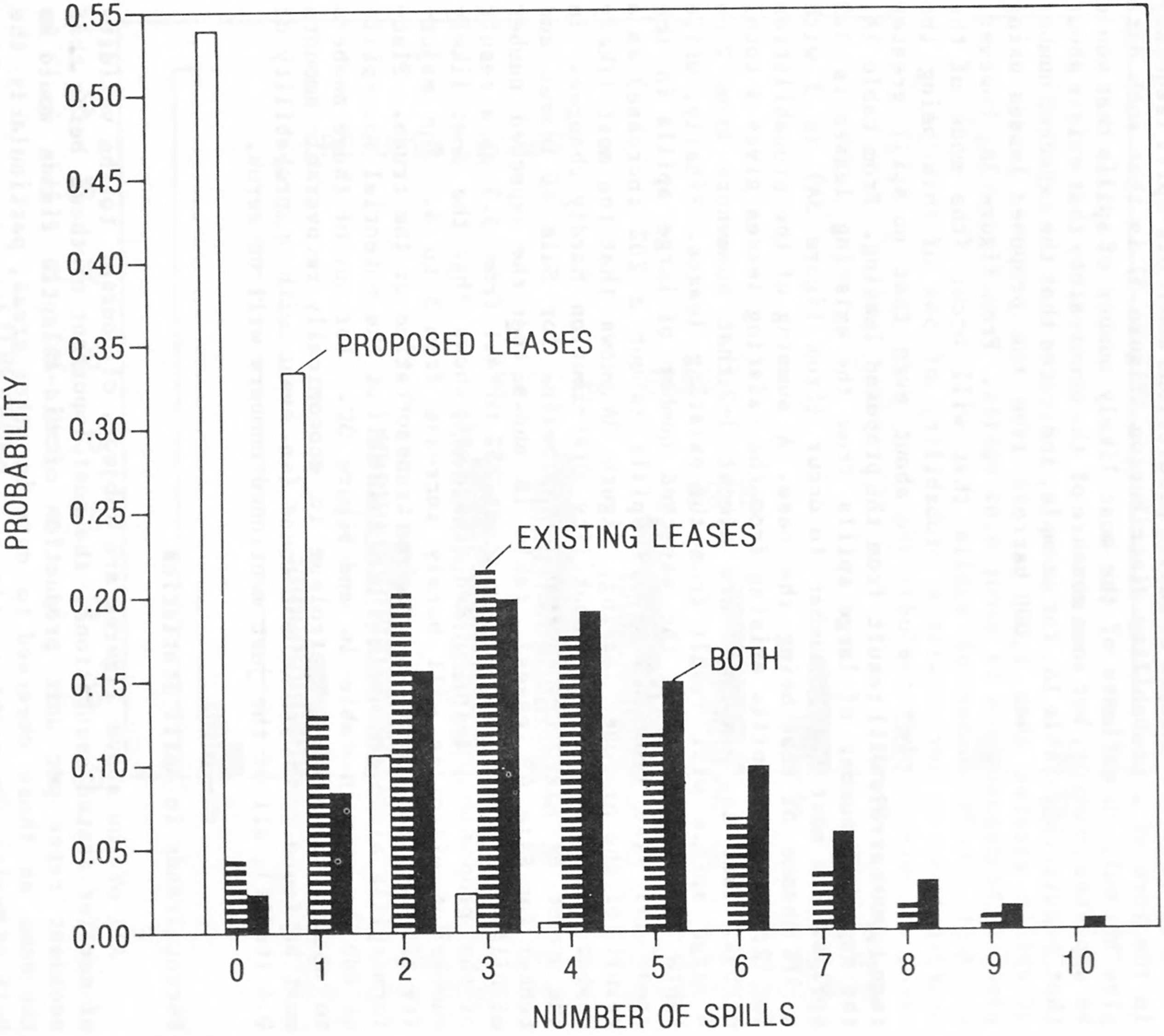

Figure 3A.--Spill frequency distributions for platform and pipeline transportation spills greater than 1,000 barrels during the production lives of the lease areas assuming production takes place.

combined can be estimated, the number of small spills from platforms alone or platforms with tanker transport cannot, given the available data.

One of the advantages of making predictions about oil-spill frequency in the form of a probability distribution (figure 3) is that such data give not only an estimate of the most likely number of spills that would be expected to occur, but some measure of the uncertainty that exists about that prediction. Table 1A, for example, indicates that the expected number of spills greater than 1,000 barrels from the proposed leases using pipeline transportation is about 0.62 spills. From figure 3A, however, the most likely number of spills that will occur (the mode of the distribution) is zero - with a probability of 54% of this being the case. Or more simply, the odds are about even that no spill greater than 1,000 barrels will result from the proposed leasing. From table 1A, the expected number of large spills from the existing leases is 3.3 spills. The most likely number to occur (from figure 3A) is 3 with a 21% chance of that being the case. A summing of the probabilities for 2, 3, or 4 spills arising from the existing leases gives a total of 59%. That is, the odds are almost 3-2 that somewhere from 2 to 4 large spills will result from the existing leases. Finally, while table 1A indicates that the expected number of large spills in the area will rise from 3.3 to 3.9 spills (about a 20% increase) as a result of the proposed leasing, figure 3A shows that the most likely number remains at 3 and the probability distribution hardly changes. In the event of mixed transportation (pipeline for Sale 40 leases and tanker for Sale 49 leases), table 1B shows that the expected number of oilspills will increase by about 25% to 4.1 from 3.3 as a result of the proposed leasing. And figure 3B shows that the most likely number of oilspills will barely increase from 3 to 4. The majority of potential spills arises from transportation of the crude. Platform spills alone account for less than half of the potential for spills as can be seen in table 1C and figure 3C. For any of these numbers to obtain, of course, petroleum in economically recoverable amounts must be found. If it is not found (an event with a probability of 0.4 itself); all of the just mentioned numbers will be zeros.

Recent Trends in Spill Statistics

All of the above figures are subject, of course, to the validity of earlier stated assumptions, the most important of these being that accident rates per unit production of Mid-Atlantic fields would be the same as those observed to date in other areas, particularly the Gulf of Mexico. One might question this assumption either from the point of view that safety records might be expected to improve with time, or from the standpoint that accident rates are not transferrable to a newly opened OCS area.

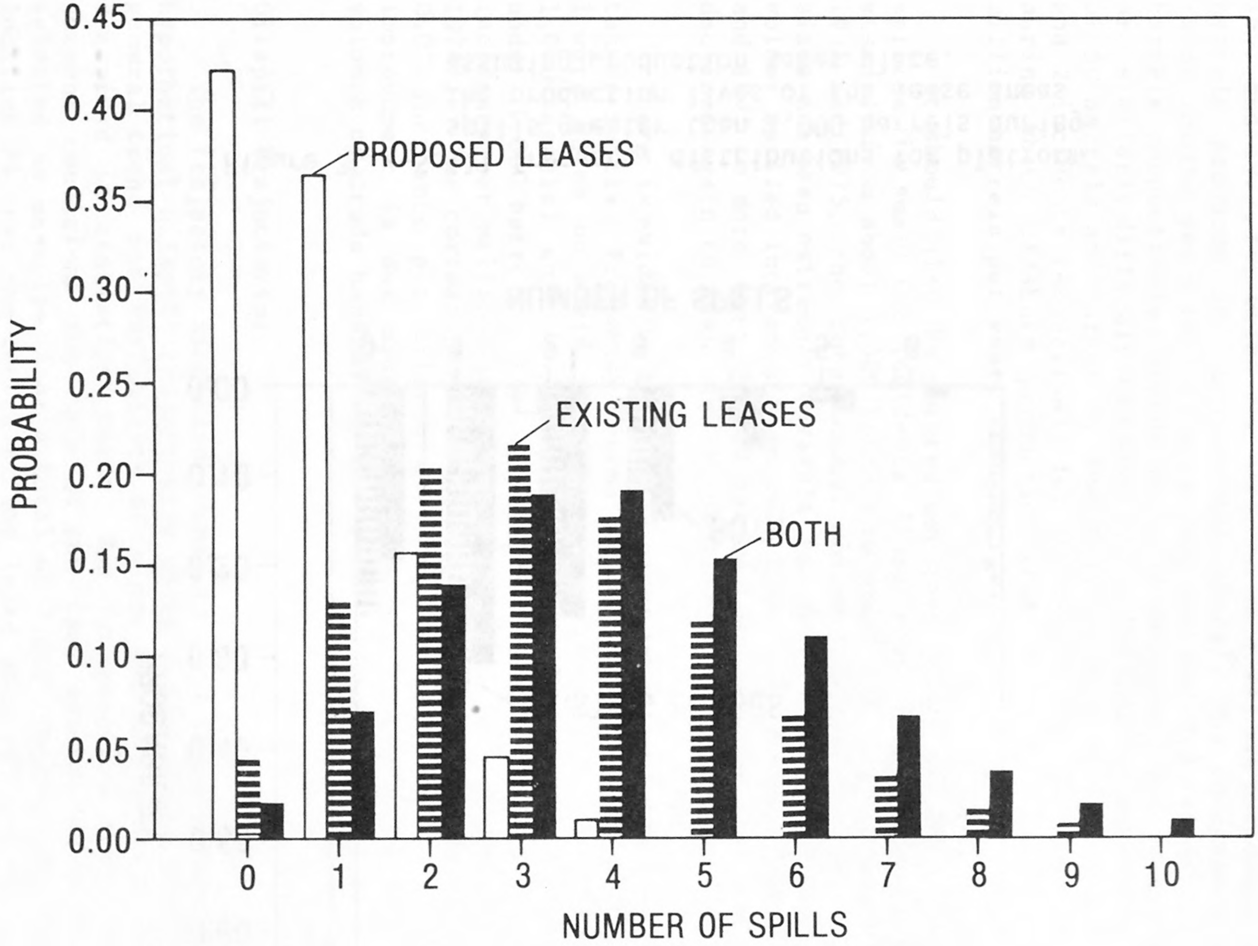

Figure 3B.--Spill frequency distributions for platform and mixed transportation spills greater than 1,000 barrels during the production lives of the lease areas assuming production takes place.

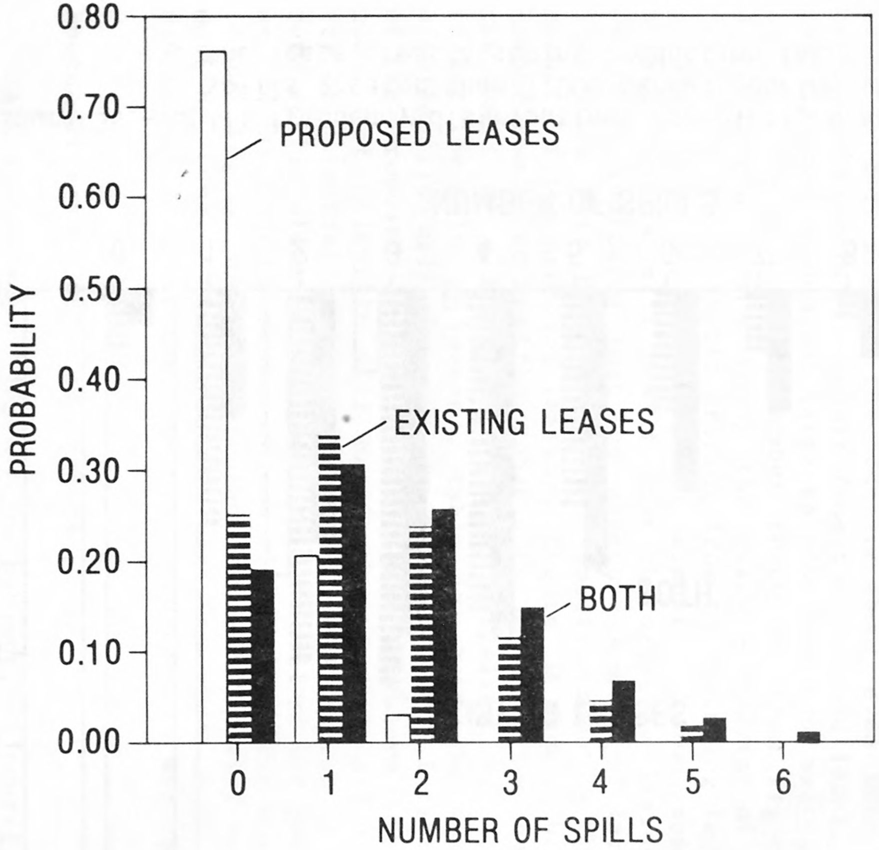

Figure 3C.--Spill frequency distributions for platform spills greater than 1,000 barrels during the production lives of the lease areas assuming production takes place.

With regard to the question of improvement in accident rates, recent statistics from Coast Guard files show no clear trend in spill frequency for production platforms and pipelines during the period 1971-75. Spill frequency estimates in table 1 for platform and pipeline spills less than 1,000 barrels were based on United States spills for the years 1971 and 1972, for which the accident rate was 3.6 incidents per million barrels produced and handled (all sizes). The corresponding accident rates for the years 1973-75 were 3.9, 4.2 and 3.2 incidents per million barrels respectively. Trends in spill frequency for larger spill sizes are similarly difficult to identify. Geological Survey records for spills of 50 barrels and larger in the Gulf of Mexico OCS list 11, 2, 4, 8, and 2 incidents respectively for the years 1971 through 1975, a period during which offshore production gradually declined from 387 to 315 million barrels per year, (Danenberger, 1976).

It should also be pointed out that while the total volume of oil spilled in small OCS incidents (less than 50 barrels) declined quite steadily from about 1,500 barrels to about 700 barrels per year between 1971 and 1975, the total annual volume lost in the OCS spills of all sizes has been extremely variable and shows no decipherable trend. Total volume spilled increased from less than 3,000 barrels per year in 1971 and 1972 to more than 23,000 barrels per year in 1973 and 1974, then declined again to less than 1,000 barrels in 1975 (Danenberger, 1976).

There is evidence, however, of recent improvement in the incidence of tanker spills. Frequency estimates for tanker spills underlying table 1 were based on world statistics for the years 1969-75 (spills over 1,000 barrels) and U.S. Coast Guard data for the years 1971-72 (spills under 1,000 barrels). for which the overall accident rate was 0.45 incidents per million barrels handled (all sizes; Devanney and Stewart, 1974). The corresponding rate for the years 1973-74 was only about 0.07 incidents per million barrels, although some of the apparent improvement is due simply to a change in the method of estimating volumes of crude handled in U.S. ports (Stewart, 1976).

Oilspill Trajectories

The trajectory simulation consists of a large number (26,000) of hypothetical oilspill trajectories which collectively reflect both the general trend and variability of winds and currents and which can be described in statistical terms. Ten trajectories based on wind and current conditions for each of the four seasons have been randomly selected as examples from a total of 2,000 trajectories released from location P4 near the center of the lease area and are shown in figures 4-7. The patterns of spill movements in figures 4-7 demonstrate several prominent features of trajectory movements in the Mid-Atlantic area.

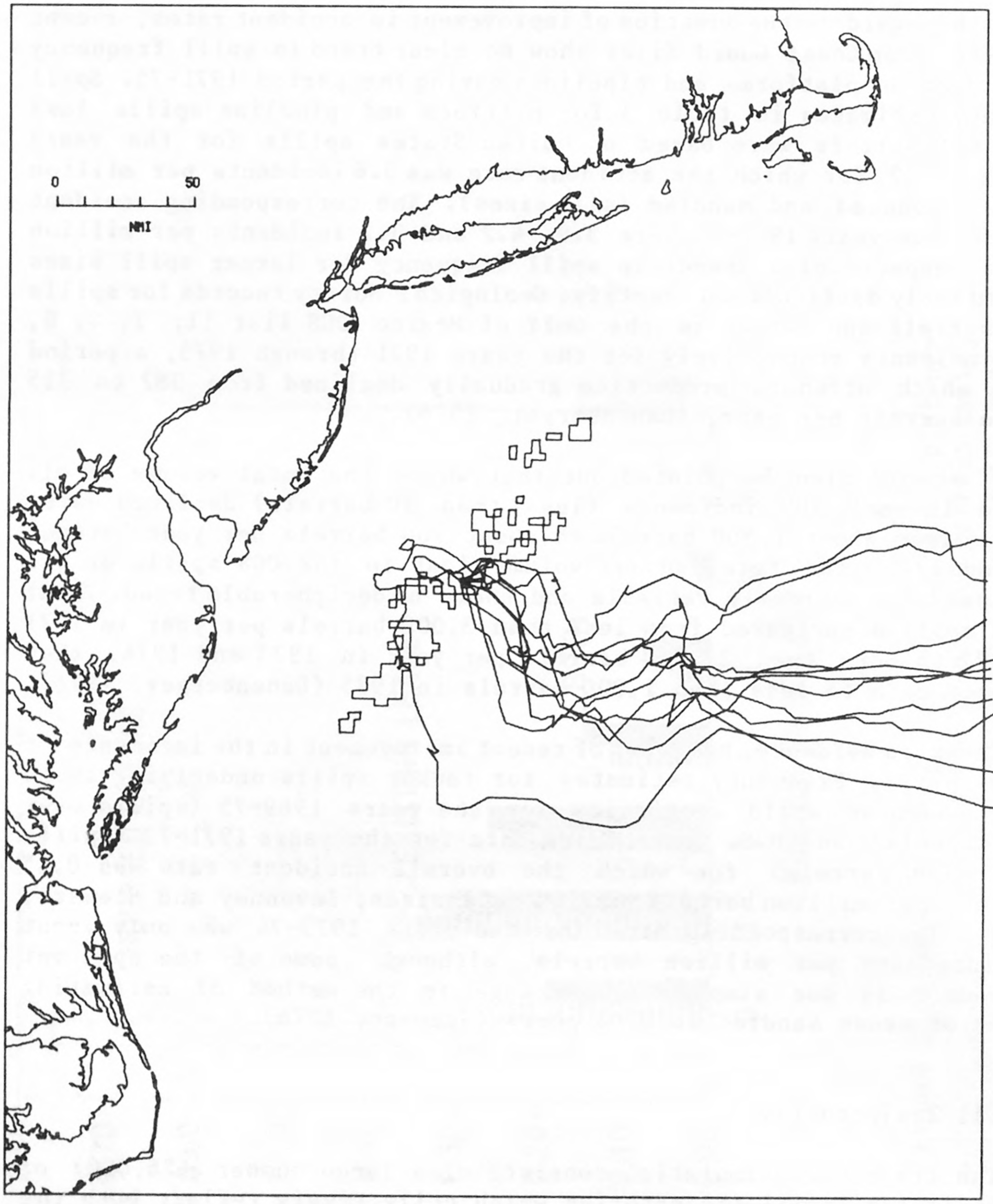

Figure 4.--Example oilspill trajectories for a spill site (P4) near the center of the proposed lease area: winter conditions.

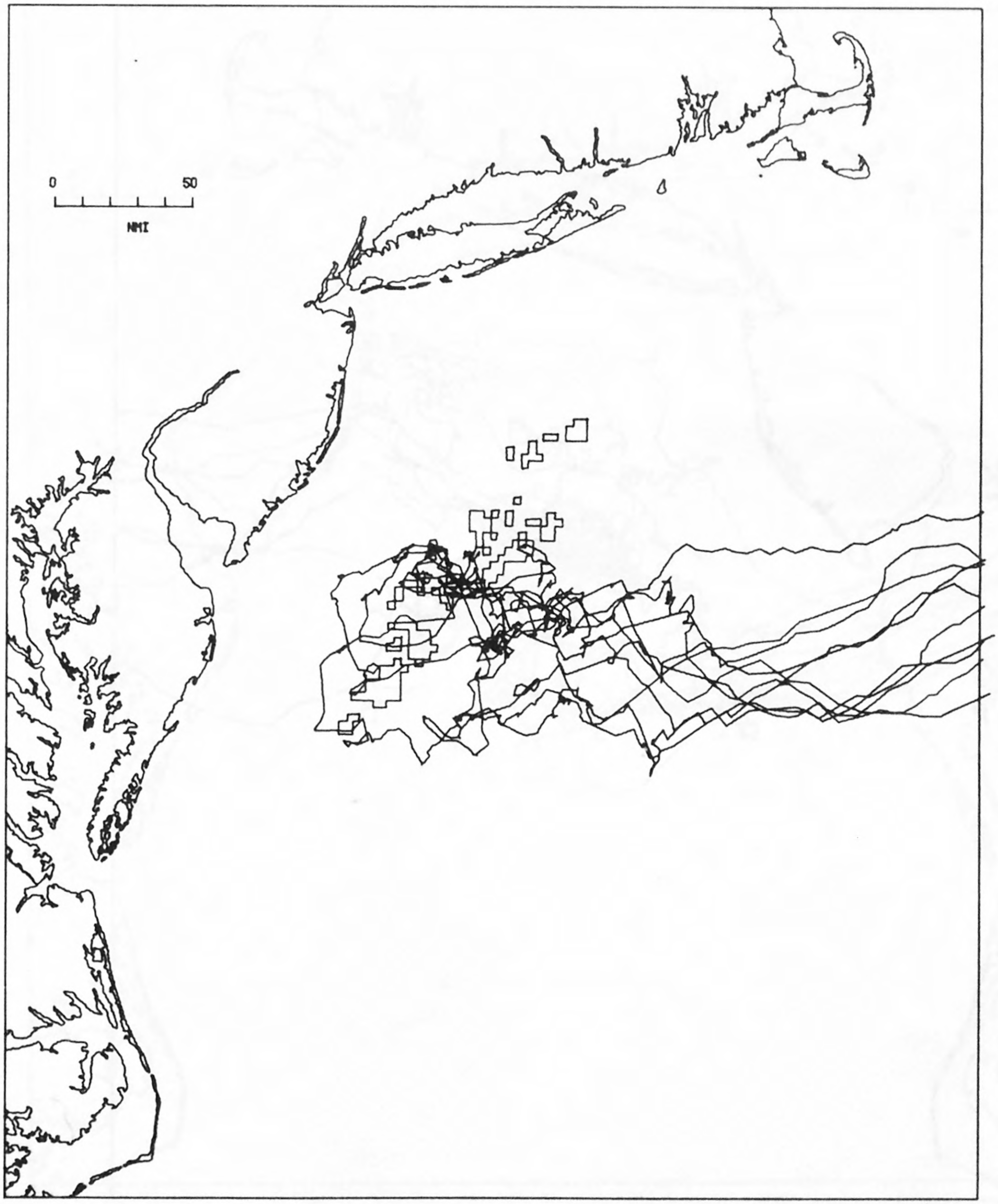

Figure 5.--Example oilspill trajectories for a spill site (P4) near the center of the proposed lease area: spring conditions.

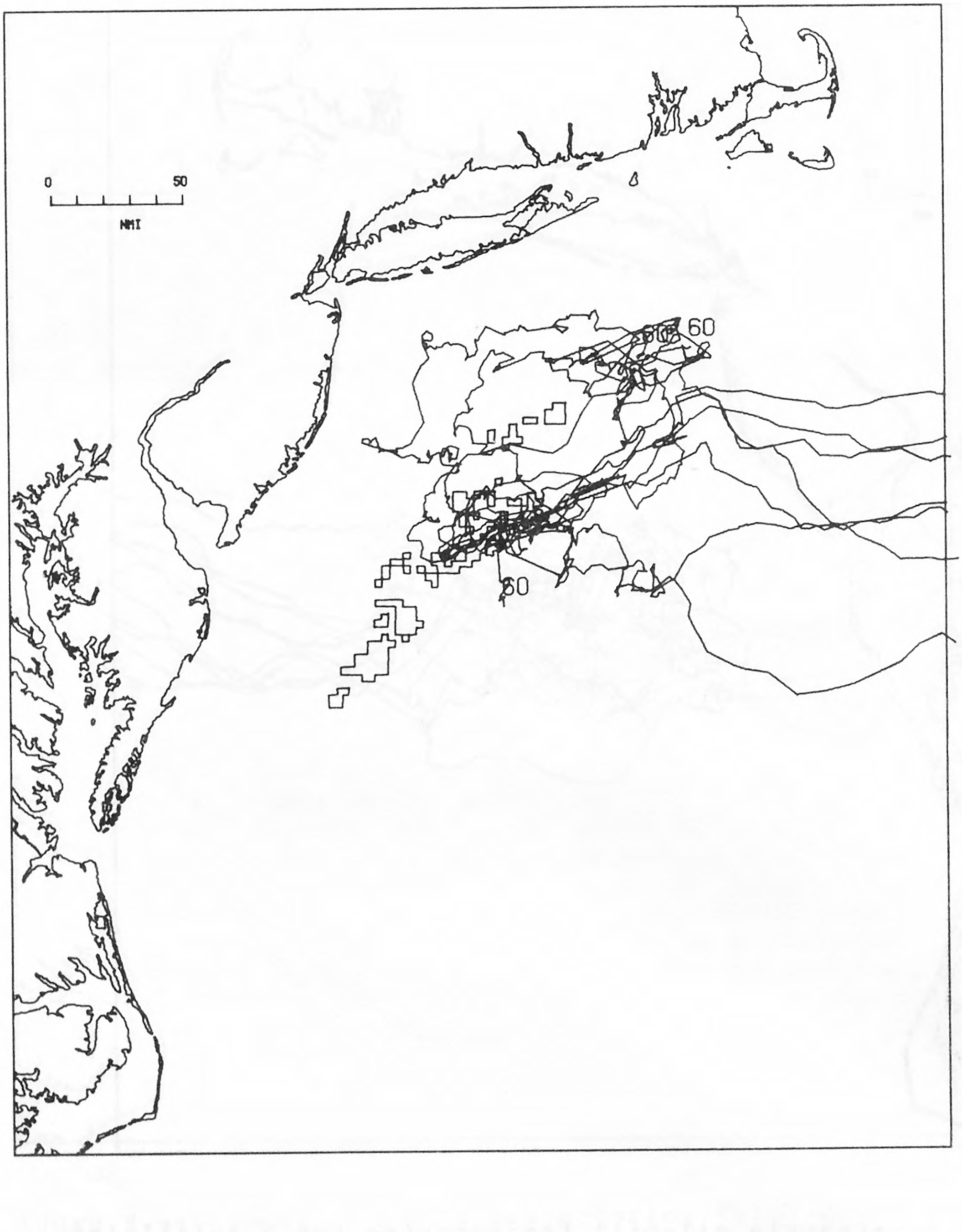

Figure 6.--Example oilspill trajectories for a spill site (P4) near the center of the proposed lease area: summer conditions. Number on trajectory is the time to the end point in days.

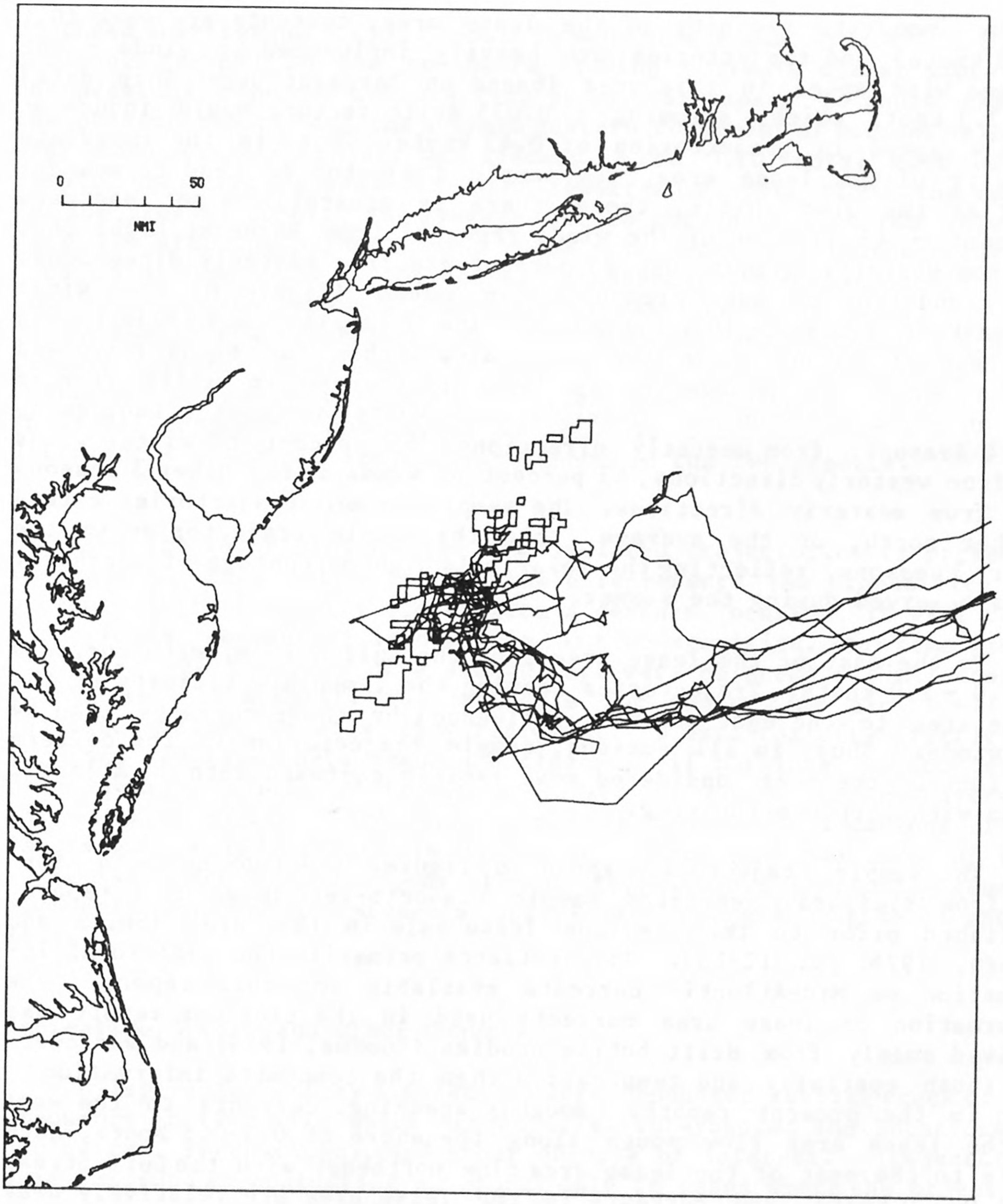

Figure 7.--Example oilspill trajectories for a spill site (P4) near the center of the proposed lease area: autumn conditions.

In the immediate vicinity of the lease area, currents are weak (0.1 - 0.3 knots) and trajectories are heavily influenced by winds - the average wind speed in this area (based on Barnegat Light Ship data) is 12.3 knots which, assuming a 0.035 drift factor, would induce an average speed in trajectories of 0.43 knots. Thus, in the immediate vicinity of the lease area, the sample trajectories tend to meander about as the wind shifts, though there is generally a net eastward movement - 45 percent of the winds reported from Barnegat Light Ship are from westerly directions, 25 percent are from easterly directions. This meandering is most pronounced in summer (figure 6) when winds are weakest (averaging 10.1 knots); 3 of the 10 sample summer trajectories in figure 6 did not leave the lease area within the 60 days allowed by the model. The meandering is least pronounced in winter (figure 4) when winds are stongest (averaging 14.4 knots) and most often, among the 4 seasons, from westerly directions; 55 percent of winter winds are from westerly directions, 43 percent of winds in the other 3 seasons are from westerly directions. The sample summer trajectories extend further north, on the average, than the sample trajectories in the other 3 seasons, reflecting the relatively high percentage of southerly winds observed during the summer.

To the east of the lease area runs the Gulf Stream, with currents of 1.0 - 2.0 knots. Trajectories leaving the immediate vicinity of the lease area to the east are more influenced by those currents than by the winds. Thus, in all seasons, sample trajectories in the eastern portions of the area considered move rapidly eastward into the Atlantic Ocean with little meandering.

The sample trajectories shown in figures 4-7 look quite different from similarly generated sample trajectories shown in a report published prior to the previous lease sale in this area (Smith and others, 1976, pp. 12-15). This reflects primarily the additional information on Mid-Atlantic currents available for this report. The information on lease area currents used in the previous report was derived solely from drift bottle studies (Bumpus, 1973) and was coarser (both spatially and temporally) than the composite information used in the present report. Roughly speaking, currents to the west of the lease area flow south along the shore at 0.3-0.5 knots, currents to the east of the lease area flow northeast with the Gulf Stream at 1.0-2.0 knots, and currents in the lease area are relatively weak (0.1-0.3 knots) and more variable in direction. The starting points for the sample trajectories shown in figures 4-7 and in the previous report are in the area of relatively weak currents but close to the area of the stronger, southward flowing currents. Thus, assumptions on current velocities in the immediate vicinity of these starting points are critical - a small increase in the assumed eastern component of current velocity used in the model drive simulated trajectories in the vicinity of these starting points will result in many of the simulated trajectories becoming trapped in the southward flowing currents nearer shore. In the previous report, the starting point was closer to shore than in the present report, and the average eastern component of current velocity near both starting points was assumed to be 0.20 knots. Most of the sample trejectories shown in that report move south along the coast. In the present report, the average eastern component of current velocity near the starting points, based on the more recent and improved current data, is assumed to be 0.06 knots, 30 percent of the assumed eastern component in the previous report. This apparently explains why none of the sample trajectories in figures 4-7 become trapped in the southward flowing currents. This analysis is, of course, based on a much simplified characterization of the complex current fields used for this area in the spill trajectory models, but is adequate to account for the grosser differences in sample trajectories shown in the two reports.

The spatial disposition of the simulated trajectories is presented in table 2. Each entry in the table represents the probability (in percent) that if a spill starts from a certain location, it will reach a particular segment of land within the time specified. Four time limits of 3 days, 10 days, 30 days and 60 days were selected as "milestones" in the life of a spill. The rationale for these time limits will be mentioned below. Briefly, they represent: 3 days-toxicity greatly diminished; 10 days-containment and clean-up, if possible, accomplished; 30 days-major spills difficult to locate or track; and 60 days-very large spills mostly dissipated. Figure 8 shows the locations of the land segments referred to in table 2. There are two sets of land segments: set A corresponds closely to political (typically county) boundaries and set B represents approximately equal lengths of shoreline.

Recreation Areas, and Other Objects

Oilspill trajectory simulations were conducted keeping track of the frequency in time with which trajectories intersected the locations of biological, recreational, and other objects of interest. Trajectories were recorded as contacting an object only in cases where the object was listed as being vulnerable to oilspills in the month the contact took place. Table 3 gives the probability of contact on each of the 28 categories of biological resources, recreation areas, and other objects (see Appendix A, figures A1-28) for a spill originating at the thirteen spill sites within the lease area (see figure 2). Once again, the

Table 2A. -- Probabilities (in percent) that an oilspill starting at a particular location will reach a certain land segment in 3 days.

Land Segment	Hypothetical spill location P1	P2 -E2	P3 -E3	P4 -E4	P5	P6	T1	T2	T3	T4	T5	T6	T7
A 1	n	n	n	n	n	n	n	n	n	n	n	n	n
A 2	n	n	n	n	n	n	n	n	n	n	n	n	n
A 3	n	n	n	n	n	n	n	n	n	n	n	n	n
A 4	n	n	n	n	n	n	n	n	n	n	n	n	n
A 5	n	n	n	n	n	n	n	n	n	n	n	n	n
A 6	n	n	n	n	n	n	n	n	n	n	n	n	n
A 7	n	n	n	n	n	n	n	n	n	n	n	n	n
A 8	n	n	n	n	n	n	n	n	n	n	n	n	n
A 9	n	n	n	n	n	n	n	n	n	n	1	n	n
A10	n	n	n	n	n	n	n	n	n	n	4	n	n
A11	n	n	n	n	n	n	n	n	n	n	n	n	n
A12	n	n	n	n	n	n	n	n	n	n	n	n	1
A13	n	n	n	n	n	n	n	n	n	n	n	n	1
A14	n	n	n	n	n	n	n	1	1	n	n	n	n
A15	n	n	n	n	n	n	n	1	12	n	n	n	n
A16	n	n	n	n	n	n	n	n	1	n	n	n	n
A17	n	n	n	n	n	n	n	n	1	n	n	n	n
A18	n	n	n	n	n	n	n	n	1	n	n	n	n
A19	n	n	n	n	n	n	n	n	n	n	n	n	n
A20	n	n	n	n	n	n	n	n	n	n	n	n	n
A21	n	n	n	n	n	n	n	n	n	n	n	n	n
A22	n	n	n	n	n	n	n	n	n	n	n	n	n
A23	n	n	n	n	n	n	n	n	n	n	n	n	n
A24	n	n	n	n	n	n	n	n	n	n	n	n	n
A25	n	n	n	n	n	n	n	n	n	n	n	n	n
A26	n	n	n	n	n	n	n	n	n	n	n	n	n
A27	n	n	n	n	n	n	n	n	n	n	n	n	n
A28	n	n	n	n	n	n	n	n	n	n	n	n	n
A29	n	n	n	n	n	n	n	n	n	n	n	n	n
A30	n	n	n	n	n	n	n	n	n	n	n	n	n
B 1	n	n	n	n	n	n	n	n	n	n	n	n	n
B 2	n	n	n	n	n	n	n	n	n	n	n	n	n
B 3	n	n	n	n	n	n	n	n	n	n	n	n	n
B 4	n	n	n	n	n	n	n	n	n	n	n	n	n
B 5	n	n	n	n	n	n	n	n	n	n	n	n	n
B 6	n	n	n	n	n	n	n	n	n	n	n	n	n
B 7	n	n	n	n	n	n	n	n	n	n	n	n	n
B 8	n	n	n	n	n	n	n	n	n	n	5	n	n
B 9	n	n	n	n	n	n	n	n	n	n	n	n	n
B10	n	n	n	n	n	n	n	n	n	n	n	n	2
B11	n	n	n	n	n	n	n	n	n	n	n	n	1
B12	n	n	n	n	n	n	n	1	1	n	n	n	n
B13	n	n	n	n	n	n	n	1	12	n	n	n	n
B14	n	n	n	n	n	n	n	n	n	n	n	n	n
B15	n	n	n	n	n	n	n	n	2	n	n	n	n
B16	n	n	n	n	n	n	n	n	n	n	n	n	n
B17	n	n	n	n	n	n	n	n	n	n	n	n	n
B18	n	n	n	n	n	n	n	n	n	n	n	n	n
B19	n	n	n	n	n	n	n	n	n	n	n	n	n
B20	n	n	n	n	n	n	n	n	n	n	n	n	n
B21	n	n	n	n	n	n	n	n	n	n	n	n	n
B22	n	n	n	n	n	n	n	n	n	n	n	n	n
B23	n	n	n	n	n	n	n	n	n	n	n	n	n
B24	n	n	n	n	n	n	n	n	n	n	n	n	n
B25	n	n	n	n	n	n	n	n	n	n	n	n	n
B26	n	n	n	n	n	n	n	n	n	n	n	n	n
B27	n	n	n	n	n	n	n	n	n	n	n	n	n
B28	n	n	n	n	n	n	n	n	n	n	n	n	n

n - less than 0.5 percent.

Table 2B. -- Probabilities (in percent) that an oilspill starting at a particular location will reach a certain land segment in 10 days.

Land Segment	Hypothetical spill location P1	P2 -E2	P3 -E3	P4 -E4	P5	P6	T1	T2	T3	T4	T5	T6	T7
A 1	n	n	n	n	n	n	n	n	n	n	n	n	n
A 2	n	n	n	n	n	n	n	n	n	n	n	n	n
A 3	n	n	n	n	n	n	n	n	n	n	n	n	n
A 4	n	n	n	n	n	n	n	n	n	n	n	n	n
A 5	n	n	n	n	n	n	n	n	n	n	n	n	n
A 6	n	n	n	n	n	n	n	n	n	n	n	n	n
A 7	n	n	n	n	n	n	n	n	n	n	n	n	n
A 8	n	n	n	n	n	n	n	n	n	1	1	n	n
A 9	n	n	n	n	n	n	n	n	n	1	5	n	n
A10	n	n	n	n	n	n	n	n	n	n	5	n	1
A11	n	n	n	n	n	n	n	n	n	n	1	n	n
A12	n	n	n	n	n	n	n	n	n	n	n	n	3
A13	n	n	n	n	n	n	n	n	n	n	n	n	3
A14	n	n	n	n	n	n	1	5	6	n	n	n	n
A15	n	n	n	n	n	n	n	1	17	n	n	n	n
A16	n	n	n	n	n	n	n	n	1	n	n	n	n
A17	n	n	n	n	n	n	n	n	3	n	n	n	n
A18	n	n	n	n	n	n	n	n	4	n	n	n	n
A19	n	n	n	n	n	n	n	n	n	n	n	n	n
A20	n	n	n	n	n	n	n	n	n	n	n	n	n
A21	n	n	n	n	n	n	n	n	n	n	n	n	n
A22	n	n	n	n	n	n	n	n	n	n	n	n	n
A23	n	n	n	n	n	n	n	n	n	n	n	n	n
A24	n	n	n	n	n	n	n	n	n	n	n	n	n
A25	n	n	n	n	n	n	n	n	n	n	n	n	n
A26	n	n	n	n	n	n	n	n	n	n	n	n	n
A27	n	n	n	n	n	n	n	n	n	n	n	n	n
A28	n	n	n	n	n	n	n	n	n	n	n	n	n
A29	n	n	n	n	n	n	n	n	n	n	n	n	n
A30	n	n	n	n	n	n	n	n	n	n	n	n	n
B 1	n	n	n	n	n	n	n	n	n	n	n	n	n
B 2	n	n	n	n	n	n	n	n	n	n	n	n	n
B 3	n	n	n	n	n	n	n	n	n	n	n	n	n
B 4	n	n	n	n	n	n	n	n	n	n	n	n	n
B 5	n	n	n	n	n	n	n	n	n	n	n	n	n
B 6	n	n	n	n	n	n	n	n	n	n	1	n	n
B 7	n	n	n	n	n	n	n	n	n	1	3	n	n
B 8	n	n	n	n	n	n	n	n	n	1	8	1	1
B 9	n	n	n	n	n	n	n	n	n	n	n	n	n
B10	n	n	n	n	n	n	n	n	n	n	n	n	4
B11	n	n	n	n	n	n	n	n	n	n	n	n	2
B12	n	n	n	n	n	n	1	4	5	n	n	n	n
B13	n	n	n	n	n	n	n	1	17	n	n	n	n
B14	n	n	n	n	n	n	n	n	n	n	n	n	n
B15	n	n	n	n	n	n	n	n	6	n	n	n	n
B16	n	n	n	n	n	n	n	n	1	n	n	n	n
B17	n	n	n	n	n	n	n	n	n	n	n	n	n
B18	n	n	n	n	n	n	n	n	n	n	n	n	n
B19	n	n	n	n	n	n	n	n	n	n	n	n	n
B20	n	n	n	n	n	n	n	n	n	n	n	n	n
B21	n	n	n	n	n	n	n	n	n	n	n	n	n
B22	n	n	n	n	n	n	n	n	n	n	n	n	n
B23	n	n	n	n	n	n	n	n	n	n	n	n	n
B24	n	n	n	n	n	n	n	n	n	n	n	n	n
B25	n	n	n	n	n	n	n	n	n	n	n	n	n
B26	n	n	n	n	n	n	n	n	n	n	n	n	n
B27	n	n	n	n	n	n	n	n	n	n	n	n	n
B28	n	n	n	n	n	n	n	n	n	n	n	n	n

n - less than 0.5 percent.

Table 2C. -- Probabilities (in percent) that an oilspill starting at a particular location will reach a certain land segment in 30 days.

Land Segment	Hypothetical spill location P1	P2 -E2	P3 -E3	P4 -E4	P5	P6	T1	T2	T3	T4	T5	T6	T7
A 1	n	n	n	n	n	n	n	n	n	n	n	n	n
A 2	n	n	n	n	n	n	n	n	n	n	n	n	n
A 3	n	n	n	n	n	n	n	n	n	1	2	n	1
A 4	n	n	n	n	n	n	n	n	n	n	1	n	n
A 5	n	n	n	n	n	n	n	n	n	n	n	n	n
A 6	n	n	n	n	n	n	n	n	n	n	n	n	n
A 7	n	n	n	n	n	n	n	n	n	1	1	n	n
A 8	n	n	n	n	n	n	n	n	n	1	2	n	1
A 9	n	n	n	n	n	n	n	n	n	1	5	n	1
A10	n	n	n	n	n	n	n	n	n	n	5	n	1
A11	n	n	n	n	n	n	n	n	n	n	1	n	n
A12	n	n	n	n	n	n	n	n	n	n	n	n	3
A13	n	n	n	n	n	n	1	1	1	n	n	1	3
A14	n	n	n	n	n	n	2	6	8	n	n	n	1
A15	n	n	n	n	n	n	n	2	18	n	n	n	n
A16	n	n	n	n	n	n	n	n	1	n	n	n	n
A17	n	n	n	n	n	n	n	n	3	n	n	n	n
A18	n	n	n	n	n	n	n	2	8	n	n	n	n
A19	n	n	n	n	n	n	n	n	n	n	n	n	n
A20	n	n	n	n	n	n	n	n	n	n	n	n	n
A21	n	n	n	n	n	n	n	n	n	n	n	n	n
A22	n	n	n	n	n	n	n	n	n	n	n	n	n
A23	n	n	n	n	n	n	n	n	n	n	n	n	n
A24	n	n	n	n	n	n	n	n	n	n	n	n	n
A25	n	n	n	n	n	n	n	n	n	n	n	n	n
A26	n	n	n	n	n	n	n	n	n	n	n	n	n
A27	n	n	n	n	n	n	n	n	n	n	n	n	n
A28	1	n	n	n	n	n	n	n	n	n	n	n	n
A29	1	n	n	n	n	n	n	n	n	n	n	n	n
A30	n	n	n	n	n	n	n	n	n	n	n	n	n
B 1	n	n	n	n	n	n	n	n	n	n	n	n	n
B 2	n	n	n	n	n	n	n	n	n	n	1	n	n
B 3	n	n	n	n	n	n	n	n	n	1	2	n	1
B 4	n	n	n	n	n	n	n	n	n	n	n	n	n
B 5	n	n	n	n	n	n	n	n	n	n	n	n	n
B 6	n	n	n	n	n	n	n	n	n	1	2	n	1
B 7	n	n	n	n	n	n	n	n	n	2	4	n	1
B 8	n	n	n	n	n	n	n	n	n	1	8	1	2
B 9	n	n	n	n	n	n	n	n	n	n	n	n	n
B10	n	n	n	n	n	n	1	n	1	n	n	1	4
B11	n	n	n	n	n	n	1	1	1	n	n	n	2
B12	n	n	n	n	n	n	1	5	8	n	n	n	n
B13	n	n	n	n	n	n	n	2	18	n	n	n	n
B14	n	n	n	n	n	n	n	n	n	n	n	n	n
B15	n	n	n	n	n	n	n	n	7	n	n	n	n
B16	n	n	n	n	n	n	n	n	2	n	n	n	n
B17	n	n	n	n	n	n	n	1	2	n	n	n	n
B18	n	n	n	n	n	n	n	n	n	n	n	n	n
B19	n	n	n	n	n	n	n	n	n	n	n	n	n
B20	n	n	n	n	n	n	n	n	n	n	n	n	n
B21	n	n	n	n	n	n	n	n	n	n	n	n	n
B22	n	n	n	n	n	n	n	n	n	n	n	n	n
B23	n	n	n	n	n	n	n	n	n	n	n	n	n
B24	1	n	n	n	n	n	n	n	n	n	n	n	n
B25	1	n	n	n	n	n	n	n	n	n	n	n	n
B26	n	n	n	n	n	n	n	n	n	n	n	n	n
B27	n	n	n	n	n	n	n	n	n	n	n	n	n
B28	n	n	n	n	n	n	n	n	n	n	n	n	n

n - less than 0.5 percent.

Table 2D. -- Probabilities (in percent) that an oilspill starting at a particular location will reach a certain land segment in 60 days.

Land Segment	Hypothetical spill location P1	P2 -E2	P3 -E3	P4 -E4	P5	P6	T1	T2	T3	T4	T5	T6	T7
A 1	n	n	n	n	n	n	n	n	n	n	n	n	n
A 2	n	n	n	n	n	n	n	n	n	n	n	n	n
A 3	n	n	n	n	n	1	n	n	n	1	2	n	1
A 4	n	n	n	n	n	n	n	n	n	n	1	n	n
A 5	n	n	n	n	n	n	n	n	n	n	n	n	n
A 6	n	n	n	n	n	n	n	n	n	n	n	n	n
A 7	n	n	n	n	n	n	n	n	n	1	1	n	n
A 8	n	n	n	n	n	n	n	n	n	1	2	n	1
A 9	n	n	n	n	n	n	n	n	n	1	5	n	1
A10	n	n	n	n	n	n	n	n	n	n	5	n	1
A11	n	n	n	n	n	n	n	n	n	n	1	n	n
A12	n	n	n	n	n	n	n	n	n	n	n	n	3
A13	n	n	n	n	n	n	1	1	1	n	n	1	3
A14	n	1	n	n	n	n	2	6	8	n	n	n	1
A15	n	n	n	n	n	n	n	2	18	n	n	n	n
A16	n	n	n	n	n	n	n	n	1	n	n	n	n
A17	n	n	n	n	n	n	n	n	3	n	n	n	n
A18	n	1	n	n	n	n	1	2	9	n	n	n	n
A19	1	n	n	n	n	n	n	n	n	n	n	n	n
A20	n	n	n	n	n	n	n	n	n	n	n	n	n
A21	n	n	n	n	n	n	n	n	n	n	n	n	n
A22	n	n	n	n	n	n	n	n	n	n	n	n	n
A23	n	n	n	n	n	n	n	n	n	n	n	n	n
A24	n	n	n	n	n	n	n	n	n	n	n	n	n
A25	1	n	n	n	n	n	n	n	n	n	n	n	n
A26	n	n	n	n	n	n	n	n	n	n	n	n	n
A27	n	n	n	n	n	n	n	n	n	n	n	n	n
A28	2	1	n	n	n	n	1	1	n	n	n	1	1
A29	4	1	1	n	n	n	1	1	1	n	n	1	1
A30	1	n	n	n	n	n	1	n	n	n	n	n	n
B 1	n	n	n	n	n	n	n	n	n	n	n	n	n
B 2	n	n	n	n	n	n	n	n	n	1	1	n	n
B 3	n	n	n	n	n	n	n	n	n	1	2	n	1
B 4	n	n	n	n	n	n	n	n	n	n	n	n	n
B 5	n	n	n	n	n	n	n	n	n	n	n	n	n
B 6	n	n	n	n	n	n	n	n	n	1	2	n	1
B 7	n	n	n	n	n	n	n	n	n	2	4	n	1
B 8	n	n	n	n	n	n	n	n	n	1	8	1	2
B 9	n	n	n	n	n	n	n	n	n	n	n	n	n
B10	n	n	n	n	n	n	1	1	1	n	n	1	5
B11	n	n	n	n	n	n	1	1	1	n	n	n	2
B12	n	n	n	n	n	n	1	6	8	n	n	n	1
B13	n	n	n	n	n	n	n	2	18	n	n	n	n
B14	n	n	n	n	n	n	n	n	n	n	n	n	n
B15	n	n	n	n	n	n	n	n	7	n	n	n	n
B16	n	n	n	n	n	n	n	n	2	n	n	n	n
B17	n	n	n	n	n	n	n	2	3	n	n	n	n
B18	1	1	n	n	n	n	1	n	n	n	n	n	n
B19	n	n	n	n	n	n	n	n	n	n	n	n	n
B20	n	n	n	n	n	n	n	n	n	n	n	n	n
B21	1	n	n	n	n	n	1	n	n	n	n	n	n
B22	n	n	n	n	n	n	n	n	n	n	n	n	n
B23	n	n	n	n	n	n	n	n	n	n	n	n	n
B24	3	1	n	n	n	n	1	1	n	n	n	n	1
B25	2	1	n	n	n	n	1	1	n	n	n	1	1
B26	1	n	n	n	n	n	n	n	n	n	n	n	n
B27	n	n	n	n	n	n	n	n	n	n	n	n	n
B28	n	n	n	n	n	n	n	n	n	n	n	n	n

n - less than 0.5 percent.

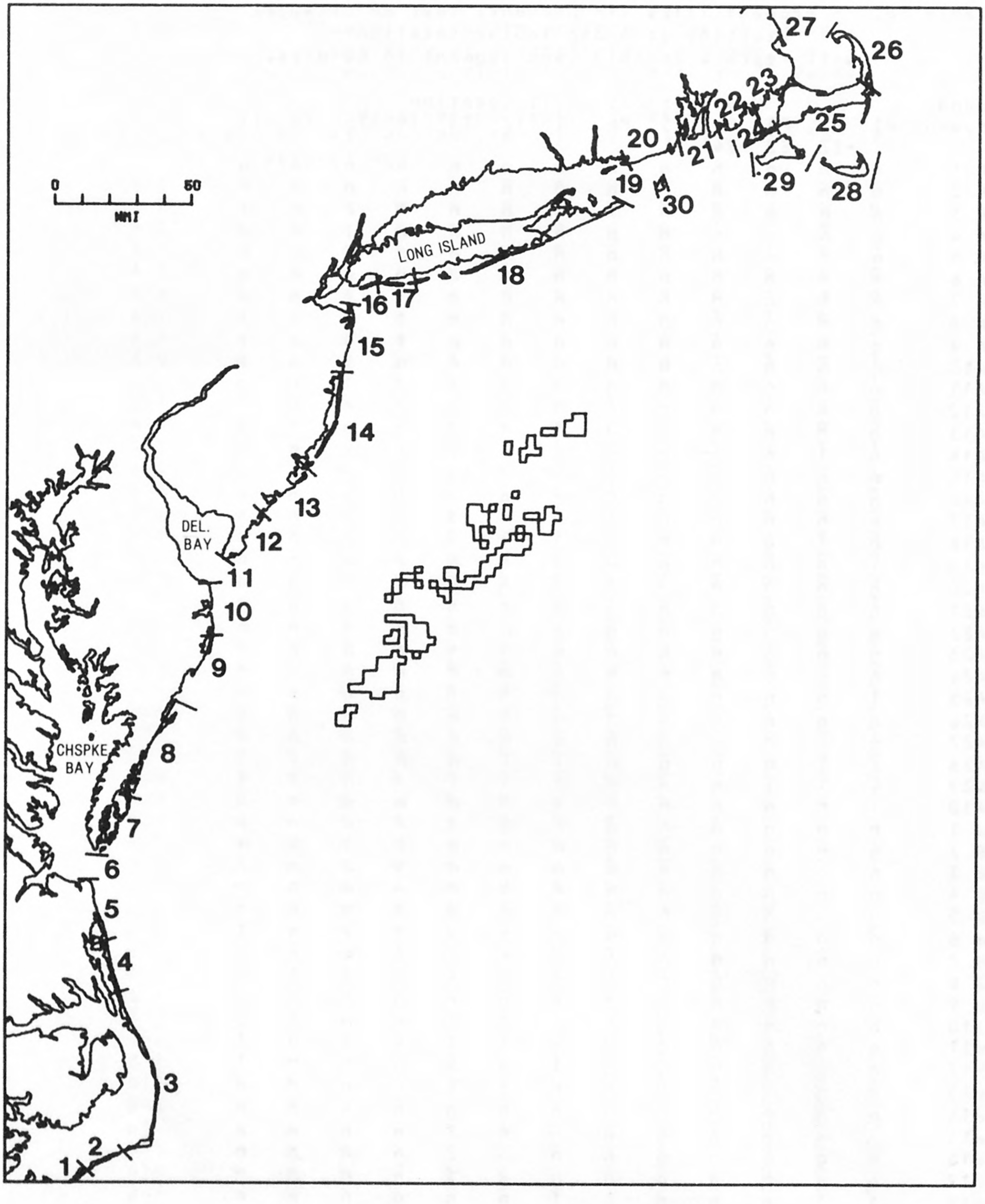

Figure 8A.--Map of land segment numbers for land segment set A.

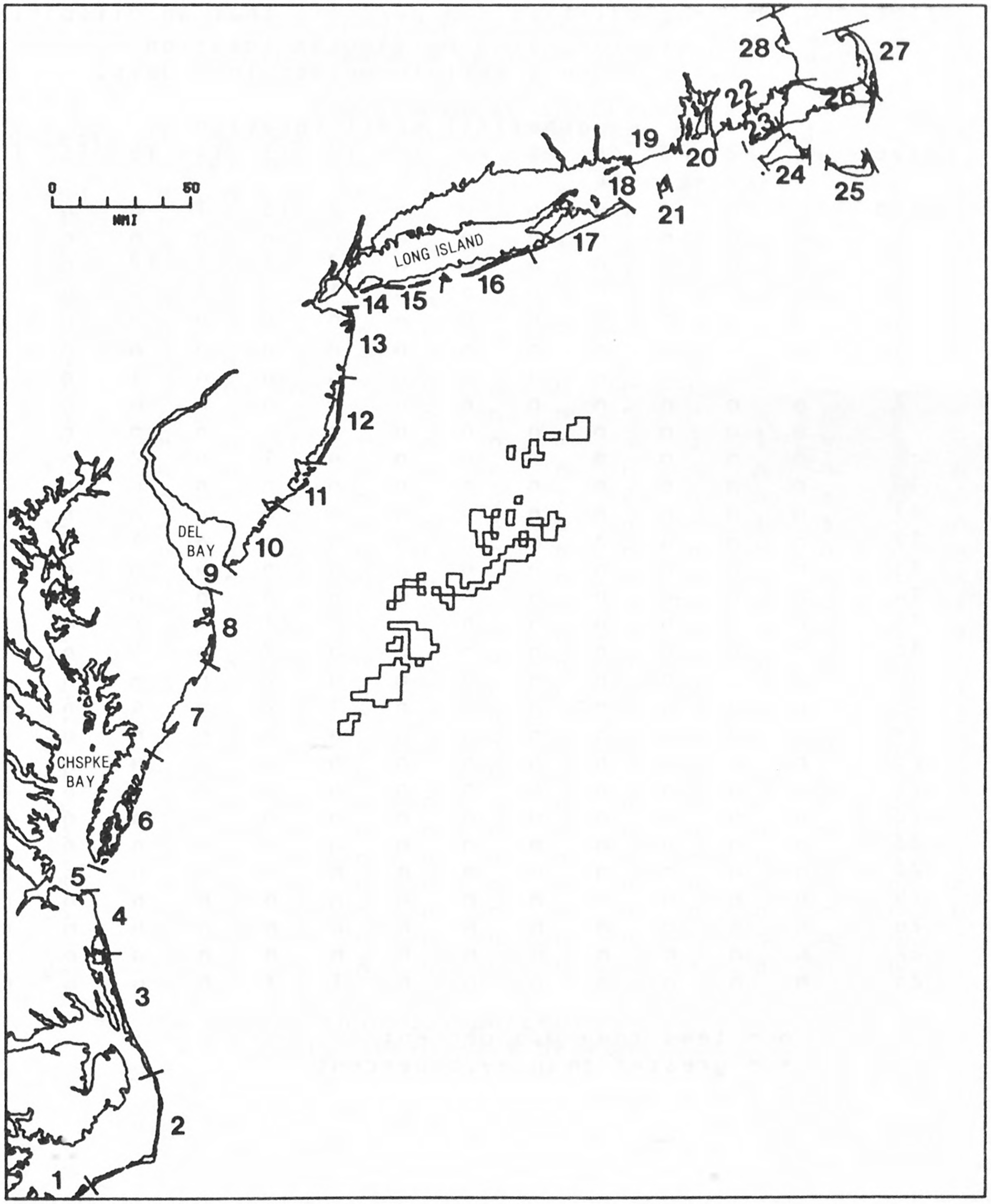

Figure 8B.--Map of land segment numbers for land segment set B.

Table 3A. -- Probabilities (in percent) that an oilspill starting at a particular location will reach a certain object in 3 days.

Object	Hypothetical spill location: P1	P2 -E2	P3 -E3	P4 -E4	P5	P6	T1	T2	T3	T4	T5	T6	T7
Land	n	n	n	n	n	n	n	2	15	1	6	n	3
1	n	n	n	n	n	n	n	n	n	n	n	n	2
2	n	n	n	n	n	n	n	2	7	1	12	n	1
3	n	n	n	n	n	n	n	1	5	1	4	n	1
4	n	n	n	n	n	n	n	n	n	n	n	n	n
5	n	n	n	n	n	n	n	n	n	n	n	n	n
6	n	n	n	n	n	n	n	n	n	n	1	n	n
7	n	n	n	n	n	n	n	n	n	n	n	n	n
8	n	n	n	n	n	n	n	n	n	n	n	n	n
9	n	n	n	n	n	n	n	n	1	n	2	n	2
10	n	n	n	n	n	n	n	n	n	n	n	n	n
11	n	n	n	n	n	n	n	n	n	n	n	n	n
12	n	n	n	n	n	n	n	n	n	n	1	n	n
13	n	n	n	n	n	n	n	n	n	n	n	n	n
14	n	n	n	n	n	n	n	n	n	n	n	n	n
15	n	n	n	n	n	n	n	2	21	1	7	n	3
16	n	n	n	n	n	n	n	n	2	n	1	n	1
17	n	n	n	n	n	n	n	n	2	n	n	n	n
18	n	n	n	n	n	n	n	1	2	n	4	n	n
19	n	n	n	n	n	n	n	n	n	n	n	n	n
20	n	n	n	n	n	n	n	n	n	n	n	n	1
21	n	n	n	n	n	n	n	n	n	n	n	n	n
22	n	n	n	n	n	n	n	n	n	n	n	n	n
23	n	n	n	n	n	n	n	n	n	n	n	n	n
24	n	n	n	n	n	n	n	n	n	n	n	n	n
25	n	n	n	n	n	n	n	n	n	n	n	n	n
26	n	n	n	n	n	n	n	n	n	n	n	n	n
27	n	n	n	n	n	n	n	n	n	n	n	n	n
28	n	n	n	n	n	n	n	1	*	n	n	n	n

n - less than 0.5 percent
* - greater than 99.5 percent

Table 3B. -- Probabilities (in percent) that an oilspill starting at a particular location will reach a certain object in 10 days.

Object	Hypothetical spill location P1	P2 -E2	P3 -E3	P4 -E4	P5	P6	T1	T2	T3	T4	T5	T6	T7
Land	n	n	n	n	n	n	2	7	30	3	12	1	8
1	n	n	n	n	n	n	1	1	4	1	4	n	5
2	n	n	n	n	n	n	1	4	13	4	18	1	4
3	n	n	n	n	n	n	n	3	8	3	10	1	3
4	n	n	n	n	n	n	n	n	n	1	3	n	n
5	n	n	n	n	n	n	1	3	2	n	n	n	1
6	n	n	n	n	n	n	1	1	1	2	4	1	1
7	n	n	n	n	n	n	n	n	n	1	2	n	n
8	n	n	n	n	n	n	n	n	n	n	n	n	n
9	n	n	n	n	n	n	1	n	3	1	4	n	4
10	n	n	n	n	n	n	n	n	n	n	n	n	n
11	n	n	n	n	n	n	1	2	3	n	n	n	n
12	n	n	n	n	n	n	n	n	n	1	3	n	n
13	n	n	n	n	n	n	n	n	n	n	n	n	n
14	n	n	n	n	n	n	n	n	n	n	n	n	n
15	n	n	n	n	n	n	2	7	36	4	14	1	8
16	n	n	n	n	n	n	n	2	6	1	2	n	3
17	n	n	n	n	n	n	n	n	4	1	4	n	n
18	n	n	n	n	n	n	n	2	9	n	5	n	1
19	n	n	n	n	n	n	1	2	2	1	3	n	2
20	n	n	n	n	n	n	n	n	n	n	n	n	1
21	n	n	n	n	n	n	n	n	n	n	n	n	n
22	n	n	n	n	n	n	n	n	n	1	1	n	n
23	n	n	n	n	n	n	n	n	n	n	n	n	n
24	n	n	n	n	n	n	n	n	n	n	n	n	n
25	n	n	n	n	n	n	n	n	n	n	1	n	n
26	n	n	n	n	n	n	n	n	n	n	n	n	n
27	n	n	n	n	n	n	n	n	1	n	n	n	n
28	n	n	n	n	n	n	n	2	*	n	n	n	n

n - less than 0.5 percent
* - greater than 99.5 percent

Table 30. -- Probabilities (in percent) that an oilspill starting at a particular location will reach a certain object in 30 days.

Object	Hypothetical spill location: P1	P2 -E2	P3 -E3	P4 -E4	P5	P6	T1	T2	T3	T4	T5	T6	T7
Land	3	2	n	1	1	1	4	11	39	5	17	2	11
1	1	1	n	n	n	n	2	3	6	3	6	1	8
2	n	1	n	1	1	n	2	6	15	5	19	2	6
3	2	1	n	1	1	n	1	4	11	4	12	1	5
4	n	n	n	n	n	n	n	n	n	2	3	n	1
5	n	1	n	n	n	n	2	4	4	n	n	n	2
6	n	1	n	1	n	n	1	2	2	2	6	1	3
7	n	n	n	n	n	n	n	n	n	2	4	n	1
8	n	n	n	n	n	n	n	n	n	n	n	n	n
9	1	1	n	n	n	n	1	1	5	2	5	1	5
10	n	n	n	n	n	n	n	1	1	n	n	n	n
11	n	n	n	n	n	n	1	3	4	n	n	n	n
12	n	n	n	n	n	n	n	n	n	1	4	n	1
13	n	n	n	n	n	n	n	n	n	n	n	n	n
14	n	n	n	n	n	n	n	n	n	n	n	n	n
15	3	2	n	1	1	1	4	12	44	6	19	3	11
16	n	1	n	n	n	n	1	3	9	1	3	1	4
17	n	1	n	n	n	n	n	1	5	2	5	1	1
18	n	n	n	n	n	n	1	3	11	1	5	n	1
19	1	1	n	n	n	n	2	4	4	2	4	1	3
20	n	n	n	n	n	n	n	n	n	n	n	n	2
21	3	n	n	n	n	n	1	n	n	n	n	n	n
22	n	n	n	n	n	n	n	n	n	1	3	n	1
23	n	n	n	n	n	n	n	n	n	n	n	n	n
24	n	n	n	n	n	n	n	n	n	n	n	n	n
25	n	n	n	n	n	n	n	n	n	n	1	n	n
26	n	n	n	n	n	n	n	n	n	n	n	n	n
27	n	n	n	n	n	n	n	n	1	n	n	n	n
28	n	n	n	n	n	n	n	3	*	n	n	n	n

n - less than 0.5 percent
* - greater than 99.5 percent

Table 30. -- Probabilities (in percent) that an oilspill starting at a particular location will reach a certain object in 60 days.

Object	Hypothetical spill location: P1	P2 -E2	P3 -E3	P4 -E4	P5	P6	T1	T2	T3	T4	T5	T6	T7
Land	10	6	2	2	1	1	6	15	42	6	17	5	14
1	2	2	n	1	1	n	3	4	7	3	6	2	8
2	1	2	n	1	1	n	2	6	15	5	19	2	6
3	4	3	1	1	1	n	3	6	12	4	12	2	6
4	n	n	n	n	n	n	n	n	n	2	3	n	1
5	1	1	n	n	n	n	2	4	4	n	n	n	2
6	1	1	n	1	n	n	2	2	2	3	6	1	3
7	n	1	n	1	n	n	n	1	n	2	4	1	2
8	2	1	n	n	n	n	1	n	n	n	n	n	n
9	3	2	1	n	n	n	2	2	6	2	5	1	6
10	1	n	n	n	n	n	n	1	2	n	n	n	n
11	1	n	n	n	n	n	1	3	4	n	n	n	n
12	n	1	n	n	n	n	n	n	n	1	4	n	1
13	n	n	n	n	n	n	n	n	n	n	n	n	n
14	1	1	n	n	n	n	1	n	n	n	n	n	n
15	9	5	1	2	1	1	7	15	46	7	19	5	14
16	1	1	n	n	n	n	1	4	10	1	3	1	4
17	n	1	n	n	n	n	n	1	5	2	6	1	2
18	1	1	n	n	n	n	1	4	12	1	5	1	1
19	2	2	n	1	n	n	3	5	4	2	4	1	3
20	n	n	n	n	n	n	n	n	n	n	n	n	2
21	8	2	1	1	1	n	3	3	1	n	n	2	2
22	n	n	n	n	n	n	n	n	n	2	3	n	1
23	n	n	n	n	n	n	n	n	n	n	n	n	n
24	1	1	n	n	n	n	1	n	n	n	n	n	n
25	n	n	n	n	n	n	n	n	n	n	1	n	n
26	n	n	n	n	n	n	n	n	n	n	n	n	n
27	n	n	n	n	n	n	n	n	1	n	n	n	n
28	n	n	n	n	n	n	n	3	*	n	n	n	n

n - less than 0.5 percent
* - greater than 99.5 percent

conditional probabilities are given for the four time limits stated above.

Estimates of Weathering Rates and Slick Dispersion

It must be emphasized that up to this point the analysis has dealt only with trajectories for the transport of surface oil by winds and currents and has not involved any direct consideration of dispersion or weathering processes which would progressively reduce the quantity of oil contained in the slick as it traveled towards shore. The probabilities given in tables 2 and 3, therefore, present a worst-case picture in the sense that some fraction of the spills (possibly all) occurring offshore in the lease area would be expected to deteriorate to the point of insignificance before reaching either land or an object. Some attempt at quantifying weathering and dispersive effects and accounting for them in probability estimates is thus in order.

One important factor determining the significance of weathering in reducing oilspill effects is the time required for spills to reach an object. Times to land, segments, or objects for the simulated trajectories, in fact, cover a very wide range, and it is therefore particularly important to consider this factor in interpreting results of the spill trajectory analysis. The change with time of the likelihood of a spill (once it occurs) coming in contact with an object is shown in tables 2 and 3.

Also in the list of factors that would determine the potency of spills at the time of contact would be spill size and the quality or composition of the oil (since lighter weight crudes evaporate at a much more rapid rate than those with a large proportion of high molecular weight hydrocarbons). This latter factor is hard to predict in advance and the significance of weathering is therefore difficult to quantify despite its obvious importance in interpreting these results. Also, the dispersion of a spill and the likelihood that it would contact an object are potentially reduced by cleanup efforts, but this mitigating factor is not directly incorporated in the probability analysis.

The most important conclusion to be reached from the data in tables 2 and 3 is that travel times to objects for spills emanating from the proposed leases will be fairly long, so that they will no longer exist as an identifiable slick but rather will have fragmented into a large number of discrete particles or "blobs" by the time any oil arrives at an object. Observations by Jeffery (1973) of actual spills in the North Atlantic indicate breakup of the slick can be expected within about 4 days, and that the particles of residual oil typically consist of spongy emulsions of oil of widely varying sizes. Moreover, it is generally agreed that large fractions of the original volume of oil will evaporate in the first few days of weathering and that further loss to the atmosphere occurs at a very slow rate. Data from Nelson (1958) for crude oil of API gravity 40°, for example, indicate that about 50 percent of the original spill volume would be lost to evaporation.

Thus for oil spills originating from the proposed leases it would appear that an important consideration is the extent to which fragments of the slick are dispersed in time. Using lateral dispersion coefficients from Csanady (1974), estimates of slick dispersion were made for various travel times and for two spill sizes, 1,000 barrels and 50 barrels, assuming 50 percent loss of the original volume by evaporation. The resulting distribution of oil along an assumed straight shoreline or object is given in figure 9A. It is important to note that the profiles will flatten considerably relative to a shoreline or object as the outline of the object becomes more irregular. Even for straight objects it appears that residual oil from a single spill as small as 50 barrels would not be easily detected after 30 days at sea. Figure 9B shows the profile of a medium large spill after 30 days at sea.

The action of wind and waves will further disperse a spill. After 30 days it was difficult due to high winds to locate the oilspill resulting from the breakup of the Argo Merchant (about 180,000 barrels of No. 6 fuel oil spilled). In contrast, the Torrey Canyon went ashore on 18 March 1967 in the Scilly Isles southwest of England and spilled some 700,000 barrels of crude oil. Oil from this wreck came ashore in Brittany as late as 60 days later (Wardley-Smith, 1976).

The reduction in toxicity with time of spilled oil is another factor that must be considered. Shellfish and finfish can be distinguished from other biological resources on the basis that their sensitivity to spilled crude is dependent on contact with soluble toxic components of the oil fractions which tend to evaporate relatively rapidly from a spreading slick. Past experience with oilspills in shellfish areas has ranged from reportedly severe and lasting effects in the case of the West Falmouth spill, when toxic components of the oil were quickly churned into near-shore sediments (Blummer, 1970), to much more modest effects following the Torrey Canyon spill when more time was available for weathering before contact (Smith, 1968). These differences in effects occurred despite the fact that the Torrey Canyon spilled more than 150 times the volume lost in the West Falmouth spill. Three days is reported to be sufficient time for evaporation and dissolution of most of the toxic aromatic fractions of crude oil, with less time required under high wind conditions (Offshore Oil Task Group, 1973).

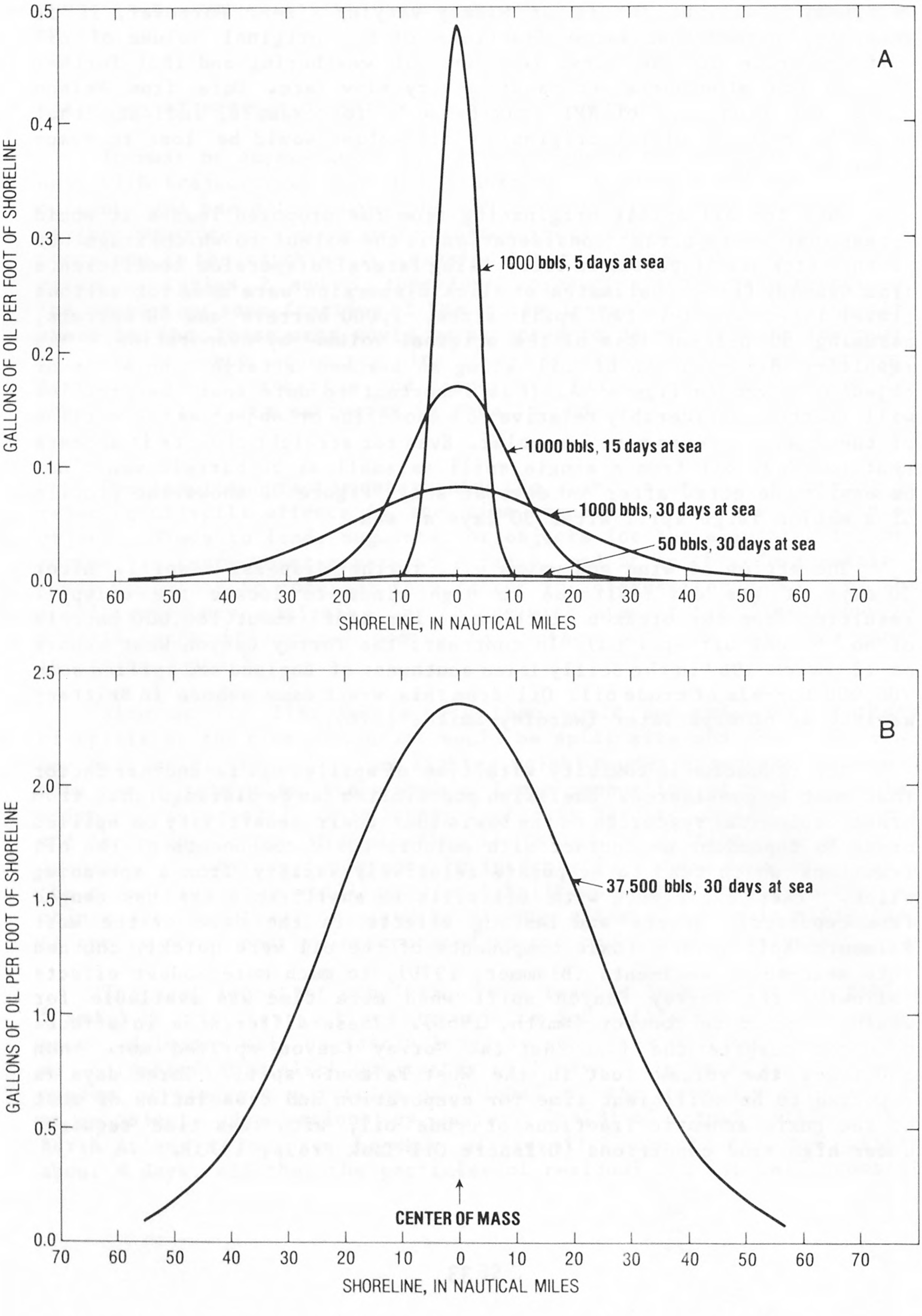

Figure 9.--Density of oil reaching an idealized shoreline (or object) as a function of travel time and initial size.

Combined Analysis: Spill Frequency Estimates and Oilspill Trajectories

It is worth briefly summarizing some of the important points to be drawn from the results presented thus far. Data in table 1A indicate that, if pipelines are used to transport the crude oil to shore, the proposed leasing will add about 530 spills to the already existing expected number of spills of about 2,810 (a ratio of about 5 to 1) and none are likely to exceed 1,000 barrels. Furthermore, consideration of travel time to contact (tables 2 and 3), evaporation rates, and rates of slick dispersion (figure 9) leads to the conclusion that an individual spill would need to be as large as 1,000 barrels in size in order to have significant ecological contact. The probabilities in tables 2 and 3 give the chances that if a spill occurs in the lease area it would contact an object within the allotted time.

With respect to the hazard of major spills (that is, greater than 1,000 barrels), the data presented in tables 2 and 3 represent only a partial solution to the problem of assessing oilspill risks to important resources. The overall oilspill risk posed by oil and gas production in the proposed sale must be assessed as a joint function of the probability that spills will occur in the course of development as well as the likelihood that spills will follow certain trajectories. Thus, the data in tables 2 and 3 must be combined with the spill frequency estimates presented in figures 2 and 3 to obtain a total probability distribution for contacts with individual objects.

Despite the intuitive logic of simply multiplying the probabilities in figure 3 by those in tables 2 and 3, the correct computation of the overall or "total" probability is in fact somewhat more complicated. This results from the fact that the probabilities presented in tables 2 and 3 are actually conditional probabilities and refer to the probabilities of contact on objects, "conditioned" on the chance of spills occurring in the first place. The overall probability that oilspills will contact a particular object exactly k times during the production life of the area, P(k), is given by

$$P(k) = \sum_{n=k}^{\infty} P(k|n)\ P(n) \qquad (1)$$

where $P(k|n)$ is the probability of k contacts with the resource given the occurrence of n spills, and $P(n)$ is the probability of n spills occurring. The conditional probability $P(k|n)$ can be assumed to be distributed bionomially and is given by

$$P(k|n) = \binom{n}{k} p^{k} (1-p)^{n-k} \qquad (2)$$

where p is the probability of contact with the object given the occurrence of a spill (tables 2 and 3).

The resulting probabilities of an object being contacted one or more times by an oilspill and the most likely number of contacts are presented in table 4. Similar numbers for land segments are presented in table 5. The numbers in these tables are based on the assumption that economically recoverable amounts of petroleum will in fact be found in the area. If not, of course, all the numbers would be zeros.

It can be seen from table 4, that the mixed transportation scenario results in the higher risk. Considering the numbers in table 3, it would seem that much of this increase comes from point T3. Even so, the probability that any object will be contacted by one or more spills within 10 days is only 10%. And only 21% for 60 days of travel. Finally, for either transportation scenario, for any combination of leasing, for any travel time, and for any object, the most likely number of contacts is zero.

It is emphasized that probability estimates refer only to the chances that oil in some form or another, from a spill originating larger than 1,000 barrels will come in contact with some portion of an object. The mitigating effects of weathering processes and clean-up efforts are only indirectly reflected in the probabilities in tables 4 and 5 by virtue of the fact that estimates apply only to large spills. Figure 9 provides a rough description of the likely effects of evaporation and dispersion on spills of various sizes as a function of time. To this must be added the likelihood of at least some, and perhaps considerable, success in containing oil in the course of the days or weeks separating the occurrence of a spill on the OCS and its arrival on shore. Finally, it is important to remember that oilspills can occur only if petroleum is produced from the area.

It is important that the distinction between the probabilities given in tables 2 and 3 and those in tables 4 and 5 be very clear. The data given in tables 2 and 3 refer only to the likelihood that spills would follow certain trajectories and have nothing to do with the chances that spills would occur in the first place. The probabilities in tables 4 and 5, by contrast, reflect both the expected frequency of spill occurrence given that petroleum production occurs as well as the likelihood of certain trajectories.

Table 4A. -- Probabilities (in percent) of one or more spills and most likely number of spills greater than 1,000 barrels occurring and contacting objects over the production life of the lease area. Pipeline transportation.

Object	Within 3 days						Within 10 days						Within 30 days						Within 60 days					
	Proposed Leases		Existing Leases		Both		Proposed Leases		Existing Leases		Both		Proposed Leases		Existing Leases		Both		Proposed Leases		Existing Leases		Both	
	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode
Land	n	0	2	0	2	0	1	0	5	0	6	0	2	0	10	0	11	0	2	0	16	0	18	0
1	n	0	1	0	2	0	1	0	4	0	4	0	1	0	7	0	8	0	1	0	8	0	9	0
2	n	0	n	0	1	0	1	0	3	0	4	0	1	0	6	0	7	0	1	0	7	0	8	0
3	n	0	1	0	1	0	n	0	3	0	3	0	1	0	5	0	6	0	1	0	8	0	9	0
4	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0	n	0	1	0	1	0
5	n	0	n	0	n	0	n	0	1	0	1	0	n	0	2	0	2	0	n	0	2	0	2	0
6	n	0	n	0	n	0	n	0	1	0	1	0	n	0	3	0	4	0	1	0	4	0	4	0
7	n	0	n	0	n	0	n	0	n	0	n	0	n	0	2	0	2	0	n	0	2	0	3	0
8	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0
9	n	0	1	0	1	0	n	0	3	0	3	0	1	0	4	0	5	0	1	0	6	0	7	0
10	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0
11	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
12	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0	n	0	1	0	1	0
13	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
14	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0
15	n	0	2	0	2	0	1	0	6	0	7	0	2	0	10	0	12	0	2	0	16	0	18	0
16	n	0	1	0	1	0	n	0	2	0	2	0	n	0	3	0	4	0	1	0	4	0	5	0
17	n	0	n	0	n	0	n	0	n	0	n	0	n	0	2	0	2	0	n	0	2	0	2	0
18	n	0	n	0	n	0	n	0	1	0	1	0	n	0	1	0	1	0	n	0	2	0	2	0
19	n	0	n	0	n	0	n	0	1	0	2	0	n	0	3	0	4	0	1	0	5	0	5	0
20	n	0	n	0	n	0	n	0	1	0	1	0	n	0	1	0	1	0	n	0	1	0	1	0
21	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	5	0	6	0
22	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0	n	0	1	0	2	0
23	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
24	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0
25	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
26	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
27	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
28	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0

Notes: Prob is the probability (in percent) of one or more spills contacting the object.
Mode is the most likely number of contacts.
n - less than 0.5 percent.
All numbers are based on the assumption that economically recoverable amounts of petroleum will be found in the area.

Table 4B. -- Probabilities (in percent) of one or more spills and most likely number of spills greater than 1,000 barrels occurring and contacting objects over the production life of the lease area.
Mixed transportation.

Object	Within 3 days						Within 10 days						Within 30 days						Within 60 days					
	Proposed Leases		Existing Leases		Both		Proposed Leases		Existing Leases		Both		Proposed Leases		Existing Leases		Both		Proposed Leases		Existing Leases		Both	
	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode
Land	1	0	2	0	3	0	3	0	5	0	9	0	5	0	10	0	15	0	6	0	16	0	21	0
1	n	0	1	0	1	0	1	0	4	0	5	0	2	0	7	0	8	0	2	0	8	0	10	0
2	2	0	n	0	3	0	4	0	3	0	7	0	5	0	6	0	11	0	5	0	7	0	11	0
3	1	0	1	0	2	0	2	0	3	0	5	0	3	0	5	0	8	0	3	0	8	0	11	0
4	n	0	n	0	n	0	1	0	n	0	1	0	1	0	1	0	2	0	1	0	1	0	2	0
5	n	0	n	0	n	0	n	0	1	0	1	0	n	0	2	0	2	0	n	0	2	0	2	0
6	n	0	n	0	n	0	1	0	1	0	2	0	2	0	3	0	5	0	2	0	4	0	6	0
7	n	0	n	0	n	0	n	0	n	0	1	0	1	0	2	0	3	0	1	0	2	0	4	0
8	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0
9	n	0	1	0	1	0	1	0	3	0	4	0	1	0	4	0	5	0	1	0	6	0	7	0
10	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0
11	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0
12	n	0	n	0	n	0	1	0	n	0	1	0	1	0	1	0	2	0	1	0	1	0	2	0
13	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
14	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0
15	2	0	2	0	3	0	4	0	6	0	10	0	6	0	10	0	16	0	6	0	16	0	21	0
16	n	0	1	0	1	0	1	0	2	0	3	0	1	0	3	0	4	0	1	0	4	0	5	0
17	n	0	n	0	n	0	1	0	n	0	1	0	1	0	2	0	3	0	2	0	2	0	4	0
18	1	0	n	0	1	0	1	0	1	0	2	0	1	0	1	0	2	0	1	0	2	0	4	0
19	n	0	n	0	n	0	1	0	1	0	2	0	1	0	3	0	5	0	2	0	5	0	6	0
20	n	0	n	0	n	0	n	0	1	0	1	0	n	0	1	0	1	0	n	0	1	0	1	0
21	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	5	0	5	0
22	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0	2	0	1	0	1	0	2	0
23	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
24	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0
25	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
26	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
27	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
28	2	0	n	0	2	0	2	0	n	0	2	0	2	0	n	0	3	0	2	0	n	0	3	0

Notes: Prob is the probability (in percent) of one or more spills contacting the object.
Mode is the most likely number of contacts.
n - less than 0.5 percent.
All numbers are based on the assumption that economically recoverable amounts of petroleum will be found in the area.

Table 5A. -- Probabilities (in percent) of one or more spills and most likely number of spills greater than 1,000 barrels occurring and contacting land segments over the production life of the lease area. Pipeline transportation.

Land Segment	Within 3 days						Within 10 days						Within 30 days						Within 60 days					
	Proposed Leases		Existing Leases		Both		Proposed Leases		Existing Leases		Both		Proposed Leases		Existing Leases		Both		Proposed Leases		Existing Leases		Both	
	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode
A 1	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A 2	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A 3	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0	n	0	1	0	2	0
A 4	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A 5	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A 6	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A 7	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0
A 8	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0	n	0	1	0	1	0
A 9	n	0	n	0	n	0	n	0	n	0	1	0	n	0	1	0	1	0	n	0	1	0	1	0
A10	n	0	n	0	n	0	n	0	1	0	1	0	n	0	1	0	1	0	n	0	1	0	1	0
A11	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A12	n	0	1	0	1	0	n	0	2	0	2	0	n	0	2	0	2	0	n	0	2	0	2	0
A13	n	0	1	0	1	0	n	0	2	0	2	0	n	0	3	0	3	0	n	0	3	0	3	0
A14	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0	n	0	1	0	1	0
A15	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A16	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A17	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A18	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0
A19	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0
A20	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A21	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A22	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A23	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A24	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A25	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A26	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A27	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A28	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0
A29	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	2	0	2	0
A30	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0
B 1	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B 2	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B 3	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0	n	0	2	0	2	0
B 4	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B 5	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B 6	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0	n	0	1	0	1	0
B 7	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0	n	0	1	0	1	0
B 8	n	0	n	0	n	0	n	0	1	0	1	0	n	0	2	0	2	0	n	0	2	0	2	0
B 9	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B10	n	0	1	0	2	0	n	0	3	0	3	0	n	0	3	0	4	0	n	0	3	0	4	0
B11	n	0	n	0	n	0	n	0	1	0	2	0	n	0	2	0	2	0	n	0	2	0	2	0
B12	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0
B13	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B14	n	0	n	0	n	0	n	0.	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B15	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B16	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B17	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0
B18	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0
B19	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B20	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B21	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0
B22	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B23	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B24	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	2	0	2	0
B25	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0
B26	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B27	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B28	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0

Notes: Prob is the probability (in percent) of one or more spills contacting the segment.
Mode is the most likely number of contacts.
n - less than 0.5 percent.
All numbers are based on the assumption that economically recoverable amounts of petroleum will be found in the area.

Table 5B. -- Probabilities (in percent) of one or more spills and most likely number of spills greater than 1,000 barrels occurring and contacting land segments over the production life of the lease area. Mixed transportation.

Land Segment	Within 3 days: Proposed Leases		Within 3 days: Existing Leases		Within 3 days: Both		Within 10 days: Proposed Leases		Within 10 days: Existing Leases		Within 10 days: Both		Within 30 days: Proposed Leases		Within 30 days: Existing Leases		Within 30 days: Both		Within 60 days: Proposed Leases		Within 60 days: Existing Leases		Within 60 days: Both	
	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode	Prob	Mode
A 1	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A 2	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A 3	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0	1	0	1	0	1	0	2	0
A 4	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A 5	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A 6	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A 7	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	n	0	1	0	1	0
A 8	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0	2	0	1	0	1	0	2	0
A 9	n	0	n	0	n	0	1	0	n	0	1	0	1	0	1	0	2	0	1	0	1	0	2	0
A10	1	0	n	0	1	0	1	0	1	0	2	0	1	0	1	0	2	0	1	0	1	0	2	0
A11	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A12	n	0	1	0	1	0	n	0	2	0	2	0	n	0	2	0	2	0	n	0	2	0	2	0
A13	n	0	1	0	1	0	n	0	2	0	2	0	n	0	3	0	3	0	n	0	3	0	3	0
A14	n	0	n	0	n	0	n	0	n	0	1	0	n	0	1	0	1	0	n	0	1	0	1	0
A15	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A16	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A17	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A18	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0
A19	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0
A20	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A21	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A22	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A23	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A24	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A25	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A26	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A27	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
A28	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0
A29	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	2	0	2	0
A30	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0
B 1	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B 2	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B 3	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0	1	0	2	0	2	0
B 4	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B 5	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B 6	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0	1	0	1	0	1	0	2	0
B 7	n	0	n	0	n	0	1	0	n	0	1	0	1	0	1	0	2	0	1	0	1	0	2	0
B 8	1	0	n	0	1	0	1	0	1	0	3	0	2	0	2	0	3	0	2	0	2	0	3	0
B 9	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B10	n	0	1	0	1	0	n	0	3	0	3	0	n	0	3	0	3	0	n	0	3	0	3	0
B11	n	0	n	0	n	0	n	0	1	0	1	0	n	0	2	0	2	0	n	0	2	0	2	0
B12	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	n	0	1	0	1	0
B13	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B14	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B15	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B16	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B17	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0
B18	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0
B19	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B20	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B21	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0
B22	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B23	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B24	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	2	0	2	0
B25	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	1	0	1	0
B26	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B27	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0
B28	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0	n	0

Notes: Prob is the probability (in percent) of one or more spills contacting the segment.
Mode is the most likely number of contacts.
n - less than 0.5 percent.
All numbers are based on the assumption that economically recoverable amounts of petroleum will be found in the area.

Comparison with Previous Results

The existing leases in the Mid-Atlantic OCS area were the subject of a similar oilspill risk analysis study (Smith and others, 1976). A direct comparison of the results of that study and this study is not possible for several reasons. The quantity of petroleum expected to be produced is somewhat different because some of the tracts considered for leasing in Sale 40 were not leased and the methodology for estimating the quantity of petroleum has been improved. The data on currents for this study are believed to be better, as discussed above. The statistical base for calculating spill potential has been revised as discussed above. Spills arising from transportation are accounted for in a more realistic fashion. The net effect of these differences works in the present case to lower most estimates of both spills occurring and contacting objects.

Relative Risks of Leasing

The risk due to the proposed leasing appears to be quite small. The risk due to the existing leases is also rather small. The "worst case" present is an oilspill occurring under the mixed transportation scenario, traveling for 60 days, and contacting Sandy beaches. For the proposed leases, there is a 94% chance that this will not happen; for the existing leases, 84%; and for the combination, 79%.

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APPENDIX A

Figures A-1 to A-28

The locations of biological resources in the vicinity of the Mid-Atlantic Outer Continental Shelf Lease Area

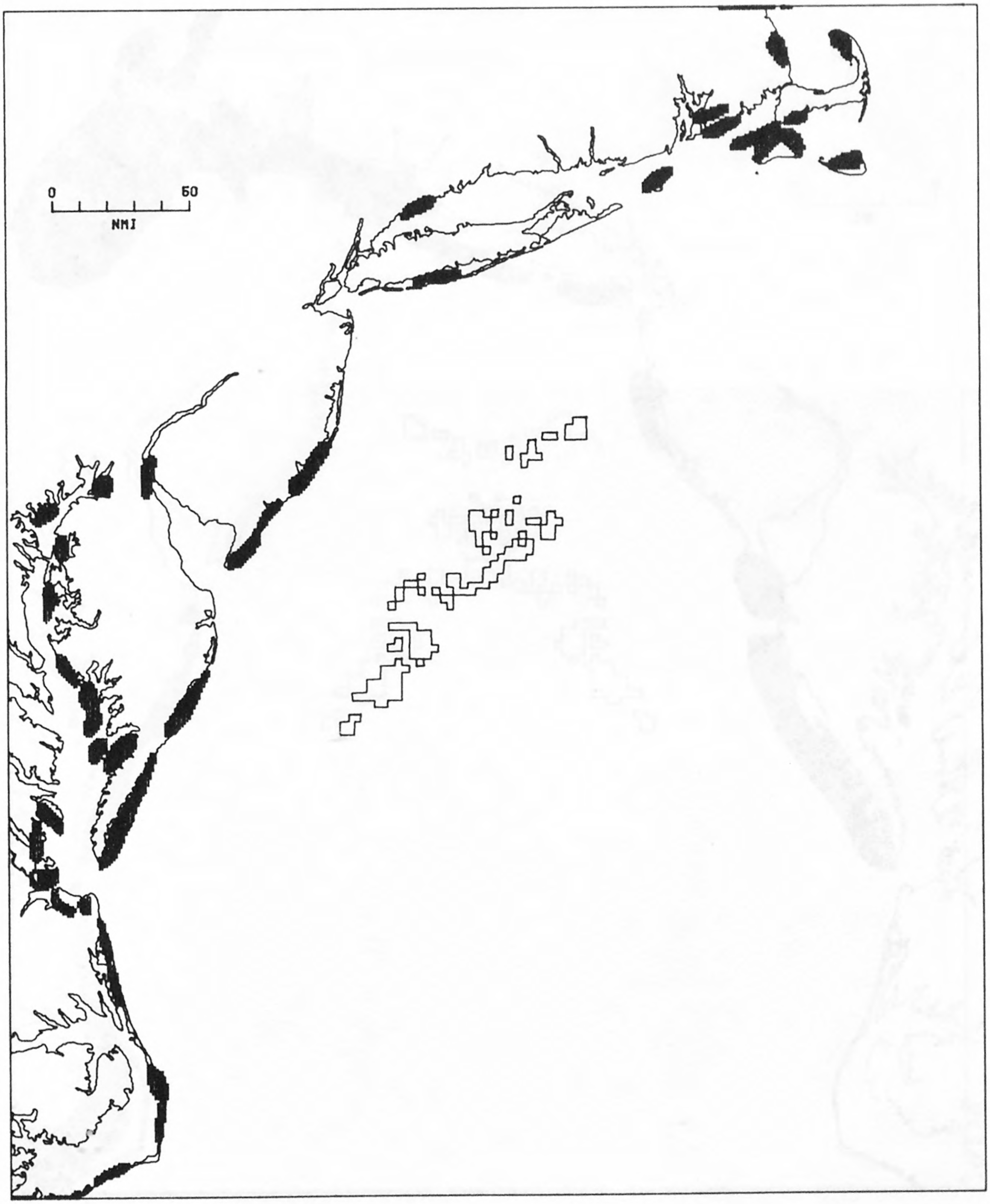

Figure A-1.--Hatched area indicates arealextent of wading bird colonies.

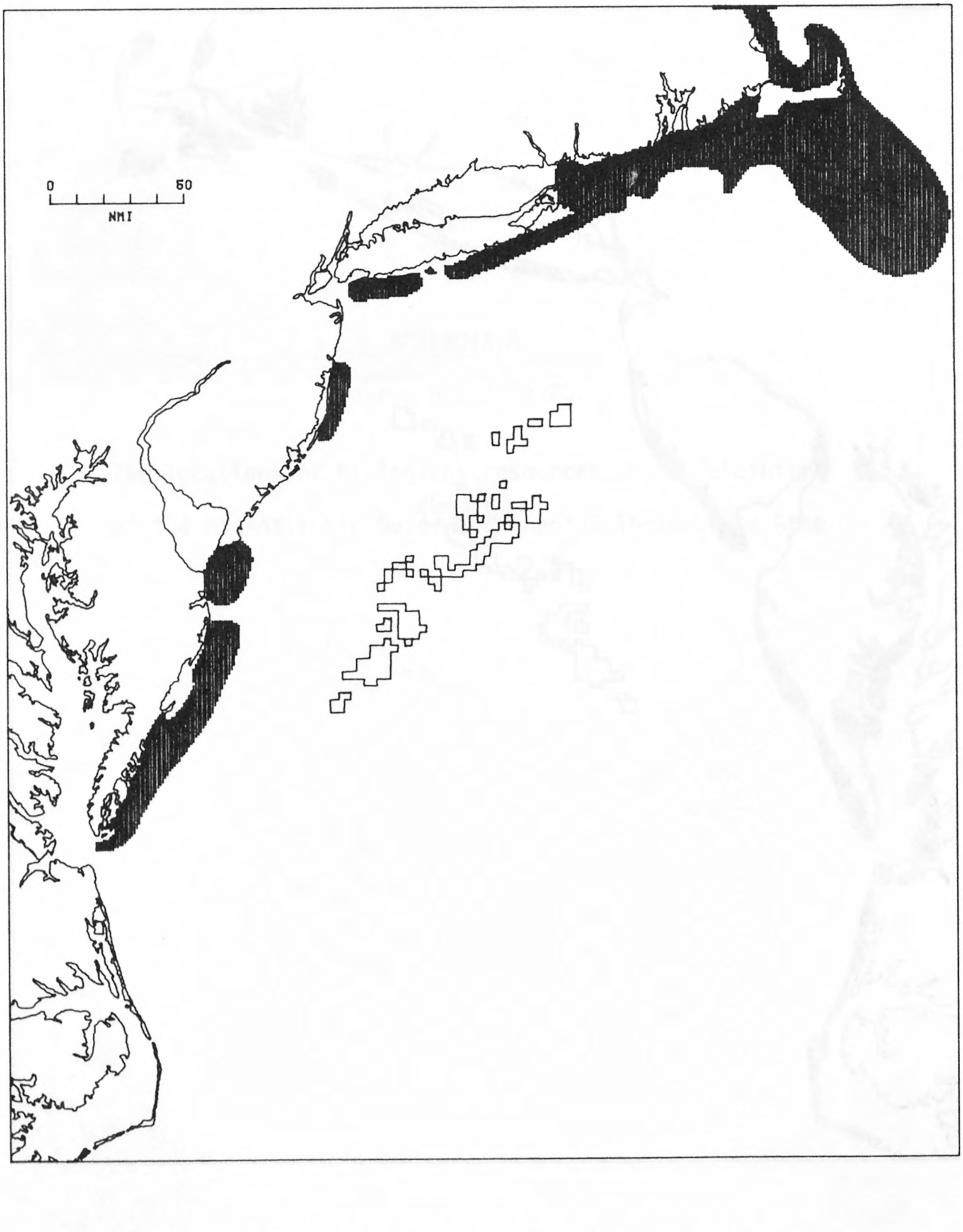

Figure A-2.--Hatched area indicates areal extent of sea duck wintering areas.

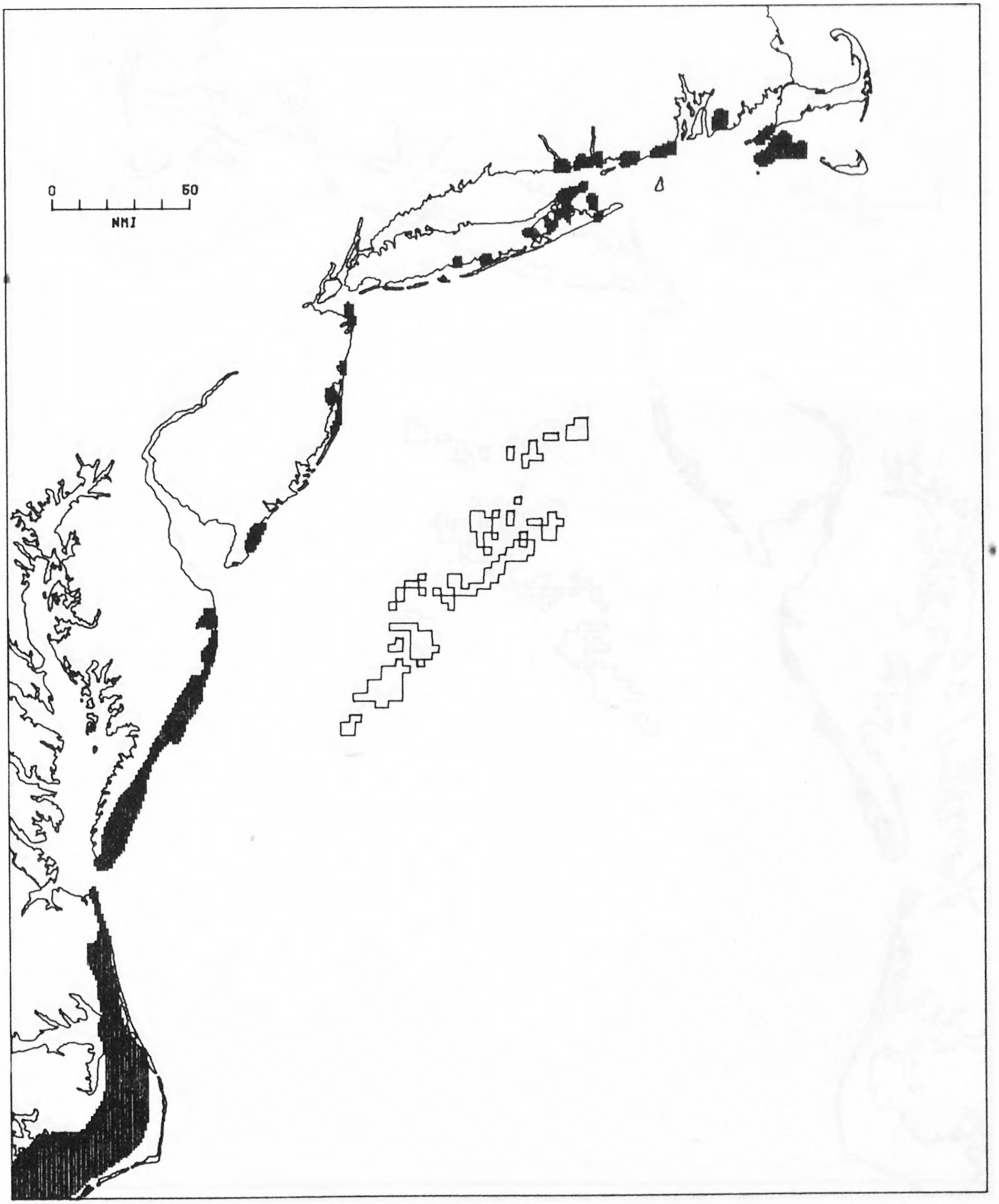

Figure A-3.--Hatched area indicates areal extent of osprey nesting areas.

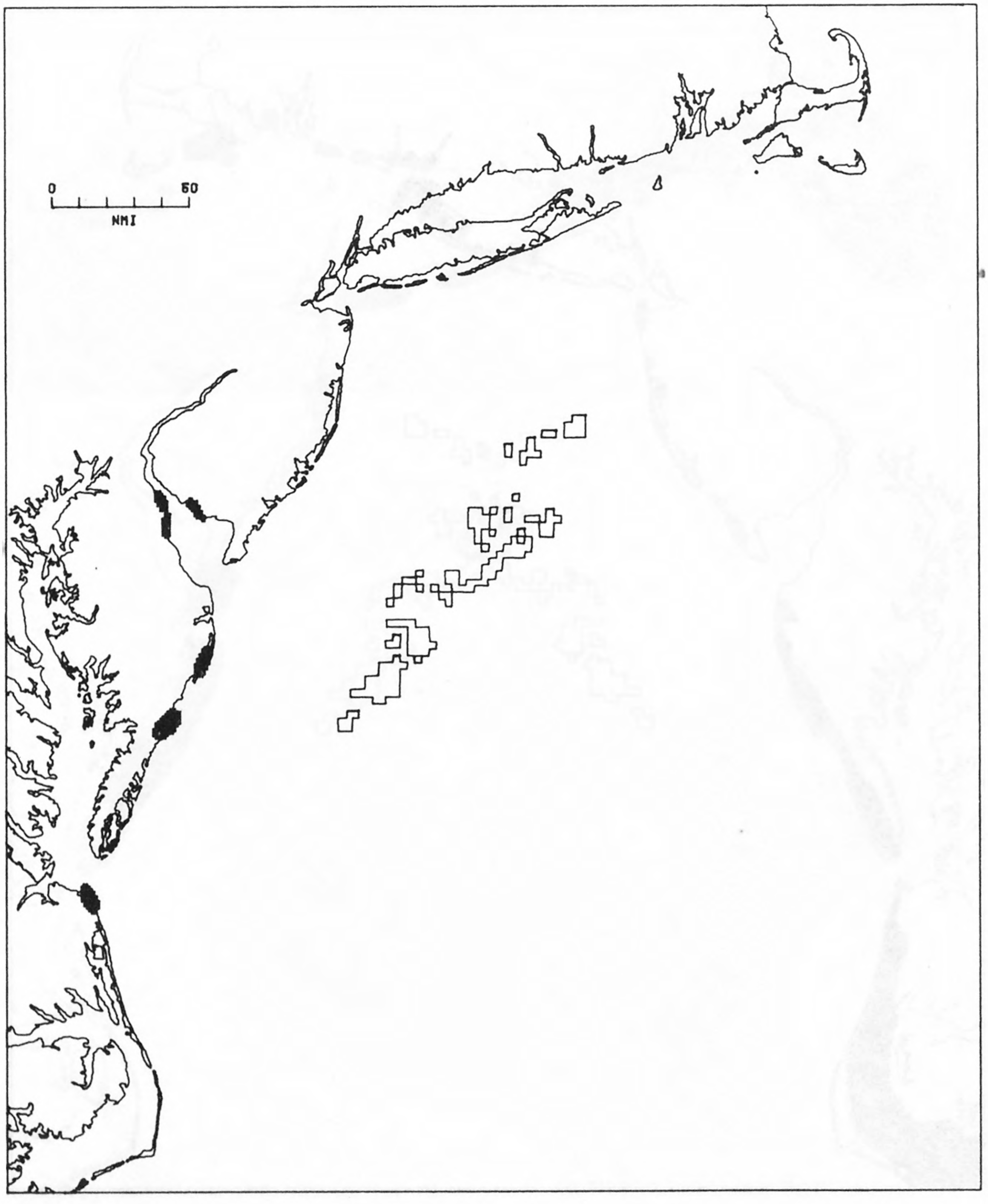

Figure A-4.--Hatched area indicates areal extent of bald eagle nesting areas.

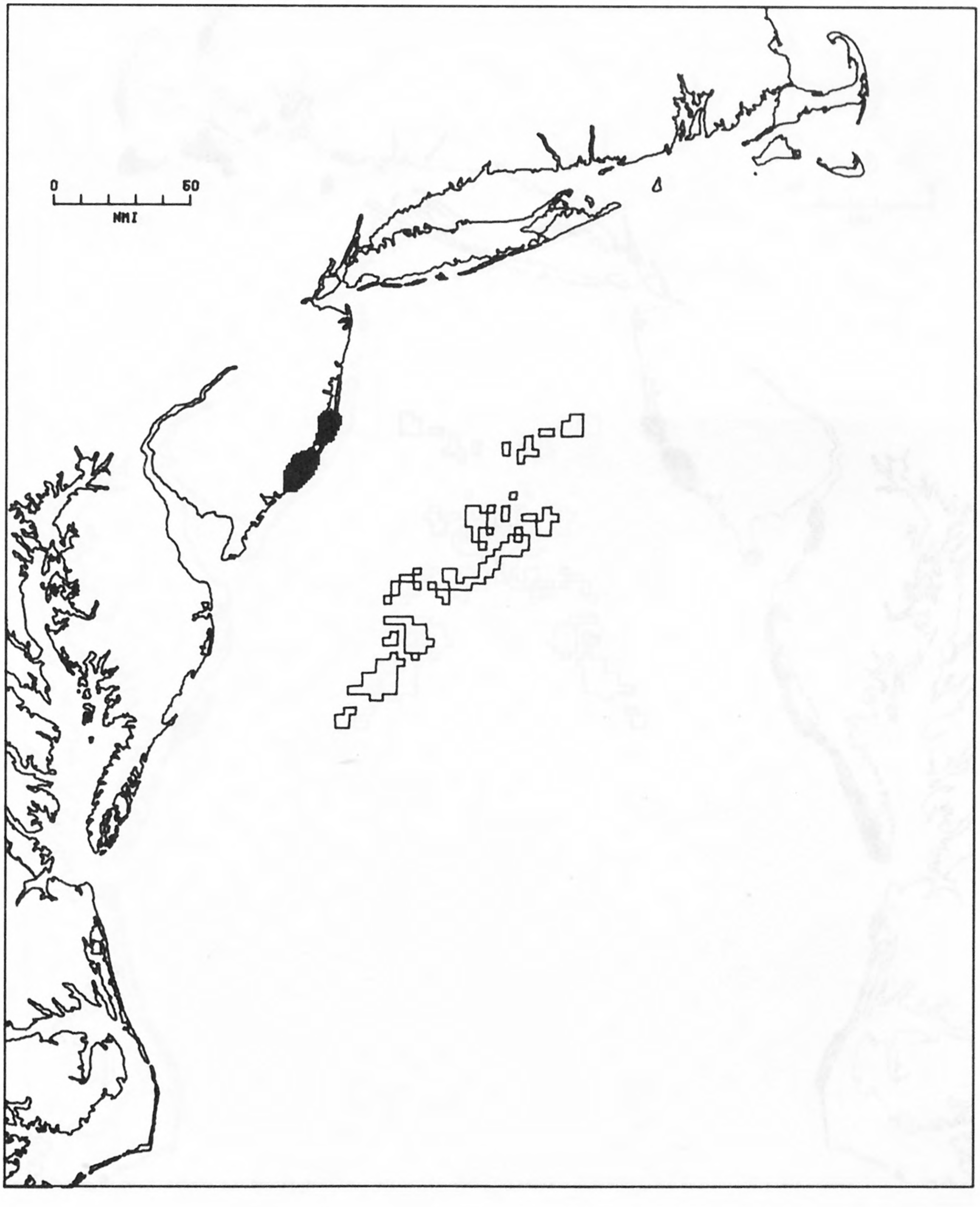

Figure A-5.--Hatched area indicates areal extent of peregrine falcon nesting areas.

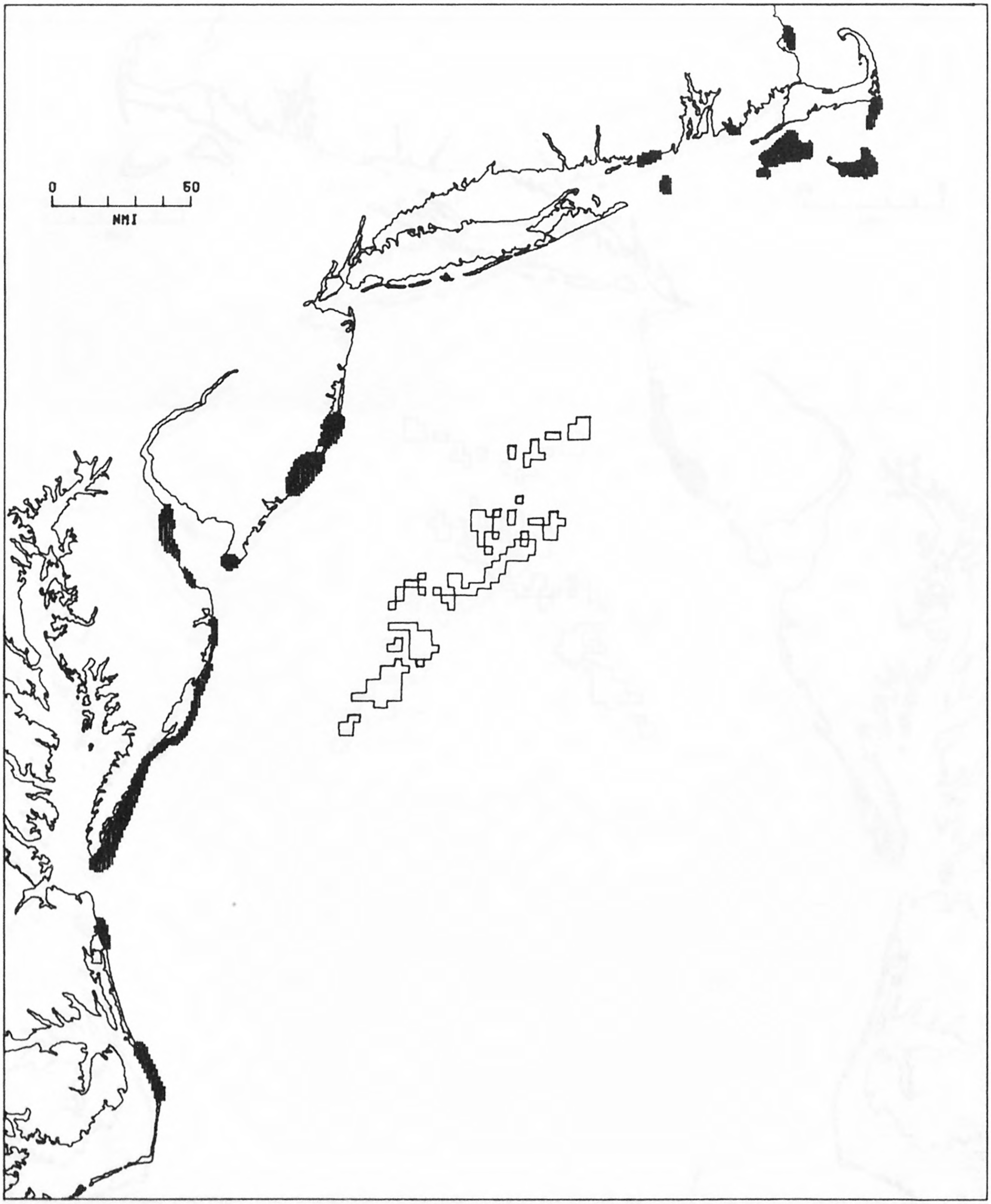

Figure A-6.--Hatched area indicates areal extent of peregrine falcon migratory stopover areas.

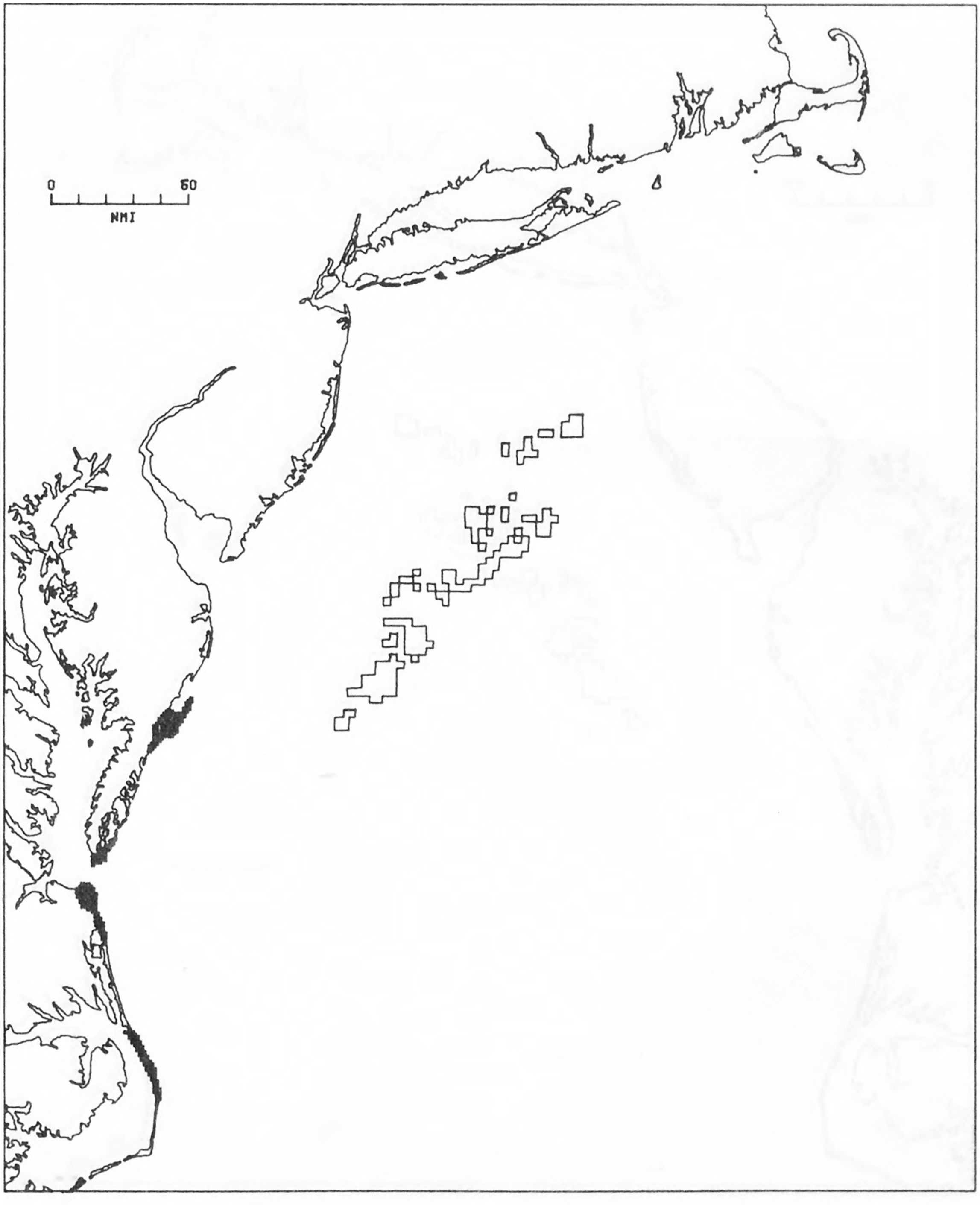

Figure A-7.--Hatched area indicates areal extent of sea turtle nesting areas.

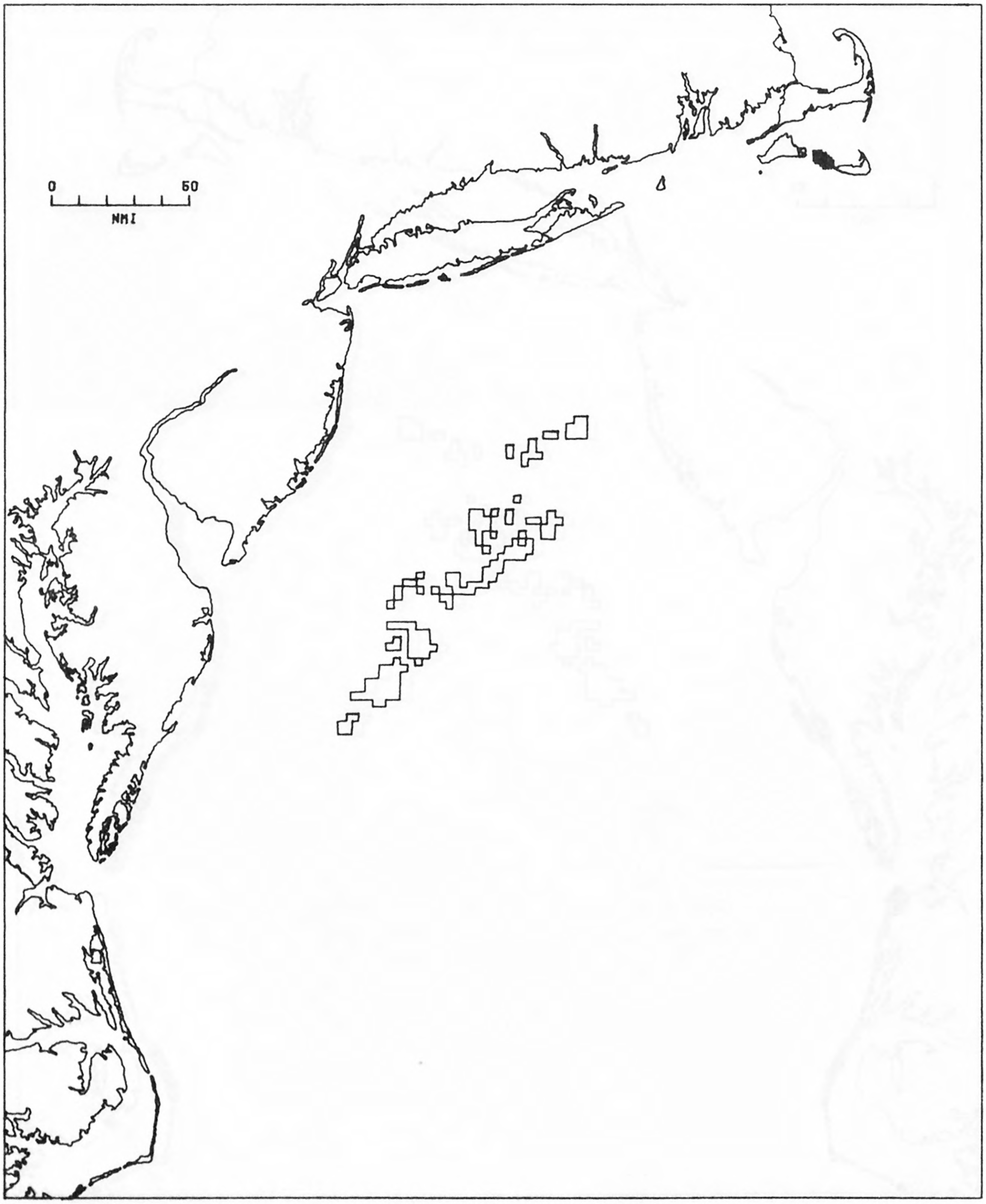

Figure A-8.--Hatched area indicates areal extent of grey seal area.

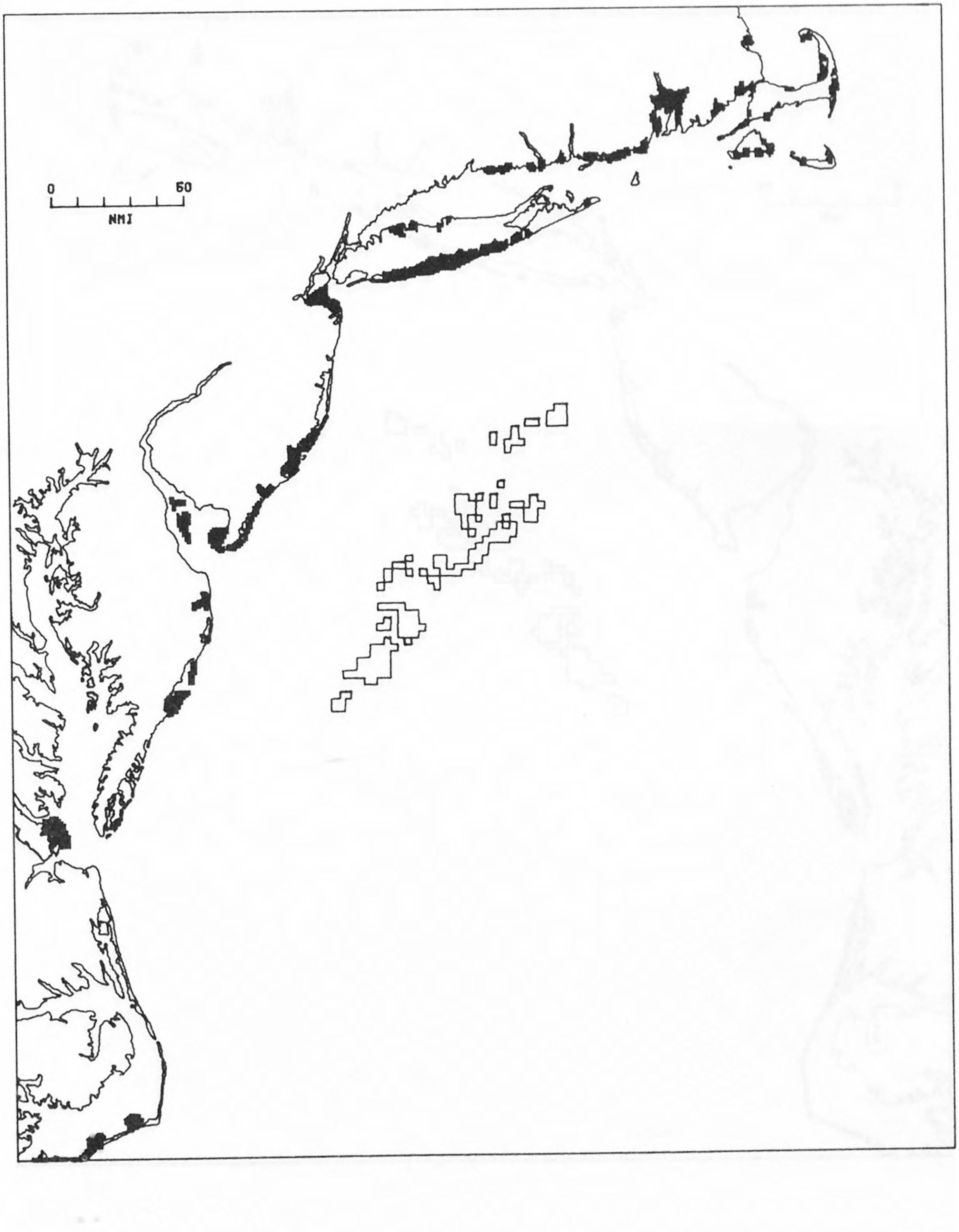

Figure A-9.--Hatched area indicates areal extent of hard clam grounds.

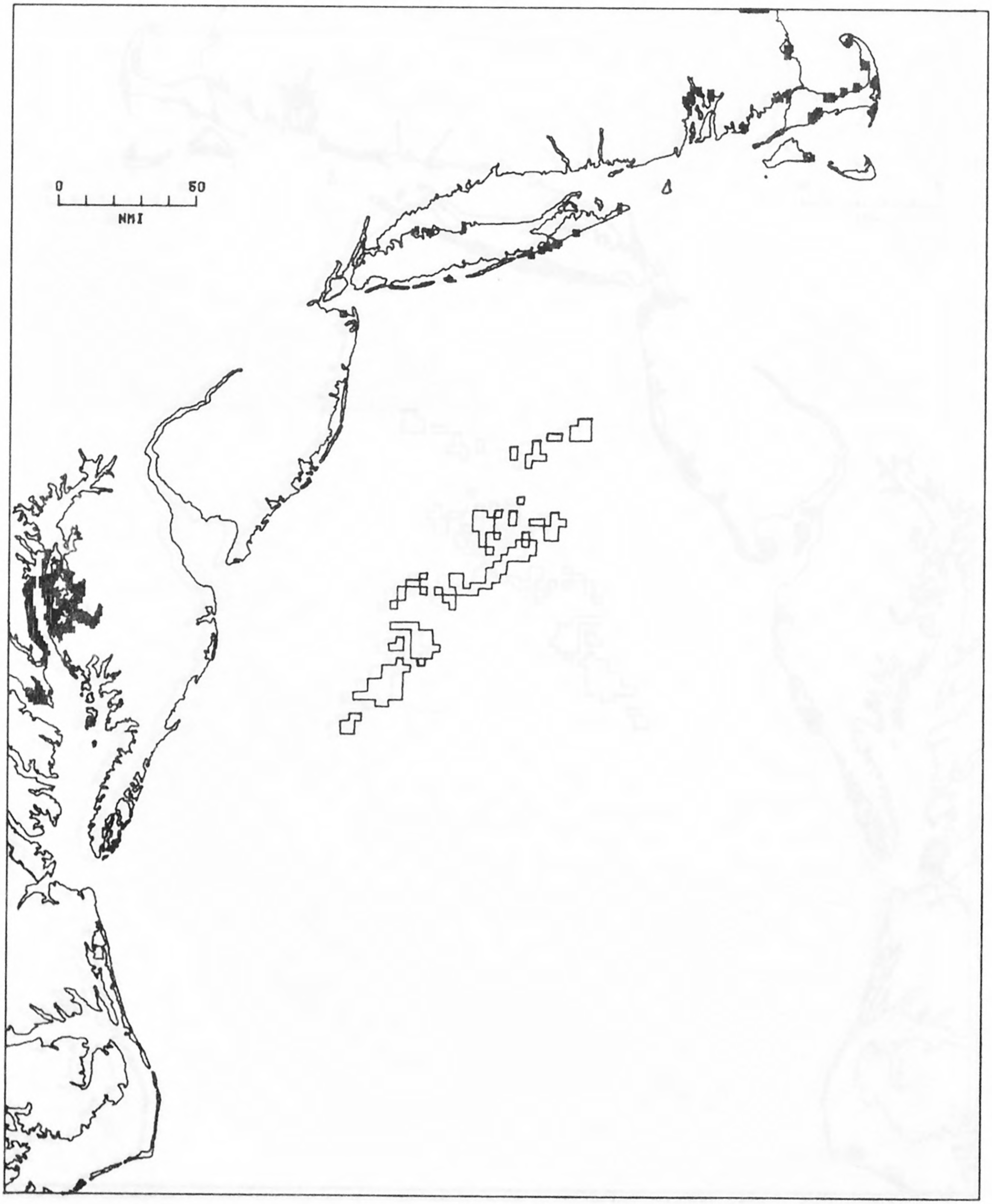

Figure A-10--Hatched area indicates areal extent of soft clam grounds.

Figure A-11.--Hatched area indicates areal extent of bay scallop areas.

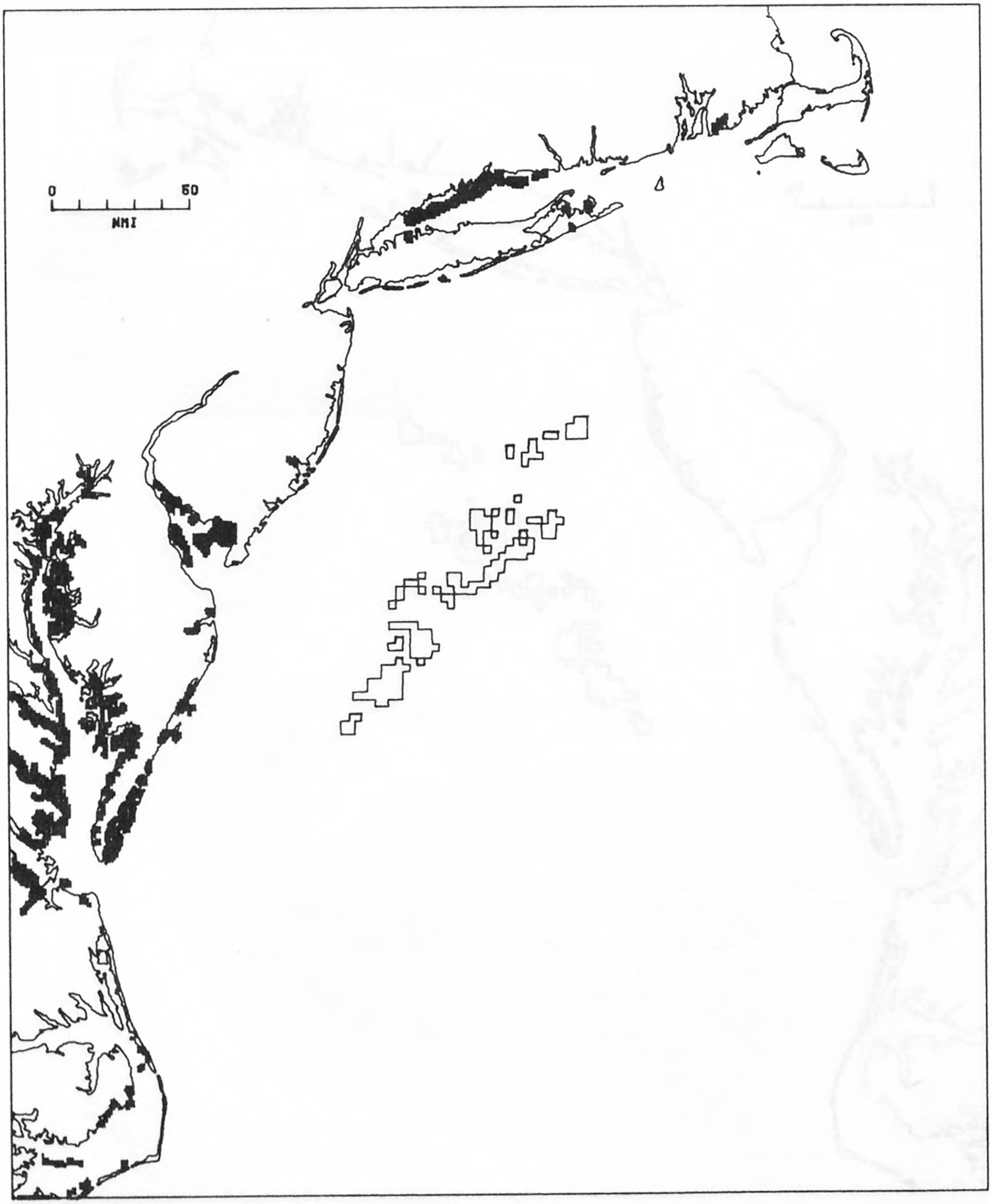

Figure A-12.--Hatched area indicates areal extent of oyster grounds.

Figure A-13.--Hatched area indicates areal extent of blue crab grounds.

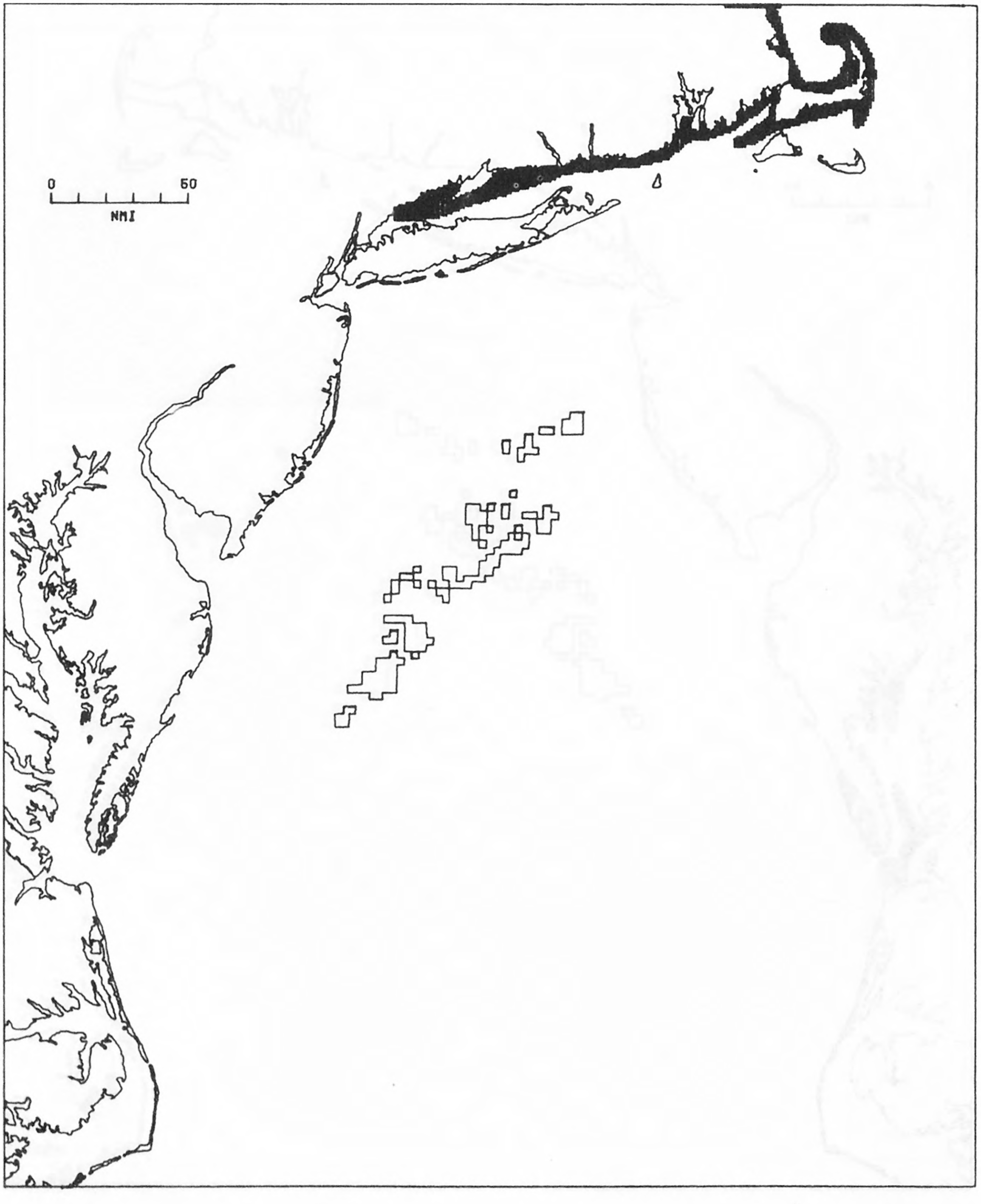

Figure A-14.--Hatched area indicates areal extent of lobster grounds.

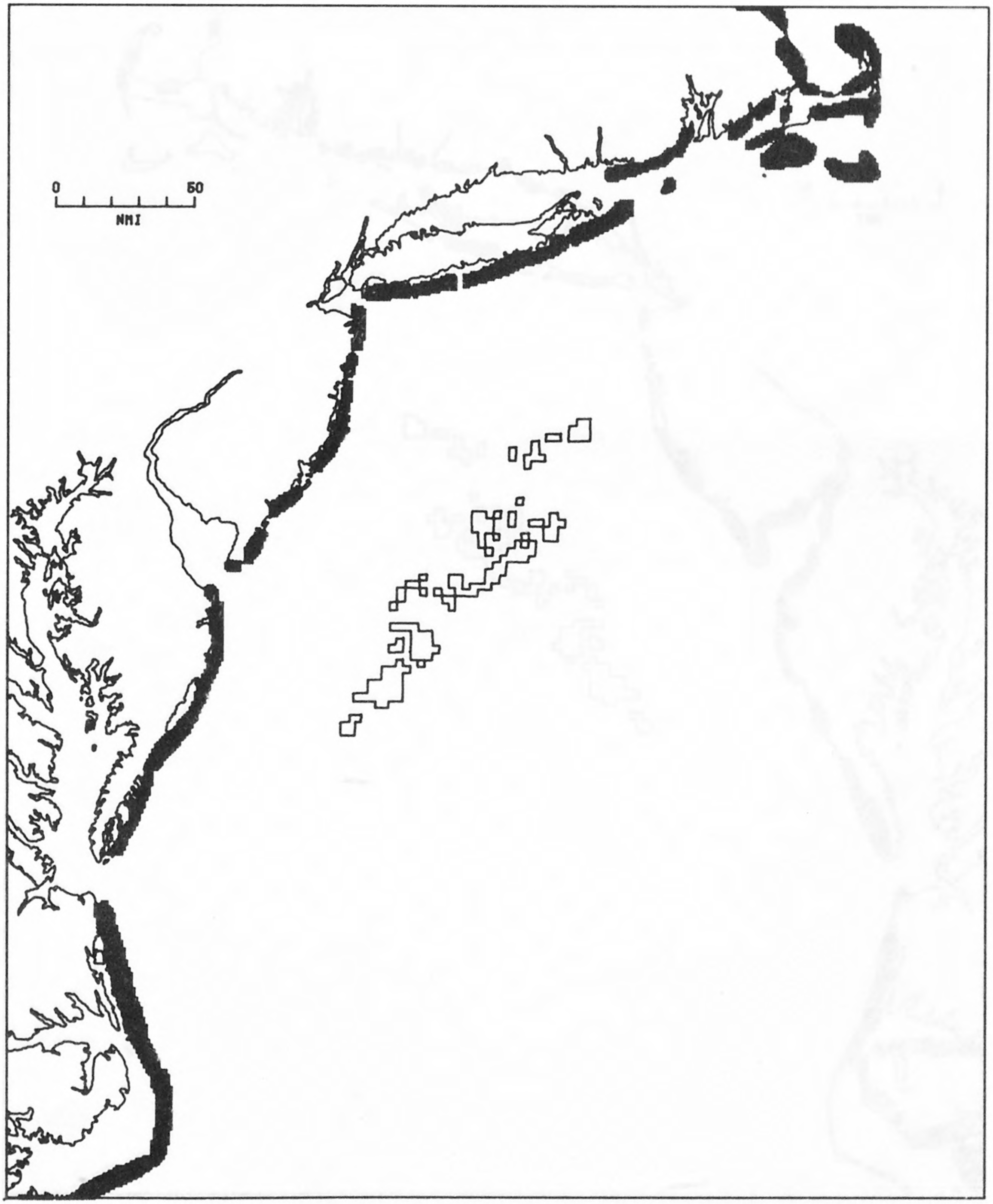

Figure A-15.--Hatched area indicates areal extent of sandy beaches.

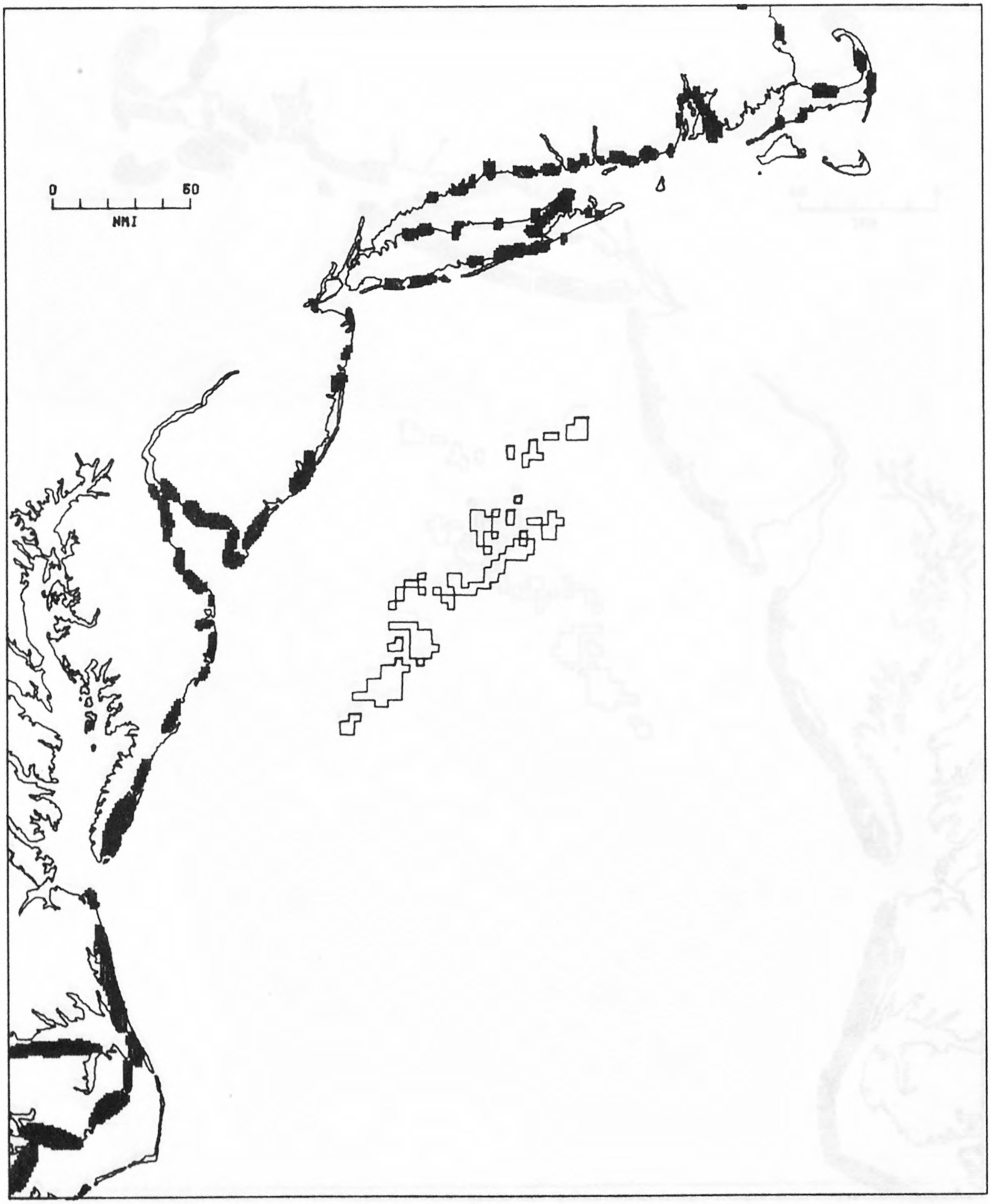

Figure A-16.--Hatched area indicates areal extent of coastal marshes.

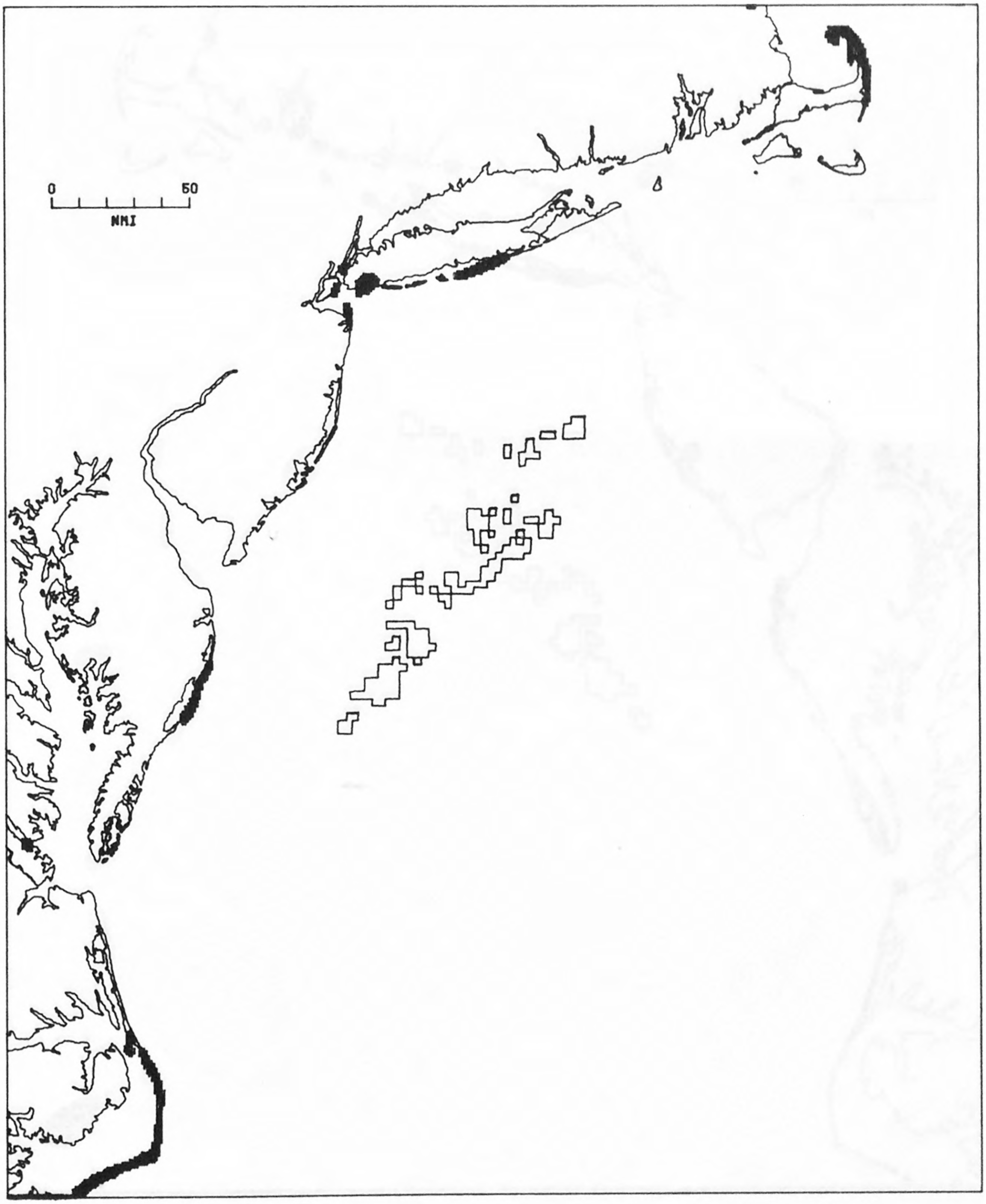

Figure A-17.--Hatched area indicates areal extent of national parks, seashores, and recreation areas.

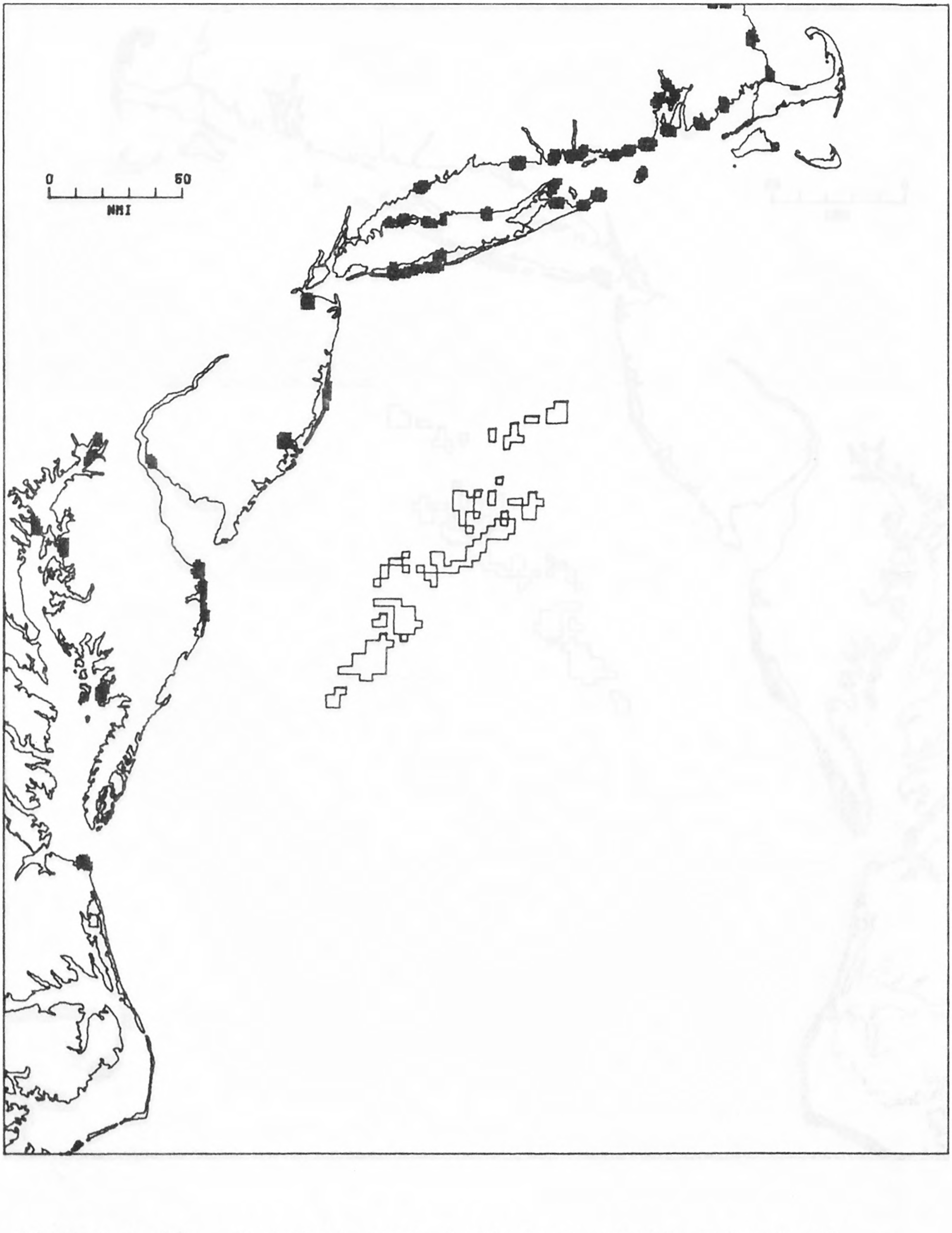

Figure A-18.--Hatched area indicates areal extent of local and state parks and seashores.

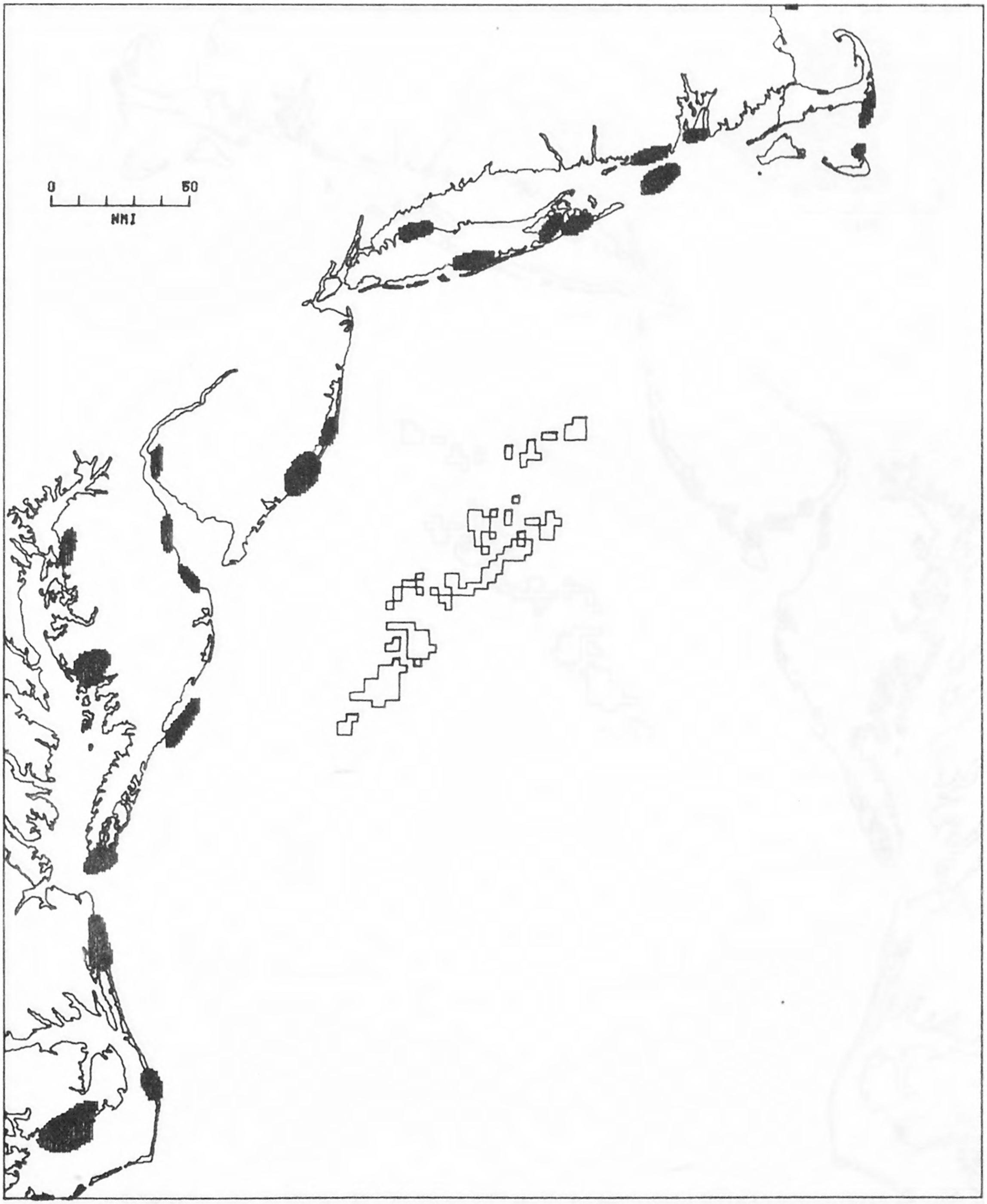

Figure A-19.--Hatched area indicates areal extent of national wildlife refuges.

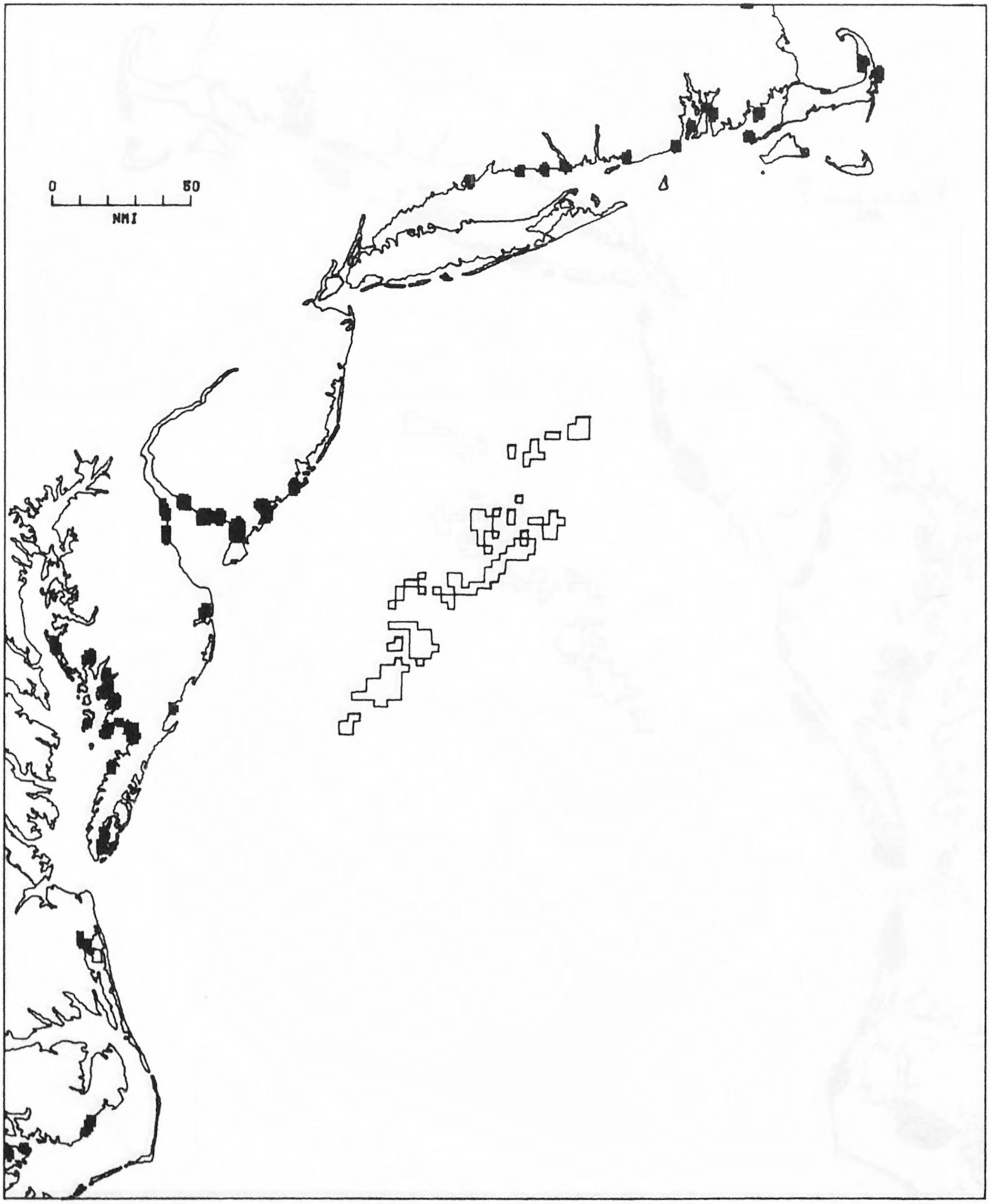

Figure A-20.--Hatched area indicates areal extent of state wildlife and natural areas.

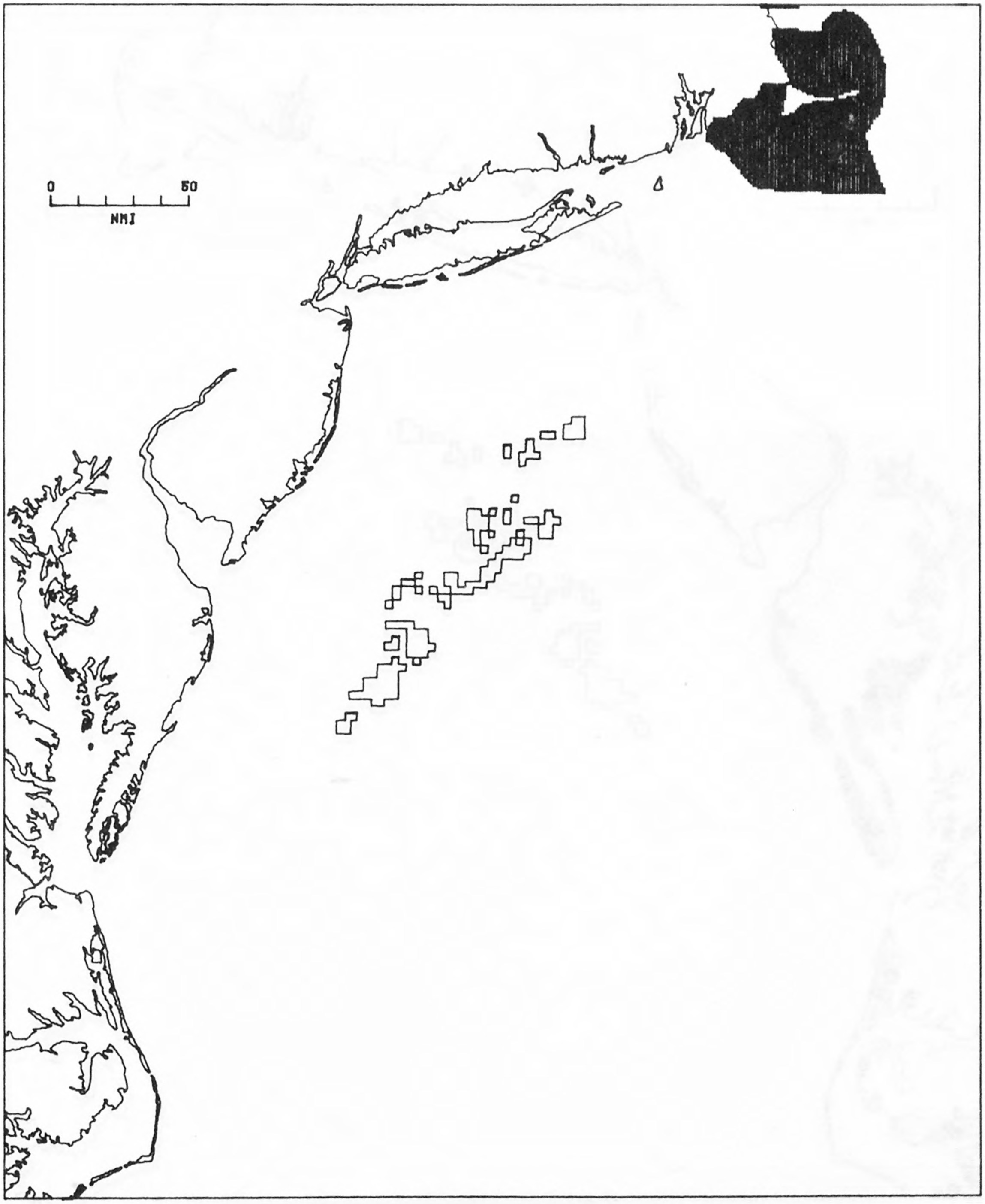

Figure A-21.--Hatched area indicates areal extent of state marine sanctuaries.

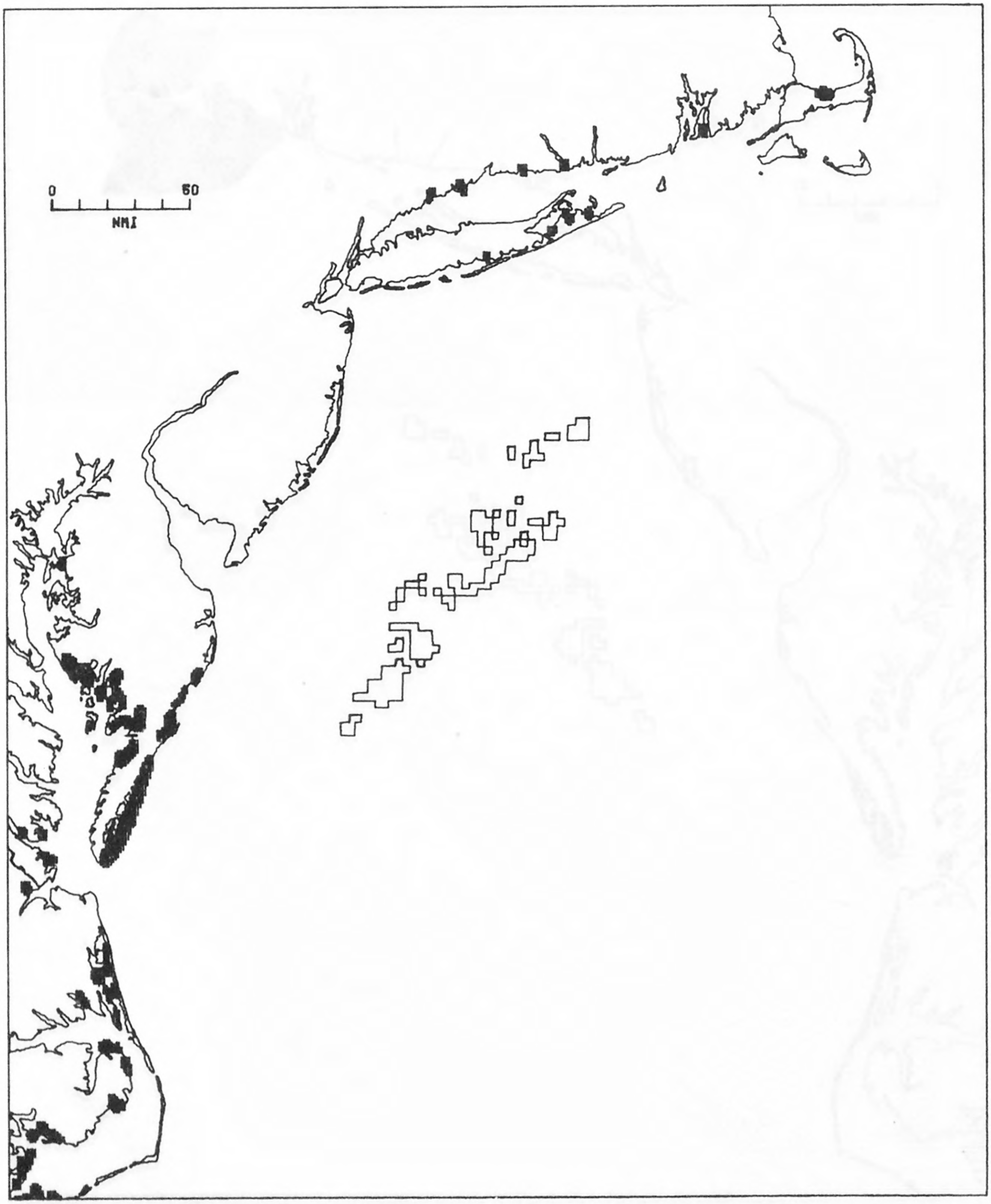

Figure A-22.--Hatched area indicates areal extent of non-government wildlife and natural areas.

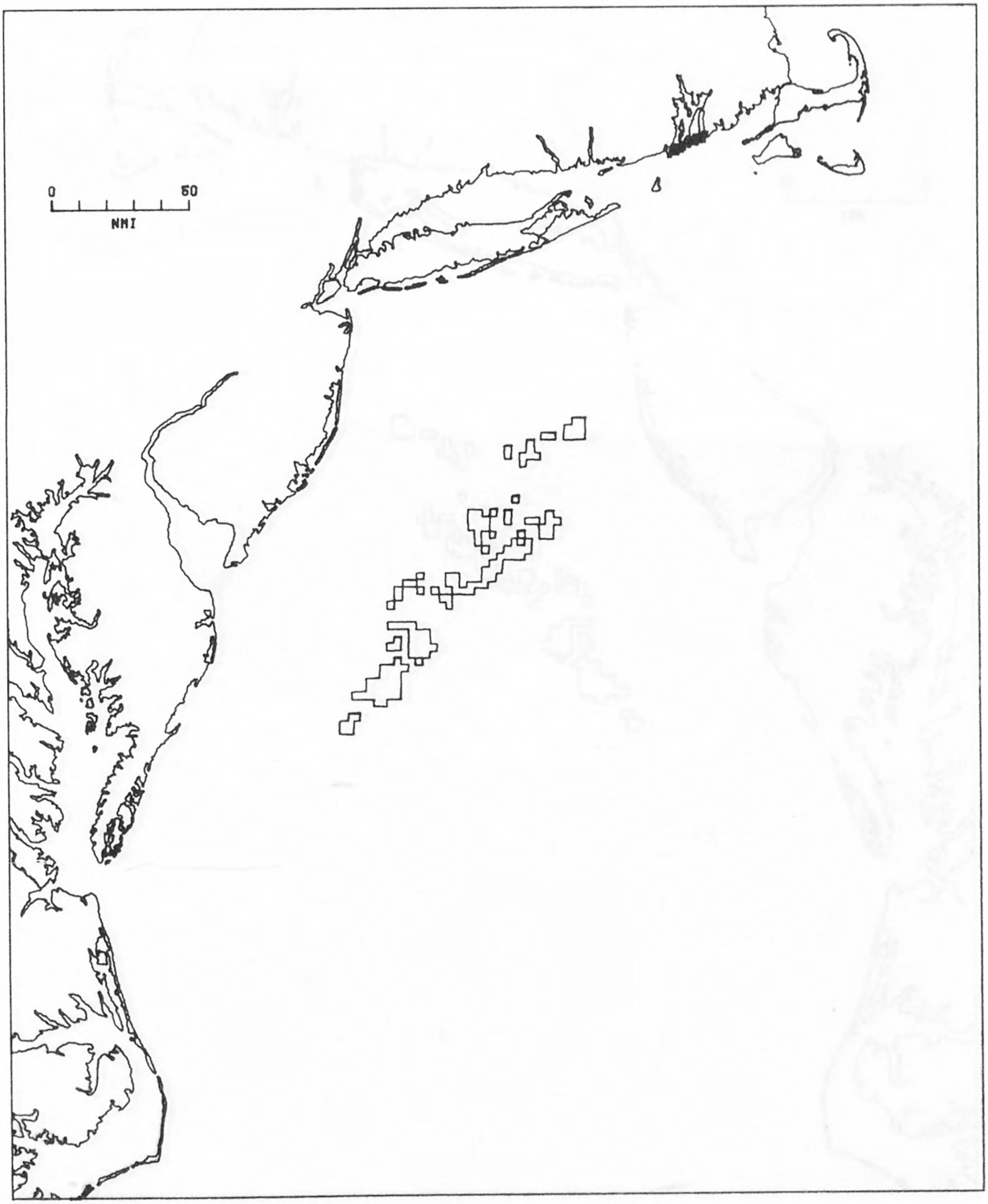

Figure A-23.--Hatched area indicates areal extent of Narragansett Bay (as seen by the model).

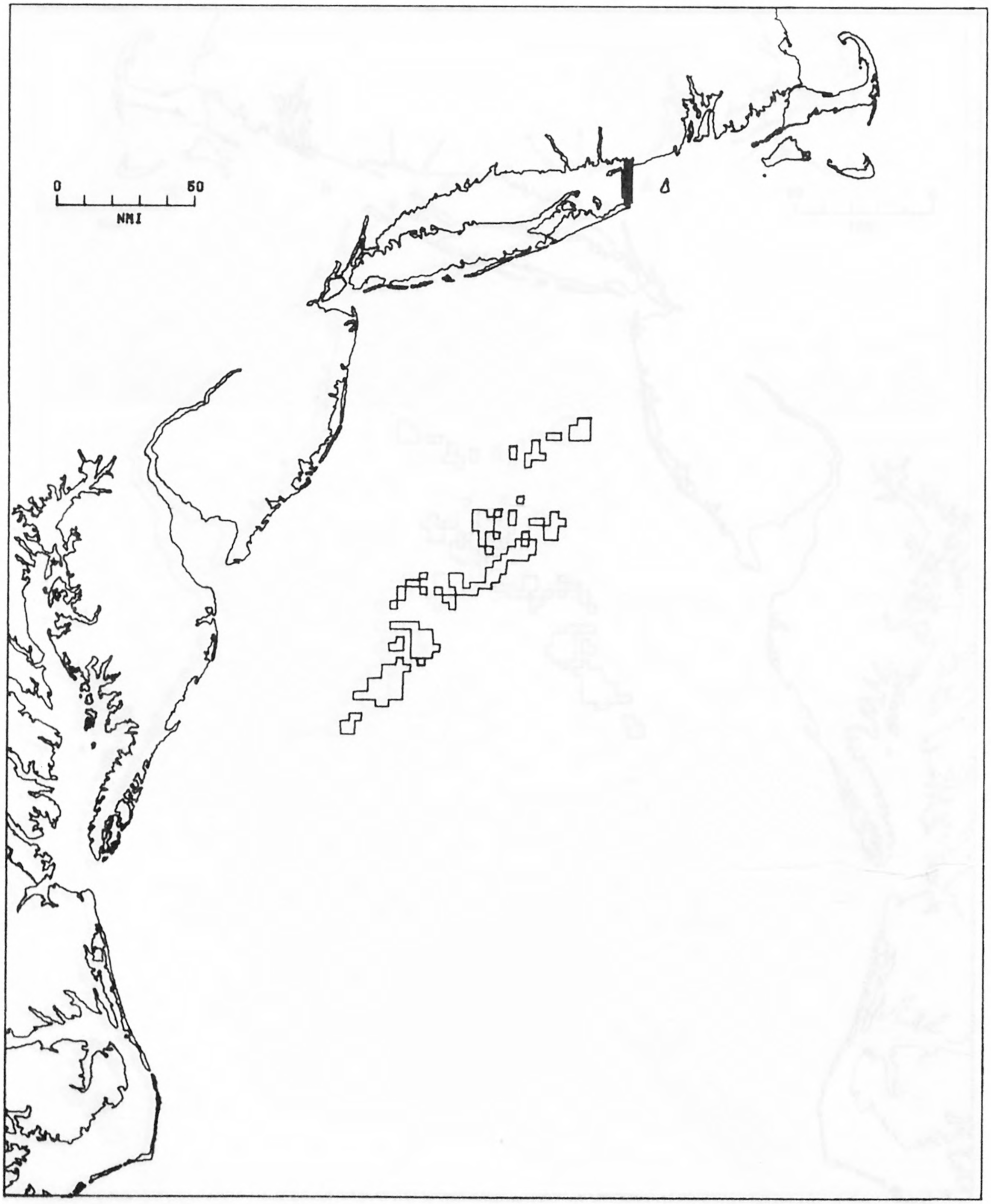

Figure A-24.--Hatched area indicates areal extent of Long Island Sound (as seen by the model).

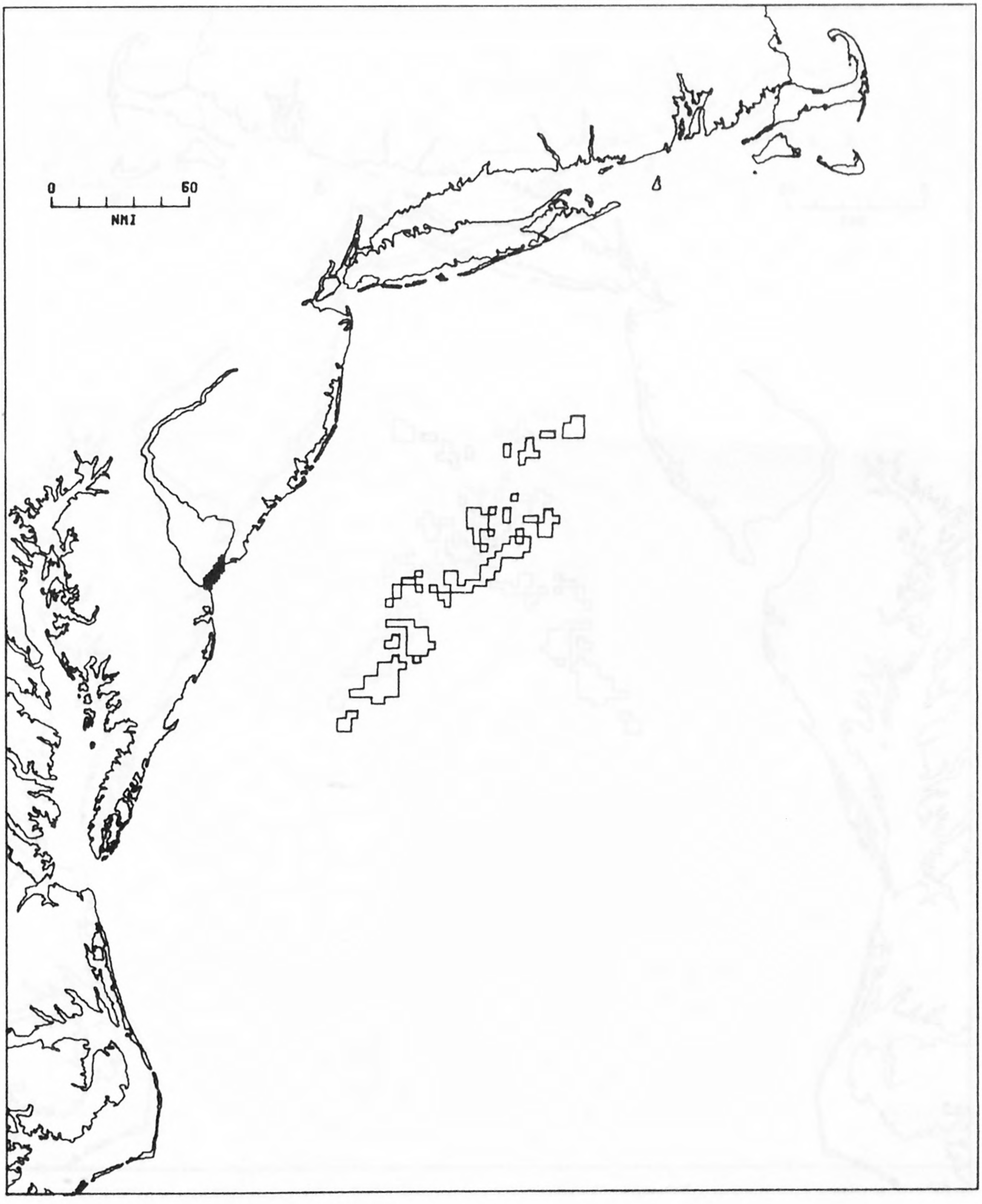

Figure A-25.--Hatched area indicates areal extent of Delaware Bay (as seen by the model).

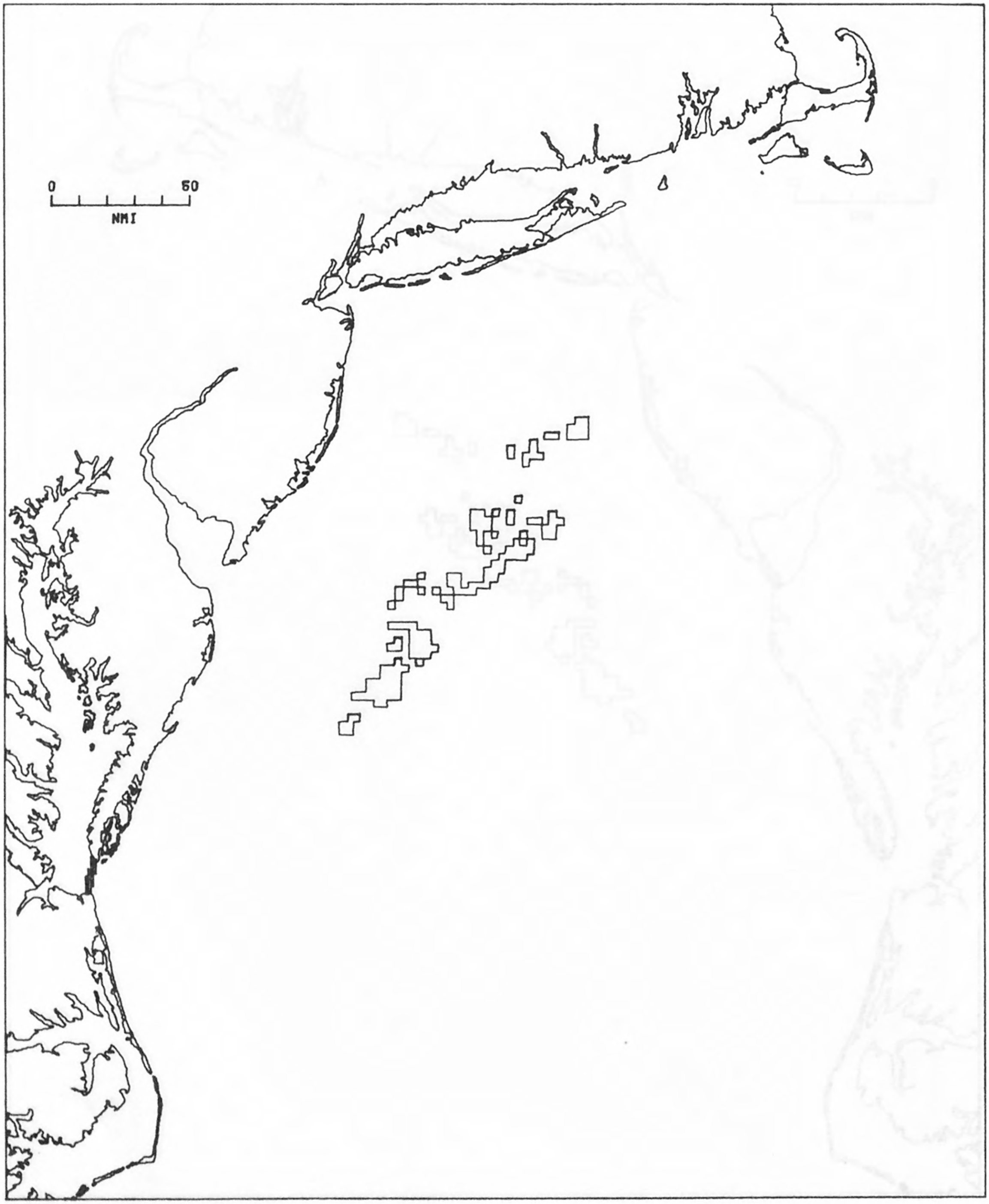

Figure A-26.--Hatched area indicates areal extent of Chesapeake Bay (as seen by the model).

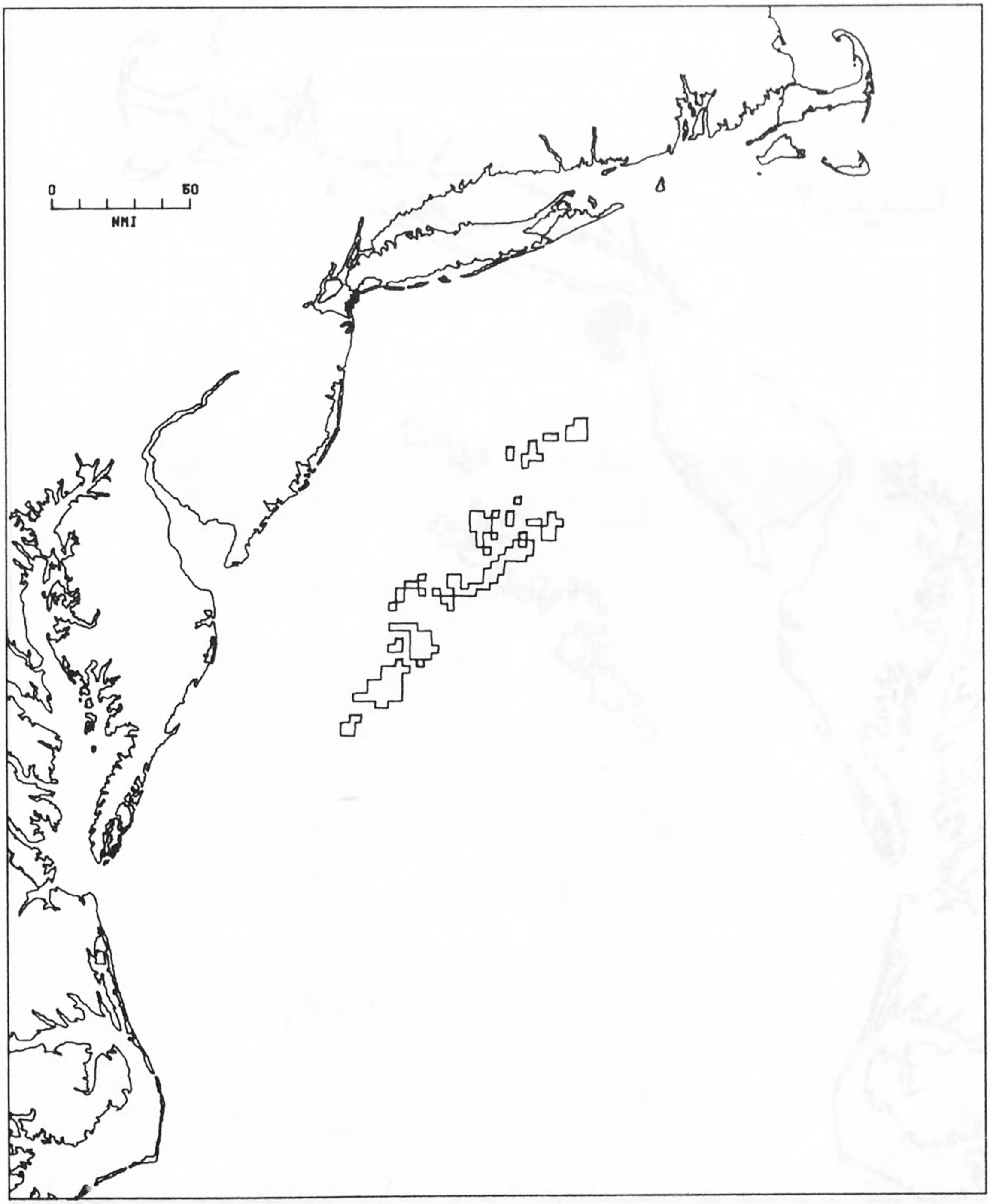

Figure A-27.--Hatched area indicates areal extent of Raritan Bay (as seen by the model).

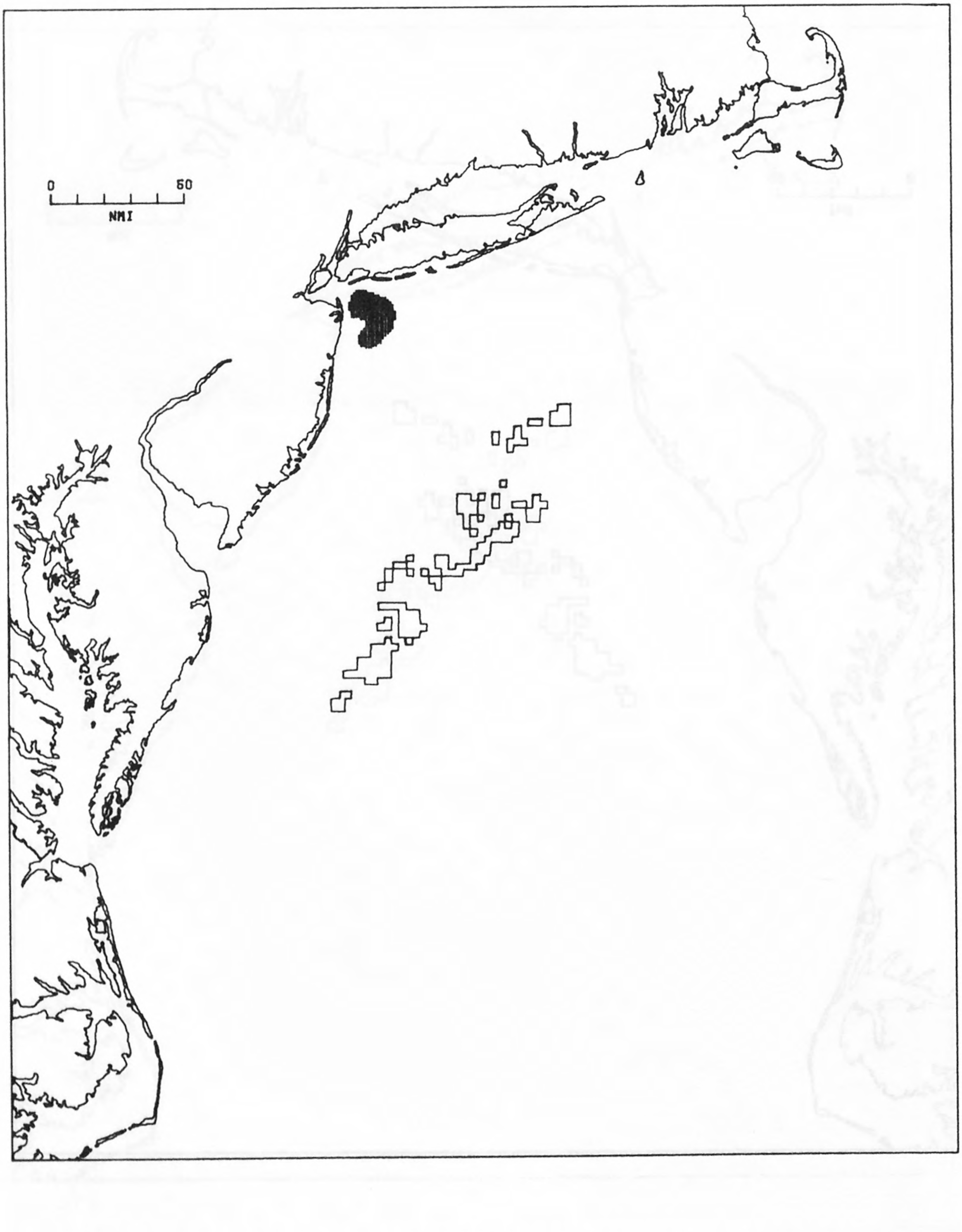

Figure A-28.--Hatched area indicates areal extent of sewage dumping site.