APPENDIX G

THE ENVIRONMENTAL IMPACT OF CONSTRUCTION AND OPERATION OF THE COOLING WATER SYSTEM FOR NEP 1 & 2, PROPOSED FOR CHARLESTOWN, RHODE ISLAND ON SELECTED REPRESENTATIVE IMPORTANT SPECIES

SECTION 316, "TYPE II" DEMONSTRATION

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APPENDIX G

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1.0 INTRODUCTION AND APPLICANTS' IMPACT ASSESSMENT RATIONALE

1.1 Background

The Federal Water Pollution Control Act, as amended by the Clean Water Act of 1977, requires that steam electric generating stations, such as the proposed NEP 1&2 plant, have the best available control technology for minimizing the discharge of pollutants. This has been interpreted by the Environmental Protection Agency as requiring the use of a closed cycle cooling system for condenser cooling water. Under Section 316(a) of the Clean Water Act, however, an exemption from closed cycle cooling can be granted if it can be demonstrated that the effluent limitations are "... more stringent than necessary to assure the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife in and on the body of water into which the discharge is to be made ...". Section 316(b) of the Clean Water Act, while not dealing with an effluent, requires "... that the location, design, construction, and capability of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact".

1.2 Objectives

It is the objective of this Appendix to summarize information found elsewhere in the Environmental Report (ER) (NEP 1&2, 1976 as amended) and present additional analyses to address the requirements of both Sections 316(a) and 316(b). The format of the

Appendix follows, as closely as practical, the Type II demonstration as proposed in the draft technical guidance manual dated May 1977 by the Environmental Protection Agency (EPA). Representative Important Species are those designated by EPA for the proposed NEP 1&2 plant.

This Appendix provides a concise and clearly documentable demonstration that the station and its proposed circulating water system meet or exceed the requirements of both 316(a) and 316(b). Presented herein are descriptions of the existing environment, the proposed circulating water system, analyses of the effects of the proposed system on the representative important species, analyses of alternative intake design concepts and a summary and conclusion of Applicants' findings.

In keeping with the spirit of the "Second Memorandum of Understanding and Policy Statement Regarding Implementation of Certain NRC and EPA Responsibilities" (40CFR60115), this demonstration will be made a part of the Environmental Report, which is used to fulfill the requirement of the National Environmental Policy Act of 1969.

1.3 Impact Assessment Rationale

The impact assessment rationale to be used in meeting the objectives described in Section 1.2 is one appropriate for a new power plant facility such as NEP 1&2 and are described below.

1.3.1 Data Requirements

Species which reflect representative biotic communities were evaluated and the appropriate rationale provided for their choice (see Section 4.1.1).

Pertinent scientific literature and site specific environmental baseline studies were reviewed to:

a. Describe selected species with respect to their population size, distribution both spatially and temporally, fecundities, survivorship, life history characteristics, and interaction with the proposed operation of the plant. Where possible, all life history stages for the selected species (e.g., eggs and larval stages) and their respective requirements for survival (e.g., food) were considered.

b. Compile thermal tolerance data on the various life history stages of any given selected species.

c. Ensure special emphasis be given to identify the effects on community function and structure within the influence of the proposed intake and/or discharge. Where appropriate, evaluations of such parameters as entrainment velocity, siltation, scouring, thermal and mechanical stress were considered.

Engineering data relative to the design of the proposed NEP 1&2 plant are provided in Section 3.0. The intake geometry of the circulating intake system is described and illustrated in detail, along with information on intake velocities and rates of flow. Seasonal operation of the intake is described, in addition to cleani g and backflushing procedures which would be instituted.

The station design and operation is characterized as it affects the intake and discharge of the circulating water system. Such operating parameters as temperature, time, flows as functions of seasonal load, frequency of occurrence and transient or nonsteady-state operation are addressed.

The discharge geometry is described in detail and illustrated. Its measurements, discharge velocities, and hydraulic characteristics are provided.

The oceanography of the water surrounding the proposed NEP 1&2 plant is presented.

Information includes freshwater input, tidal fluctuations, flushing rates, current descriptions, stratification characteristics and ambient temperature data.

The thermal plume is described with respect to temperature, velocity, area distribution, and depth. The pertinent results of model studies conducted to simulate effluent discharge under various hydrological conditions and seasonal variations are also presented.

A description of the area affected by the intake and the discharge-induced field currents, thermal plume characteristics based on relative field observations, and analytical predictions are provided.

1.3.2 Impact Predictions

Two approaches for impact prediction are used in the demonstration:

a. quantitative projections of power plant impact by model simulation, and

b. projection of power plant impact by data extrapolation derived from existing power plant environmental programs.

For those species which are judged to have a potential for power plant related mortality and for which existing population models are applicable, a quantitative projection of this impact is made.

The particular model used for the prediction depends upon the information available to define the population and the information to quantify the perturbation. Models reviewed by Horst (1975) are representative of those that are used for quantitative predictions.

Many of the more complex population dynamic models require a great deal of information for the affected population. Because of the nature of such input parameters, it is difficult to make estimates from field studies, and many times information does not exist in the literature. When sufficient information is not available for more sophisticated analyses, potential affects upon species populations will be quantitatively evaluated using more simplistic approaches. With respect to meroplankton entrainment, for example, these approaches include volumetric entrainment calculations or approaches similar to the technique suggested by Horst (1975) which translates the number of adults that would have resulted if no entrainment mortality were to occur and assuming no compensatory mechanisms in the population.

Where possible, information on the environmental effects of thermal discharges and intake structures at existing power plants will be utilized in the prediction of potential biological impacts.

1.3.3 Impact Assessment

To meet the objectives stated in Section 1.2, a detailed assessment/analysis of the biological, hydrographic, and engineering data was made. Basically, the approach to be taken first involves defining the geographic regions of the aquatic environment potentially affected by the intake and thermal effluent of NEP 1&2 and using the engineering and hydrological parameters listed in Section 1.3.1 above. Secondly, having once identified these possible zones of influence, the likelihood of any given species encountering or residing within these zones of influence was then determined.

Projections of potential power plant impact (utilizing the techniques identified in Section 1.3.2 above), were evaluated in part by comparing estimated numbers of affected biota to some reference base such as catch statistics for commercial or sport species, natural losses of biota due to predation, or year to year natural variations in population size. Species were then judged minimally affected by the power plant if they represent only a minor portion of the indigenous population.

While such comparisons are useful in impact assessment by placing potential power plant biological impacts in perspective with other natural or man-related sources of biological attraction, they were further integrated with: (1) information compiled on species' life history, geographic distribution and abundance, thermal sensitivity, growth, behavior, fecundity, and recruitment; and (2) environmental baseline data (which includes physio-chemical and biological data) collected from ecological studies at the NEP 1&2 site, in order to properly evaluate the sensitivity of the species population to any effect of power plant operation. This approach ensures that the proper consideration be given to potential ramifications at the various biological community levels.

By properly utilizing the approach outlined above, potential power plant impaccs and assessment of significance can be directed at the individual species, the species population, and the overall biological community, thus ensuring that adequate protection be provided to all biological regimes of the ecosystem.

2.0 EXISTING ENVIRONMENT

The following subsections describe the existing physical/hydrographic (Section 2.1) and biological (Section 2.2) environments. The material incorporates data acquired from published literature, the Applicant's baseline survey (1974-75), and subsequent studies conducted through 1978. The baseline data are described in detail in the NEP 1&2 Environmental Report Sections 2.2, 2.4, and 6.1 (NEP 1&2, 1976), whereas the subsequent studies are individually referenced.

2.1 Physical/Hydrographic Description

2.1.1 Block Island Sound and Ninigret Pond - General Description

The area between Block Island, located 9 miles offshore, and the Rhode Island coast defines Block Island Sound (BIS). The 400 square mile Sound (Figure G.2.1-1) is open to adjacent water bodies on three sides - Rhode Island Sound to the east, the Atlantic Ocean to the south, and Long Island Sound to the west - and has a mean depth of 120 feet, the maximum depth being about 300 feet off Fishers Island (Williams, 1969). The region of the proposed intakes and diffuser (Figure G.2.1-2), however, is between 30 and 40 feet and has a relatively smooth sea-floor punctuated only by occasional small shoals (Raytheon, 1975). The sea-floor character (Figure G.2.1-3) is generally comprised of a sandy bottom with areas of gravel and boulders (URI, 1978). The sub-bottom (upper 3 feet), likewise, is predominately sandy with the sand content ranging from 50 to 97 percent; gravel content, on the other hand, ranges from 0 to 21 percent, and silt content from 1 to 29 percent (Nacci, 1979).

No rivers of significant size reach the southern Rhode Island coast, but Narraganset Bay to the east is fed by four rivers and the Thames and Connecticut Rivers are located to the west. In addition, several coastal ponds occur in the area, Ninigret Pond being one of the largest. The long, shallow Pond has a surface area of approximately 1560 or tidal variations (Raytheon, 1975).

Ninigret Pond, unlike the open Sound, exhibits a slightly different thermocline structure. Salinity, for example, is generally lower and more varied throughout the Pond, a result of localized area runoff. Low salinity values (about 25 ppt) occur during the spring with the high (about 29 ppt) occurring during the late summer or early fall. Values, however, may vary throughout the Pond, depending on the location to potential runoff sources (Fort Neck) or BIS water - i.e., in the vicinity of the Charlestown Breachway.

The annual temperature cycle for Ninigret Pond has a trend similar to the offshore temperature cycle; however, the maximum and minimum variation is greater in Ninigret Pond. In particular, the average maximum summer temperature is about 4-6^{o}F greater than the average maximum offshore temperature. Conversely, winter average minimum temperatures, are about 2^{o}F degrees less than offshore temperatures. Unlike offshore conditions, the thermal stratification in the pond is not as well defined, a result of the shallowness of the Pond and wind-mixing. Short term variations, however, are more pronounced, especially in the region of the breachway. Because of the intrusion of BIS water into Ninigret Pond on flood tide, large tidal and diurnal variations usually occur. Variations, for instance, of nearly 11^{o}F within one-hour have been recorded (Jacobson and Snooks, 1978).

2.1.3 Current, Tide, Wave Climatology

Currents in the Sound are predominantely driven by the semidiurnal three foot tide, which enters from the east in the form of a progressive wave (Riley et al., 1952). Current directions have a dominant oscillatory component in the east-west direction, but display strong variability associated with storm events. Average current speeds in the vicinity of the proposed intakes and diffuser range from 0.4 to 0.8 feet per second (fps) for near-surface currents and 0.3 to 0.5 fps for near-bottom currents, and generally increase with distance from shore and decrease with depth (Raytheon, 1975).

Nontidal drift rates in BIS determined from drifter data range from 1.0 - 7.6 nmi/day (0.07-0.53 fps) for surface waters to 0.2 - 0.5 nmi/day (0.01-0.04 fps) for bottom waters (Williams, 1969; Cook, 1966; Paskauskey and Murphy, 1976; Collins, 1976). Recent and more long-term studies (Snooks and Jacobson, 1979) have shown the annual average surface and bottom nontidal speed to be 2.3 nmi/day (0.16 fps) and 0.35 nmi/day (0.02 fps) respectively. All the studies indicate surface water flow exhibits a complex seasonally variable pattern, but bottom water nontidal flow is generally westward throughout the year.

Snooks and Jacobson (1979) showed that nontidal drift speeds determined from current meter data, which are a good representation of the flushing velocity (Csanady, 1979), are generally always present. The nontidal speeds, for example, are greater than 0.05 fps, 0.10 fps, and 0.15 fps about 90, 80, and 60 percent of the time, respectively. These values concur with a dye study conducted in 1974 which showed the flushing ability of the discharge vicinity to be good, with little potential for background heat buildup (Brocard and Hsu, 1978).

Winds generally account for the episodic wave activity in BIS. Accordingly, the wave climate varies seasonally, with more severe conditions generally occurring during fall and winter (Raytheon, 1975); however, because of the shape of BIS and the nearly unlimited fetch to the south and east, severe storms with easterly and southerly wind produce the highest waves (Williams, 1969). Significant wave heights, however, are generally less than 1.5 feet 68 percent of the time, and less than 3 and 5 feet 92 and 98 percent of the time, respectively.

Unlike the Sound, currents within Ninigret Pond are not normally driven by the tide, which has a small range of about 0.4 feet (Raytheon, 1975), but instead by the wind. Consequently, Pond currents can best be described as episodic, with many irregularities produced by the Pond's shallowness.

Flushing of the Pond, on the other hand, is periodic. Studies conducted at the Charlestown Breachway (Raytheon, 1975) indicate that between 12 and 18 percent of the volume of Ninigret Pond is discharged through the Breachway on each ebb tide, with maximum instantaneous flows typically between 2000 and 3000 cfs, which correspond to maximum current speeds of 3 to 4 fps. Coincidently, the average flow rate over an ebb discharge from the Pond is similar to the design NEP 1&2 cooling water flow rate, or 1907 cfs. Lastly, a dye study performed at the Charlestown Breachway indicated that only 10 percent of the water discharged from Ninigret Pond returned on flood tide. Hence, approximately 11 percent of the pond volume is exchanged during each tidal cycle (Raytheon, 1975).

2.2 Summary Discussion of Regional Biota

The following subsections describe the results of the collection of baseline ecological data prior to construction. The methods, frequency, and locations utilized for the collection of the biological field samples are outlined in Tables G.2.2-1 and G.2.2-2. Samples were collected at stations depicted in Figure G.2.2-1.

Block Island Sound and the waters in the vicinity of NEP 1 and 2 are north-temperate, coastal, salt-water environments. Both marine and estuarine species are found in the region. There are no aquatic species unique to the area that are known to be rare or endangered. The species' composition of plankton changes in accordance with a seasonal succession typical of north-temperate, coastal waters. Benthic biota are, for the most part, resident in the area throughout the year, though their numbers and distribution may be influenced by spawning or other factors. Most of the pelagic fishes are seasonal in their occurrence.

2.2.1 Net Plankton

2.2.1.1 Phytoplankton

Approximately 114 species of phytoplankton and protozoans have been identified from the Ninigret Pond-Block Island Sound study area, with diatoms and flagellates most abundant. Dinoflagellates, ciliates and the group identified as "others" were relatively scarce. In Ninigret Pond, *Chaetoceros sp.*, *Thalassiosira sp.*, *Skeletonema costatum*, and *Heterocapsa triquetra* were most abundant during much of the year. In Block Island Sound, the dominant species composition was similar to that of Ninigret Pond with the exception that *Corethron criophilum* replaced *H. triquetra*.

Total phytoplankton densities in Ninigret Pond and Block Island Sound varied seasonally. The standing crop of phytoplankton was considerably higher in Ninigret Pond than that measured at the Block Island Sound stations. With the exception of early summer, primary productivity (rate of carbon uptake) measured in Ninigret Pond and Block Island Sound was similar and in general agreement with previously reported values. During the early summer months, rate of carbon uptake was somewhat greater at the Block Island Sound stations.

2.2.1.2 Zooplankton

Zooplankton and phytoplankton were collected and analyzed simultaneously. By subjecting the data to several types of analysis including a factorial analysis of variance, the following conclusions were reached;

a. The standing crop of zooplankton was generally larger at the Ninigret Pond stations than at the Block Island Sound stations. Maximum concentrations of zooplankton were attained during the summer months in the Pond and, to a lesser degree, in the Sound.

b. The zooplankton populations in Block Island Sound were dominated by crustaceans; copepods were the most abundant taxa (particularly *Acartia tonsa*, *A. clausi*, *Pseudocalanus minutis* and *Oithona spp.*). While copepods were usually the dominant form in Ninigret Pond as well, they were occasionally less abundant than polychaete, bivalve and gastropod larvae.

c. At any given station in either Block Island Sound or Ninigret Pond, the zooplankton was uniformly distributed both diurnally and throughout the water columns.

d. Within Block Island Sound there was no appreciable inter-station species abundance variation.

e. Within Ninigret Pond most of the results indicate a uniform distribution of the various species. Near the breachway (Station NP-C), however, total population densities were significantly lower.

f. Block Island Sound and Ninigret Pond frequently had different dominant species. An interaction between the Sound and the Pond was demonstrated by the species composition at Station NP-C; zooplankton characteristic of both water bodies was found here.

2.2.1.3 Ichthyoplankton

Ichthyoplankton were sampled more frequently than any other taxa during the course of this study. The species identified as eggs, larvae or juvenile in Ninigret Pond and Block Island Sound are presented in Table G.2.2-3.

The most abundant species of fish eggs collected in Ninigret Pond are presented by month in Table G.2.2-4* and the most abundant species of fish larvae are presented in Table G.2.2-5. The species of fish depicted in these two tables represent over 98% of the year's total catch.

The Labrid-Limanda group (tautog, cunner, and yellowtail flounder) probably do not have significant breeding populations in Ninigret Pond. This conclusion was reached for several reasons:

a. Due to the scarcity of suitable (rocky) habitat, comparatively few adult tautog (*Tautoga onitis*) and cunner (*Tautogolabrus adspersus*) were captured.

b. The yellowtail flounder (*Limanda ferruginea*) is an offshore species and was not collected in Ninigret Pond.

c. The eggs of the Labrid-Limanda group were concentrated at Station NP-C (Figure G.2.2-1), and, therefore, abundance was apparently affected by tidal exchange through the breachway.

With the exception of the Atlantic mackerel (*Scomber scombrus*) which probably does not breed in Ninigret Pond, the other species of fish presented in Tables G.2.2-4 and G.2.2-5 appear to spawn in the extremities of the Pond; their eggs were least abundant at Station NP-C which is adjacent to the breachway (Figure G.2.2-1). It is possible,

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*During a recent quality control check of environmental data, it was discovered that all Ninigret Pond ichthyoplankton data (Block Island Sound data were not affected) were in error by a factor of 1.56 due to utilization of an incorrect flow meter conversion factor. Therefore all Niniget Pond ichthyoplankton data presented in this document should be multiplied by 1.56 to obtain the correct densities. This error does not affect impact assessments presented in Section 4.2 since only Block Island Sound data were used.

however, that the reduced numbers observed at Station NP-C were the result of dilution from the tidal exchange through the breachway.

Winter flounder (Pseudopleuronectes americanus) led each year's catch of fish larvae in Ninigret Pond. The dominant summer species were the silversides (Menidia spp.) and the anchovy (Anchoa spp.). These three taxa accounted for more than 95% of the year's total catch of ichthyoplankton in Ninigret Pond.

The most abundant ichthyoplankton species collected in Block Island Sound are presented by month in Tables G.2.2-6 and G.2.2-7. The average percent contribution of the major species is presented in Table G.2.2-8. The most abundant species of ichthyoplankton present in Block Island Sound was the Atlantic mackerel (Scomber scombrus), which, during 1974 and 1975, accounted for an average of 41% of the eggs and 27% of the larvae. This species was more abundant at the offshore stations than at the inshore stations.

The Labrid-Limanda group was the second most abundant group in the egg collections. This group, together with the mackerel, accounted for an average of 92% of the eggs and 64% of the larvae. Other large contributions to the larvae in Block Island Sound were the anchovy, winter flounder, and sand lance (Ammodytes spp.) which accounted for additional averages of 14%, 4%, and 4%, respectively. These three species were not important in the egg collections.

A preliminary survey of lobster larval density was conducted in 1976 and an intensive sampling program was conducted to assess the density of squid juveniles and lobster larvae during 1977 (Table 2.2.2-1). In general, lobster were more abundant at the surface and during the daytime samples; they were more abundant offshore during during 1977 and inshore during 1976. Squid juveniles were more abundant inshore, near the bottom and at night.

Larval stages of sand shrimp were present year round in Block Island Sound with major abundance levels occurring from April through November. Overall abundance was higher in near bottom waters than in surface waters with evidence of diel vertical migration. During the day larval densities were higher in near bottom waters, whereas, at night larval densities appeared to increase near the surface.

2.2.2 Benthos

2.2.2.1 Rooted Aquatic Vegetation

Eelgrass (Zostera marina) was the only spermatophyte collected. Maximum and minimum eelgrass densities occurred during mid-summer and late winter, respectively. Zostera was relatively scarce near sampling Stations NP-A and NP-D. This reduced density may be partially attributed to the reduced tidal flow in these areas. Zostera was not observed in Block Island Sound.

2.2.2.2 Invertebrates

The benthos of Ninigret Pond consisted mostly of relatively small organisms; many of these live in close association with the extensive eelgrass (Zostera marina) beds. Conspicuous in this group were polychaete worms, crustaceans of the order Amphipoda, and relatively small gastropods and pelecypods. These populations, of importance in the food chain of the Pond system, tended to be more varied along the relatively shallow and sandy margins of the Pond than in the deeper areas characterized by soft bottom.

Included in the benthos of Ninigret Pond were small numbers of American oyster (Crassostrea virginica), bay scallop (Argopecten irradians), hard clam (Mercenaria mercenaria), and soft clam (Mya arenaria). The larval forms of these species are planktonic and their occasional presence in the plankton of Block Island Sound indicates that they may be flushed into the Sound by tidal exchange, not only from Ninigret Pond, but also from Narragansett Bay and the other salt ponds along the Rhode Island coastline. Since these species do not become successfully established in the Sound, at least in terms of providing a commercial or even a recreational fishery, it is presumed that the larvae swept into the Sound are lost and contribute little or nothing to the fishery.

The benthos of Block Island Sound appeared to be considerably more diverse than in the Pond. During a twelve-month period beginning in March 1975, a total of 269 species were identified in Block Island Sound as compared with 106 species identified in Ninigret Pond; those identified consisted of 149 species of polychaetes in the Sound, as compared with 49 in the Pond; 87 species of crustaceans in the Sound as compared with 44 in the Pond; and 33 species of gastropods in the Sound, as compared with 13 in the Pond. Most of the Pond samples were collected from soft-mud bottom. Although large and valuable invertebrate species such as the lobster (Homarus americanus), mahagony quahog (Artica islandica), and surf clam (Spisula solidissima) were fished commercially in the Sound off Charlestown Beach, these were not collected in any particular abundance during this survey. As was true for the benthic populations of Ninigret Pond, the numerically dominant forms in the Sound were polychaete worms, amphipods, and small mollusks, the last of which included juvenile blue mussels (Mytilus edulis). Statistical analysis of the data collected indicates that there was little or no along-shore variation in the benthic community. In an onshore to offshore direction, there was a highly significant community difference: density and diversity were lower in the 10-30′ water depth regions than in the 40-60′ water depth regions.

2.2.3 Nekton

During the two year period from April 1974 through March 1976, a total of 75 species of finfish and 2 species of motile invertebrates (lobster and squid) were collected in Ninigret Pond and the area of Block Island Sound depicted in Figure G.2.2-1; 56 species have been identified in Ninigret Pond; 51 species in Block Island Sound; and 29 species were common to both areas (Table G.2.3-1).

Those finfish species within the study area, which were found primarily in Ninigret Pond, are eurythermal and euryhaline. They prefer shallow water and, in many cases, are non-migratory. The dominant resident species were the silverside (Menidia spp.), killifish (Fundulus spp.), sheepshead minnow (Cyprinodon variegatus), sticklebacks (Apeltes quadracus and Gasterosteus aculeatus) and the northern pipefish (Syngnathus fuscus).

During the winter, spring, and fall spawning seasons, winter flounder (Pseudopleuronectes americanus) were abundant in the Pond. Highest catches were recorded at Station NP-C (Figure G.2.2-1) followed by Stations NP-A, NP-B and NP-D. The fewest winter flounder were recorded at Station NP-E. Other species of fish found seasonally in moderate numbers include the menhaden (Brevoortia tyrannus), herring (Clupea harengus), and bluefish (Pomatomus salatrix).

Neither lobster nor squid were collected in any Ninigret Pond samples.

Quantitative data on the nekton in Block Island Sound were obtained from three commercial trawlers. Two of the fishermen were requested to provide (1) information on the frequency with which they trawled the grid area depicted in Figure G.2.3-1 and (2) information on the total catch within the area. From the frequency of utilization based on 497 tows (Figure G.2.2-2), it is apparent that at least two commercial fishermen definitely prefer to fish well offshore. The greater part of the dragging took place in water deeper than 60 feet and most of the dragging was in water 90-100' deep. Little or no dragging was conducted inshore because bottom conditions were generally unfavorable. Some commercial line-trawling for cod was conducted near the Ninigret Pond breachway during the winter months. The catch of the two commercial trawlers is presented in Table G.2.3-2. By far, the largest component of the commercial catch was silver hake which accounted for 29% of the catch by weight. This species plus other members of the cod family accounted for 42% of the total catch by weight. Other major components of the commercial catch were skate, herring, and flounder.

A third commercial trawler (45′ stern trawler, chartered with a biologist on board) provided quantitative data on the species composition at two transects; one between Stations BIS-A and B and the other near Station BIS-C (Figure G.2.2-1). A total of 31 species of finfish plus squid and lobster were taken at these stations. The 12 species listed in Table G.2.3-3 account for approximately 98% of the total catch; butterfish, windowpane, scup, little skate, winter flounder and squid account for 87% of the total.

Differences in the relative importance of the species taken by the commercial trawlers, as presented in Tables G.2.3-2 and G.2.3-3, reflect differences in (1) number vs. weight as indicators, (2) location fished, and (3) trawling technique. These differences also reflect the fact that one trawler was sampling while the other two trawlers were selecting, for economic reasons, when and where they fished.

A gill net was set on the bottom near Station BIS-A from September 1974 through March 1975. Unfortunately, the net was subject to severe fouling by seaweed and the program was discontinued. During the period when it was set, the most frequently caught fish in the meager catch were scup (Stenotomus chrysops) and the northern sea robin (Prionotus carolinus).

According to Sisson (personal communication), the area between the Quonochongtaug Pond breachway and Ninigret Pond breachway receives heavy recreational fishing pressure. This area includes the barrier beach, the near-shore area off East Beach, the breachways and Ninigret Pond.

The beach area from Quonochongtaug Pond breachway to the Ninigret Pond breachway is utilized by mobile sportsmen who gain access to the area via East Beach Road. Typically, these mobile sportsmen surf cast for striped bass (Morone saxatilis) and bluefish (Pomatomus saltatrix) from spring through the fall, with the peak activity in the months of September, October and November. Some sportsmen in small boats, as well as larger charter boats, fish the area off East Beach for bluefish, summer flounder (Paralichthys dentatus) and striped bass. The area is considered poor for cod fishing and the sportfishing activity from boats is generally confined to the summer months. Additionally, there is a small recreational spear fishery for blackfish or tautog (Tautoga onitis).

The area of the Ninigret Pond breachway, including the riprap sides of the breachway and the jetties, receives very heavy fishing pressure from early May through November regardless of the availability of fish. This area has both public access and parking. Sportsmen in this area fish for striped bass, bluefish and summer flounder or fluke during the spring and summer. Additionally, winter flounder (Pseudopleuronectes americanus), are pursued during their fall movement into the pond and spring movement out of the pond.

In Ninigret Pond, the most important sport fish species is the winter flounder. During the fall and spring, a large recreational fishing activity centers around the winter flounder. There are a few marinas with small boat rental facilities that provide the sportsmen with access to the pond. Additionally, some of the sportsmen pursue striped bass in the spring and snapper bluefish during the summer in the pond.

Besides finfish, there is an active recreational shellfishery in Ninigret Pond. The hard clam or quahog (Mercenaria mercenaria) is the dominant species fished. There is some digging for soft clams or long necks (Mya arenaria), but beds are few and densities low. Ninigret Pond contains a small naturally setting population of oysters (Crassostrea acres, depths of 8 feet or less, and is generally divided into western, central, and northern basins. The northern basin, known as Fort Hill Pond, represents the drowned valley of a glacial meltwater stream, whereas the rest of the pond is a flooded portion of the outwash plain separated from the ocean by a barrier beach. Composition of the pond bottom sediment (top meter) is mostly silt topped over by a thin (1-10 cm) silty sand layer (Dillon, 1964; NEP, 1976). The Pond is connected to the east by a narrow neck to nearby and smaller Green Hill Pond, which has an approximate surface area of 420 acres. Freshwater runoff to the Pond system is appreciable (about 44×10^3 m^3/day) and enters mostly along the northern shore (Conover, 1961) Exchange between Ninigret Pond and Block Island Sound is provided by the Charlestown Breachway, a 100 foot-wide inlet artificially stabilized in its present configuration in 1952.

The waters of Block Island Sound, like the adjoining Rhode Island and Long Island Sounds, are derived, as described by Riley (1952), from a mixture of continental offshore shelf water and coastal runoff brackish water. The slow south-westerly drift of water along the continental shelf south of New England is partially diverted around either side of Block Island entering BIS mostly as low temperature, high salinity bottom water. The brackish nearshore water tends to spread over the surface, forming a fresher layer. As the shelf water moves shoreward, it is continuously freshened by mixing with the runoff. The inflow of saline water near the bottom is balanced by an outflow of the fresher surface water which passes out of BIS, to some extent south of Point Judith, but mostly between Block Island and Montauk Point.

2.1.2 Temperature, Salinity, Density Distribution

The distribution of BIS temperature, salinity and density (Figure G.2.1-4) results from a complicated interaction of currents and mixing processes generated by tides, winds, bathymetry, and meteorological effects. Measured values of salinity, for example, range from 29.00 to 33.00 ppt with surface salinity values less than bottom salinity values

(Williams, 1969; Raytheon, 1975; Snooks et al., 1977). The seasonal range of average salinity, however, is only about 1 ppt, with a minimum in late spring (about 31.0) and a maximum in autumn about (32.2 ppt). A vertical gradient of salinity between surface and bottom of about 0.5 to 1 ppt is usually present, but may be as large as 2 ppt. Horizontal salinity gradients of 1 ppt over an area extending 2 to 3 nautical miles are also common. Tidal variation of salinity, however, is usually less than 0.5 ppt.

Block Island Sound temperatures, on the other hand, undergo a more distinct annual cycle with average maximum surface values occurring in August (68-70°F) and minimum values occurring in February (34-38°F). In addition, a seasonal thermocline develops. Surface to bottom thermal gradients develop in April, reach maximum values (8-12°F) in August, rapidly dissipate to near isothermal conditions by late September and generally increase with distance offshore (Raytheon, 1975; Snooks et al., 1977). The water column generally has a slight positive thermal gradient (about 1°F warmer on the bottom) between October to December, a result of the lag between surface and bottom cooling, but is nearly isothermal thereafter until the spring. Temperatures in shallow (30 ft) nearshore regions cool and warm more quickly than temperatures at deeper (60-90 ft) offshore regions. Tidally induced variations in temperatures generally are of the order of 1 to 3°F (Raytheon, 1975) but may be as high as 13°F at the entrance to Ninigret Pond (Jacobson and Snooks, 1978).

The density structure of the Sound generally is a reflection of the temperature regime. Consequently, maximum values occur during the winter (about 26 sigma-t) and minimum values during the summer (22-24 sigma-t). The difference in density between the surface and the bottom water, however, is at a minimum in winter (about 0.5 sigma-t) and at a maximum in summer (about 1.0-1.5 sigma-t). This vertical difference between surface and bottom is fairly constant and hence no pronounced pycnocline develops. In addition, densities generally increase with distance from shore, but show no consistent lateral *virginica*). Recreational harvesting oysters is permitted from September 15 through May 15. Bay scallop (*Argopecten irradians*) populations within the pond are erratic, but when the population is up, a sizeable recreational fishery exists. Additionally, there is a summer blue crab (*Callinectes sapidus*) fishery.

3.0 PROPOSED COOLING WATER SYSTEM

The heat dissipation system for NEP 1 & 2 is a once-through offshore intake and diffuser system. This heat dissipation concept has been selected for NEP 1 & 2 on the basis of environmental, engineering, and economic considerations. The circulating water system for the two units are combined in a single intake tunnel and discharge tunnel for both units. Figures G.3.0-1 and G.3.0-2 show the route and profile of the circulating water system. All normal heat dissipation functions for the plant are performed by this system; it provides heat removal from the main condensers and service water heat exchangers.

Cooling water is taken from and returned to the waters of Block Island Sound at offshore intake and discharge structures located south of East Beach near Charlestown, Rhode Island. The physical, chemical and hydrological description of this body of water including its natural temperature pattern is presented in Section G.2.1 and ER Section 2.4.

The main objective in the selection of this heat rejection system was minimizing the potential environmental impact. Special consideration was given to the protection of terrestrial and aquatic life that now inhabit the area. Also, it was specified that the selected system of heat dissipation would not provide hazards or impediments to highway, ship or air traffic in the region. The original proposed circulating water system has been revised from a piped system to a tunnel system described herein. Tunnels will be employed unless borings and other geotechnical investigations prove that the concept is not feasible.

The quantity of heat dissipated by each unit for condenser cooling is approximately 8×10^9 Btu/hour during full load normal operation. Within limits set by turbine performance, the generator cycle can be modified by either limiting the amount of cooling water flow and having a high condenser temperature rise or having a greater flow with a lower temperature rise. To minimize pumped entrainment impacts on biota, NEP 1&2 is designed with a high condenser temperature rise and as low as practicable a cooling water flow, nominally 406,000 gpm per unit for condenser cooling. An additional flow of approximately 22,000 gpm per unit for the service water cooling is used to remove heat from the condensers and service water heat exchangers. Consequently, the total flow is 428,000 gpm per unit and 856,000 gpm for both units. The resulting temperature rise for NEP 1&2 is 37°F. Thus, NEP 1&2 will have one of the lowest water usage per kilowatt of any large power plant in the United States with once-through cooling. There is no in-plant consumptive use of cooling water.

3.1 Proposed Intake System.

The intake system includes three identical offshore submerged intakes, one 18 foot inside diameter tunnel, an intake transition structure and a pumphouse located on the site. The nearshore intake structure is located 2,000 feet south of East Beach where the water depth is approximately 30 feet. The spacing between intakes is 110 feet. At this location, the depth to bedrock is 95 feet resulting in an overburden depth of 65 feet.

The velocity of inflow at the point where water enters the inlets is no greater than 1.5 fps. This inlet velocity was selected after considering several factors which were judged to have an influence on the potential for finfish entrapment at NEP 1 & 2. These factors were: the ambient currents in the vicinity of the proposed intake; research results from studies on the effect of various inlet velocities on fish entrapment for offshore cooling water structures; and the swimming capability of finfish found in the general region of the proposed intake location. This inlet velocity is rapidly attenuated with distance from the inlet opening. This low approach velocity allows normal movement of fish in the area and reduces the possibility of fish entrapment and bottom scouring. Experience with offshore intake structures along the coast of

California indicates that a horizontal inflow current has much less potential for fish entrapment than a vertical current. A horizontal inflow direction about an offshore intake structure is maintained by means of a velocity cap. The velocity cap allows water to enter the intake opening from only a horizontal direction and has been demonstrated to reduce fish entrapment by a much as 95 percent at the offshore intakes of some power plants. Figure G.3.1-1 shows the design of the offshore velocity cap intake structure.

From the inlets, the cooling water flows through the 18 foot I.D. intake tunnel about 6,200 feet into the pumphouse located at the plant site. The time of travel through the intake tunnel at the design flow rate of 856,000 gpm is about 14 minutes at an average velocity of about 7.5 fps. The intake tunnel is constructed with an 0.5 percent slope toward the land to allow gravity flow of water seepage toward the plant during construction. The intake tunnel has a centerline elevation of 170 feet below mean sea level (MSL) at the ocean end and 200 feet below MSL at the plant. Figure G.3.0-2 presents a profile of the intake tunnel.

At the plant site, the flow passes from the intake tunnel into the intake transition structure which is a rectangular reinforced concrete box. The flow then passes through four butterfly valves (two for each unit) and enters two buried flumes which flow into the circulating water pumphouse forebay. The pumphouse and forebay are divided by a concrete wall which also divides the two inflow flumes; each serves one unit.

The pumphouse located on the site contains six circulating water pumps, three for each unit. Each pump is rated for 140,000 gpm flow at a 75 foot pumping head. Also contained in the onshore pumphouse structure are six vertical traveling screens (one for each pump), which divide the large forebay from the individual pump bays, and appropriate hydraulic equipment such as valves, stoplogs, and screen wash pumps.

From the pumphouse, the circulating water flows to the condensers through two buried pipes (one per unit). The circulating water passes through the condensers and then flows to the discharge transition structure via buried pipes. Water is returned to ocean via an 18 foot inside diameter tunnel. The temperature of the circulating water flow is raised about 37°F as it passes through the condensers and heat exchangers.

3.2 Proposed Discharge System

3.2.1 Discharge Description.

The discharge side of the NEP 1&2 cooling system consists of buried on-site pipes leading from the condensers and heat exchangers to the discharge transition structure, one 18 foot I.D. discharge tunnel and a submerged multiport diffuser. After flowing through the condensers and the service water heat exchangers, the cooling water flows to the discharge transition structure and then approximately 6,500 feet through the 18 foot I.D. discharge tunnel to the submerged offshore diffuser. Travel time from the discharge transition structure to the diffuser for design rated flow is about 14.5 minutes at approximately 7.5 fps. The discharge tunnel is constructed with an 0.5 percent slope toward the land to allow gravity flow of water seepage toward the plant during construction. The discharge tunnel has a centerline elevation of 180 feet below MSL at the ocean and 210 feet below MSL at the plant. Figure G.3.0-2 shows a profile of the discharge tunnel.

The heat dissipation system discharges into the water of Block Island Sound from diffuser nozzles located approximately 2,400 to 3,600 feet offshore south of East Beach. The discharge tunnel is connected to the diffuser by vertical riser shafts. Hydrothermal model studies (ER Appendices C1&C1A) have been undertaken to determine the design and location of the submerged multiport discharge diffuser. Many variations of nozzle spacing, number and alignment of nozzles, orientation of diffuser manifold and discharge velocity are possible for any given offshore discharge location. The purpose of the model studies was to develop a suitable diffuser design which would produce the desired thermal discharge performance.

A staged diffuser 1200 feet long was selected as the optimum diffuser type for NEP 1&2 based upon an evaluation of historical model results and the offshore hydrography at the NEP 1&2 site (Figure G.3.2-1). A staged diffuser is a diffuser whose axis is perpendicular to shore whose nozzles are directed essentially offshore. As proposed, the diffuser will start at the top of the discharge tunnel riser shafts beginning in approximately 31 feet of water, and consist of two 14 foot I.D. parallel pipes - one extending 600 feet seaward, the other extending 1,200 feet seaward. Each diffuser will have 17 equally spaced two-foot diameter nozzles, each having an exit velocity of 18 fps. The diffuser nozzles are angled up 20^{o} from horizontal and alternate 20 degrees east and west of the diffuser axis. The nozzles for the 600 foot diffuser start at the riser shafts; the nozzles for the 1,200 foot diffuser start 600 feet seaward of the riser shafts. Thus, the total length of the diffuser for NEP 1 & 2 is 1,200 feet.

3.2.2 Discharge Operation Physical Effects.

The staged diffuser selected induces rapid mixing of the ambient water with the heated discharge water. The receiving water at the site is subject to changes in tidal elevation as well as current magnitude and direction. The water current direction is predominately parallel to the shore line and has a maximum observed speed of about 1.6 fps. Because the initial temperature reduction of the thermal discharge for a given water depth is dependent on the momentum of the discharged jet as well as the magnitude and direction of ambient current, a staged diffuser takes best advantage of the ambient current condition. Since the performance of the diffuser is dependent on the magnitude of the ambient current, the size of a given isotherm varies with the ambient current and tidal stage as shown in Tables G.3.2-1 and G.3.2-2.

Two hydrothermal models are required to predict thermal discharge behavior. The region near the discharge ports where the jet discharge momentum governs the mixing of ambient water induced by the discharge momentum with the heated effluent is called the nearfield region. The region of the thermal plume at a distance from the discharge point where the jet induced momentum is dissipated, is called the farfield region. The thermal plume drifts with the ambient currents in the farfield region whereas in the nearfield region the discharge momentum predominates. Temperature reduction of the thermal effluent in the nearfield is accomplished primarily by mixing with ambient water and is therefore extremely rapid. Heat loss in the farfield is accomplished by radiation and convection to the atmosphere and is dependent on surface wind conditions and the difference between the natural equilibrium temperature of the water surface and the artificial surface temperature caused by the heated discharge. Temperature reduction in the farfield is governed by ambient processes and occurs over a longer time period than in the nearfield.

The fundamental design criteria for the diffuser is to achieve thermal plume conditions which have an acceptable environmental impact and which are consistent with applicable regulatory requirements.

Receiving waters at the site are thermally stratified during the summer with temperature differences between surface and bottom ranging from 5 to 8°F (Raytheon, 1975). Except in the nearfield jet mixing region, the diffuser discharge has no significant effect on ambient thermal stratification.

The impact of the discharge on ambient flow patterns in the vicinity of the diffuser is evident in the nearfield diffuser mixing zone. The diffuser discharge is expected to have an insignificant influence on the flow patterns outside the mixing zone and no influence in the farfield.

Discharged water jetting from the diffuser at an initial velocity of about 18 fps entrains substantial quantities of ambient receiving water. This initial velocity is reduced quickly as the ambient water mixes with the discharge jets. Within a distance of 250 to 400 feet from the diffuser nozzles, ambient water is entrained at a ratio of 6 to 1 and the discharge temperature rise is reduced to one-sixth of its original value. It usually takes about one to two minutes for water to reach the surface and undergo a temperature reduction from 37°F to less than 6°F above ambient.

Nearfield temperature rises as well as vertical temperature rise profiles as predicted by the physical model are shown in Figures G.3.2-2 through G.3.2-5. Table G.3.2-1 gives the predicted surface maximum temperature rise as well as the volumes of water occupied by various isotherms at different stages of the tide. Figure G.3.2-6 shows the variation of surface area with tidal current throughout the tidal cycle. Additional information on the nearfield temperature rises for the proposed NEP 1 & 2 diffuser system is given in Brocard (1977).

Figures G.3.2-7 through G.3.2-10 show the thermal plume configurations at various stages of the tide cycle for isothermal conditions typical of fall and winter. During spring and summer when the ambient water is stratified, these thermal plume areas are somewhat reduced. It is obvious from these figures that the thermal plume varies substantially in time and space. Table G.3.2-2 gives time-temperature relationships as well as surface areas and volumes for various temperature rises and stages of the tide. Additional information on the thermal plume is given in Brocard and Hsu (1978).

Farfield thermal modeling as well as dye study results indicate that the background temperature rise due to the discharge of heat from NEP 1&2 will be less than 0.5°F (Brocard and Hsu, 1978). Brocard and Hsu also found that the temperature rise in Ninigret Pond due to a temperature increase in Block Island Sound was equal to approximately 0.3 times the Block Island temperature rise. These studies indicate that the thermal impact of NEP 1&2 on Ninigret Pond will be less than 0.2°F.

Bottom temperature rises have been extrapolated from both the physical model results. These results indicate that the maximum bottom temperature rise is about 6°F above ambient. The area of this 6°F temperature rise isotherm is conservatively estimated to be less than 2 acres.

3.3 Biofouling Control

To maintain the cooling system in an operational condition, it is necessary to control biofouling. The intake portions of the circulating water and service water systems from the intakes to the condensers and heat exchangers are subject to the settlement and growth of marine fouling organisms. These organisms, which travel in the water, must not be allowed to accumulate on the cooling water system surfaces. Growth of attached marine organisms progressively impedes flow, eventually reaching a point where adequate cooling water cannot be obtained by the pumping system. Mechanical damage to equipment and inefficient or lost electricity production can result if fouling organisms grow to adult stages in the system. The discharge sections of the circulating water system, downstream of the condensers, are not subject to marine biofouling because the normal discharge temperature is high enough to preclude settlement and growth of fouling organisms.

From the offshore intakes to the intake transition structure adjacent to the pumphouse, biofouling control is accomplished by backflushing, that is, periodically reversing the cooling water flow in the intake and discharge tunnels. The backflushing mode of operation is used to direct heated water into the intake tunnel and thermally shock any organisms which might have settled and grown in the tunnel. Backflushing of the system for biofouling control is accomplished by redirecting circulating water flow within the plant.

For backflushing to be effective, a temperature of about 120°F must be reached and maintained at all points in the intake system for a period of approximately 2 hours. To achieve the required discharge temperature, some of the cooling water is recirculated through the condenser. The total time for the entire backflush cycle including flow reversal and heat treatment is approximately 6 hours, but the 120°F discharge temperature will only be maintained for approximately 2 hours. Backflushing heat treatment is expected to be required about once every 2 weeks during the warmer months of April to November and less frequently during other months. As a result, backflushing will account for less than 2 percent of the plant operating time.

Figures G.3.3-1, G.3.3-2 and G.3.3-3 show the backflush thermal plumes during summer conditions as predicted by the physical model. Results for other tidal stages and ambient temperatures are presented by Brocard (1977).

Provisions are also being made to permit chlorination of the offsite intake tunnel from the offshore intake structures to the plant. Chlorination of the intake tunnel will be done in accordance with applicable EPA effluent limitations.

Control of marine fouling in the circulating water pumphouse and onsite pipes, the condensers and service water system is accomplished by a combination of chlorination, mechanical cleaning and the application of protective anti-fouling coatings.

The pumphouse is divided by a concrete partition into two sections, one for each unit. Each half contains three circulating water pumps, traveling screens, screenwells and one forebay. During a scheduled shutdown of one of the NEP units, its half of the pumphouse is isolated from the intake transition structure by closing appropriate valves. This permits dewatering of one side of the pumphouse to allow mechanical cleaning of the fouled surfaces. After the pumphouse surfaces have been scraped, they are prepared and covered with a protective coating such as a commercially available anti-fouling marine paint.

3.4 Chemical Discharges

Chemical discharges to Block Island Sound through the diffuser system will include chlorine used for biofouling control, regeneration wastes from the demineralizers, steam generator blowdown as well as chemicals from the pipe cleaning prior to startup.

Biofouling control in the pumphouse and onsite intake pipes is accomplished by intermittent chlorination and the application of an anti-fouling coating. The active chlorine is provided by the injection of sodium hypochlorite at feed points in the intake system. The chlorine discourages the settlement and growth of mussels and barnacles. Accumulation of these organisms could limit the circulating water flow by increasing the effective roughness of the pipes and if allowed to grow too large, could also plug condenser tubes after detachment from the pipe surfaces.

The chlorination treatment adheres to the EPA Effluent Guidelines. Chlorine is injected for a maximum of two hours per day on each unit. The dosage is adjusted to restrict the average level of the free residual chlorine at the discharge to 0.2 mg/l over the allowable two hour period (maximum 0.5 mg/l); the feed rate will depend on the chlorine demand of the water.

The free residual chlorine decays rapidly from the point of injection to the ocean discharge point for two reasons: (a) continuing consumption of this available chlorine with the extended contact time and (b) increased rate of consumption with the higher reaction temperature. In the discharge tunnel the presence of chlorine (even at the reduced concentration) will supplement the effect of the heated water in preventing growth of fouling organisms.

The chlorine injected at the pumphouse also prevents the accumulation of slime in the condenser tubes. Whereas the control of marine growth in the tunnels is required essentially only during the warmer months, the control of slime is required all year round. Therefore, the chlorine is injected throughout the year. If slime were allowed to grow in the condenser, the heat transfer characteristics could be reduced to unacceptable levels and plant output could be significantly reduced. If necessary for effective slime control, a booster dose of chlorine may be injected just upstream of the condensers. However, this will not result in discharge chlorine levels in excess of allowable EPA guidelines.

Biofouling is controlled in the service water system by continuous chlorination. To accomplish this sodium hypochlorite is continuously injected in the service water pumphouse. It is impossible to dewater and paint the inside surfaces of the service water piping because it is of relatively small diameter and inaccessible. Continuous chlorination, however, is known to be effective for biofouling control and consequently is proposed for the service water system.

Water for the plant makeup system is supplied from wells on the site. The well water is treated as required to produce a suitable quality for drinking and demineralizer feed. The feedwater passes through a vacuum deaerator and two parallel strings of demineralizer trains. Each demineralizer train consists of a strong acid (cation) exchanger, a strong base (anion) exchanger and a mixed bed exchanger. The treated water is then delivered to the condensate and primary water storage tanks. Each demineralizer train has a capacity of 240,000 gallons per day (20 hours in service, 4 hours regenerating). During normal operation, one demineralizer train can supply normal plant makeup requirements. The regeneration wastes consist of the ions removed from the process water plus the excesses of sodium hydroxide and sulfuric acid used in regeneration. Any excess acidity or alkalinity is neutralized to a pH range of 6.5

to 8.0 by adding caustic or acid as required. After the local pH adjustment, the batch of waste is pumped into the circulating water discharge. A regeneration waste batch of about 30,000 gallons occurs approximately every 3.5 days. The dissolved solids content is approximately 5000 ppm and consists mainly of sodium sulphate with minor amounts of the other constituents normally found in ground and surface waters, such as calcium, magnesium, sodium, bicarbonate, sulfate, chloride and silica. Upon dilution in the circulating water discharge, the dissolved solids will be reduced to less than 1 ppm.

The steam generator blowdown system is designed to operate continuously at a variable flow rate which is dependent upon the concentration of solids in the steam generators. The blowdown processing system is sized to maintain the total solids concentration in the liquid phase of the steam generators at 125 ppm or less for design conditions. The normal blowdown rate is approximately 5 gpm per steam generator. The maximum continuous design blowdown rate is approximately 100 gpm per steam generator. This blowdown stream is added to the circulating water system discharge and undergoes a dilution of about 20,000 to 1. The blowdown stream contains ammonia, chloride, copper, flouride, hydrazine, iron, lead and silica. The concentration of each of these chemicals in the blowdown is less than 1 ppm and in the circulating water discharge, less than 0.00005 ppm.

The coolant, steam and condensate piping systems will be cleaned before startup to remove debris and any oily film. This involves flushing with deionized water before and after flushing with a hot alkaline solution. When the alkaline solution is displaced, it is treated by passage through the holdup tank and pH adjustment tank before being discharged to the ocean via the circulating water system.

3.5 Cooling Water System Construction Techniques

Construction methods and procedures are not finalized at this time. An extensive geotechnical exploration program of the offshore bedrock and overburden deposits along the tunnel routes and at the locations of the offshore intake and discharge structures will be conducted in order to verify the feasibility of the concepts discussed below. The exact location and depth of the tunnels together with their associated offshore structures and the methods by which they would be constructed will be established subsequent to this program.

The construction of the tunnels through the rock will be accomplished by conventional methods (drilling and blasting) or by using a tunnel boring machine; both methods working from the plant site. Dewatering effluent from the tunneling operation will be processed for separation of any contaminants such as oils, diesel fuels, etc. The processed water will then be pumped to a settling basin as described in Applicant's application for a NPDES permit.

Offshore vertical shafts will connect the deep bedrock tunnels to the intake structures and discharge diffuser. These shafts may be constructed from a floating vessel commonly referred to as a jack-up barge. The jack-up barge will be positioned over the location of the shaft, and a steel casing then driven through the overburden deposits. Once the casing is firmly seated on bedrock, the overburden within the casing will be removed, and a large rock roller bit drill will be used to drill downward through the bedrock. A cylindrical steel shaft with a concrete lining will then be installed in the casing and anchored to the bedrock with concrete grout. The steel shaft will contain diaphragm covers and valves to ensure that the ocean water does not enter the shaft or tunnels until the appropriate time in the construction sequence. The completed steel shafts will support the three intake structures and also provide a transition between the discharge tunnel and the pipe discharge diffuser. Material excavated from within the casings, estimated not to exceed 3000 cubic yards, will be deposited on the sea bed adjacent to the excavation.

A typical intake structure is shown on Figure G.3.1-1. The intakes will be constructed of reinforced, precast concrete or metal and barged or towed offshore for installation, or constructed in the dry utilizing steel cofferdams. Little, if any, environmental impact is associated with the operation.

Figure G.3.2-1 is a schematic view of the multiport discharge diffuser through which the cooling water will be discharged. The diffuser pipes will be buried under the ocean bottom as shown, and will be installed subaqueously in an open cut excavation.

Clamshell or bucket dredging will be used to remove the sediment from the diffuser pipe excavation. The total amount of sediment to be removed is approximately 122,000 cubic yards (includes 3000 cubic yards removed from the riser shafts), and will be placed alongside the trench. The diffuser pipes will be supported by approximately 14,000 cubic yards of clean bedding material. It is anticipated that the excavated material will be suitable for use as backfill and subsequently up to approximately 94,600 cubic yards will be placed back in the trench after the diffuser pipes are installed in the trench. The excess material will be naturally distributed over the affected area such that the final bottom contours will not change significantly from original conditions. The final decision on the suitability of the material for backfilling will be determined from test borings, for which a Corps of Engineers permit has been received (Permit No. RI-QUON-78-167). If the excavated material is not suitable for use as backfill, it will be disposed of at an approved location.

An alternate construction method will be considered should the boring program determine that geological conditions are suitable. The bedrock tunnels would be extended the entire 1200 foot length of the diffuser. The diffuser nozzles would be installed utilizing a drilled-in concept, whereby diffuser nozzles are directly connected to the bedrock tunnel via individual riser shafts of appropriate size.

4.0 BIOLOGICAL EFFECTS OF THE PROPOSED COOLING WATER SYSTEMS ON REPRESENTATIVE IMPORTANT SPECIES

4.1 Methodology

Impacts on the aquatic environment which are associated with anypower plant may be divided into two broad categories: (1) short term impacts associated with construction of the facility, and (2) impacts which result from the long term operation of the cooling water system throughout the plant's life. The methods utilized to evaluate these two areas of impact are addressed separately below in Section 4.1.2. The representative important species' concept was used to evaluate the significance of these categories of impact. The basis for the selection of these species is discussed in Section 4.1.1 in this document.

4.1.1 Representative Important Species and the Rationale for their Selection

The Representative Important Species (RIS) list presented in Table G.4.1-1 was selected by the Region I Administrator of the United States Environmental Protection Agency in accordance with the regulations of 40CFR, Part 122.

4.1.1.1 Basis for Selection of Species

The selection of representative species for this discussion is based upon site specific information on the population characteristics of permanent and transient species, and the experience gained on the environmental effects of power plant construction and operation upon aquatic biota at other power plant sites. The specific criteria typically used for selecting representative species are:

a. Threatened or endangered status

b. Nuisance

c. Commercial or recreational importance, and

d. Dominance.

The species which have been selected are representative of the trophic levels in the community and the major habitat types, as well as the permament and seasonal residents found within the surrounding environment. The representative species thus provide the reference points by which the general condition of the balanced indigenous community can be assessed and the biological integrity of the water determined.

A large number of species have been collected in the surveys conducted in the Block Island Sound/Ninigret Pond complex. Although all species are considered in the selection of representative species, only those species that meet the criteria listed above in Section 4.1.1 were selected.

Dominant species of phytoplankton and zooplankton were not included under the representative species category in this demonstration for several reasons. Commonly, the lower trophic levels of natural "balanced" ecosystems are characterized by wide fluctuations in population size and biomass. These fluctuations are due to a combination of factors, including density dependent mechanisms such as selective or non-selective predation and density independent mechanisms such as daily or seasonal changes in natural conditions. These extreme fluctuations lead to difficulties in data collection and analysis, and makes the use of the affected populations as indicators of minor enviornmental modifications inapproprite. In addition, short reproductive cycles and rapid regeneration of most planktonic organisms lessen any power station impact on this component of the ecosystem when compared to longer lived aquatic species. Finally, power station induced mortality of lower trophic level organisms does not negate their contribution to the ecosystem as sources of nutrients and detritus.

The representative species selected by EPA are listed in Table G.4.1-1. The following discussion provides a rationale for their selection.

4.1.1.2 Threatened and/or Endangered Species

No threatened or endangered species have been identified within the study area.

4.1.1.3 Nuisance

The only potentially significant nuisance taxa identified within the study area was the dinoflagellate genus Gonyaulax. Stone and Webster (1975) reported that there has been no observed increase in the incidence of Gonyaulax spp. as a result of the operation of Pilgrim Nuclear Power Station, and Prakash (1967) found that temperature was not as important as salinity in controlling the summer abundance of Gonyaulax tamarensis. Moreover, the volume of water affected by a thermal increase in excess of $1.5^{o}F$ is small compared to the flux of ambient water passing the discharge area and an artificially induced red tide is not likely.

4.1.1.4 Commercially or Recreationally Important

The discussion and tables in Section 2.2 of this appendix indicate that the following species provide a reasonably or potentially important component of the commercial fishery either directly as part of the catch (C) or indirectly via the planktonic life stage (P) or are important to the sport fishery (R):

Atlantic menhaden	C, P	Red hake	C
Atlantic herring	C	Little skate	C
Scup	C	Lobster	C
Atlantic mackerel	P	Squid	C
Butterfish	C	Mahogany-quahog	C
Summer flounder (fluke)	C	Surf clam	C
Windowpane	C	Oyster	C
Winter flounder	C, P, R	Bay scallop	C
Atlantic cod	C	Hard clam	C
Silver hake (whiting)	C	Soft clam	C
Striped bass	R	Bluefish	R

Two of the above commercial species (mackerel and winter flounder) have significant larval denisites in Block Island Sound. While larvae of the others may be present, their low densities suggest that the study area is not near a major spawning or nursery area. Therefore, species selected for the representative commercial species are those which have the highest potential for a power plant induced impact plus those species representative of ecological roles within the community. The selected species of the commercial and recreational fishery are: Atlantic menhaden, scup, Atlantic mackerel, butterfish, winter flounder, silver hake, lobster, squid, and hard clam.

The adults of many of the other species exist in relatively low numbers in the area of the proposed intake and discharge. Furthermore, many of the adults of these species either are not subject to entrapment and significant thermal plume contact (e.g., surf clam, bay scallop and soft clam) or are represented in this discussion by a behaviorally similar member of their taxonomic family (e.g., summer flounder, windowpane, Atlantic cod and red hake).

Among the area's most important recreational species are the winter flounder, striped bass and bluefish. These three species have all been included as representative species.

4.1.1.5 Dominance

It is appropriate in considering the representative species in an area to include dominant forage species and habitat formers which may be necessary for ecological stability. These species are (1) the cunner, which is the second most abundant ichthyoplankter (behind mackerel), (2) the bay anchovy whose larvae were the third most abundant, (3) the blue mussel which is dominant in the meroplankton of Block Island Sound, (4) eelgrass (Zostera marina) which is abundant in Ninigret Pond, (5) the sand lance (Ammodytes americanus) and (6) sand shrimp (Crangon septemspinosa) which are both important larval contributors to the plankton.

4.1.2 Methods of Impact Analysis

4.1.2.1 The Impacts of Construction

In addressing the impacts associated with construction of the cooling water system, Applicant has related various ecological parameters associated with the representative species to the temporary environmental disturbances which will be present during construction of intake and discharge structures in Block Island Sound. Construction and installation of the circulating water system tunnels will have no effect on Ninigret Pond. During the construction of offshore riser shafts and installation of the diffuser and intakes in Block Island Sound, there will be a temporary increase in siltation and turbidity of the water. There will also be disruption and removal of bottom habitat within the immediate area of this construction.

While increases in siltation and water turbidity can affect aquatic biota, not all species are equally susceptible nor are all kinds of suspensoids equally harmful. Increased turbidity can cause a reduction in the abundance and photosynthetic rate of phytoplankton (Emery and Stevenson, 1957; Bartsch, 1960; Copeland and Dickens, 1969). The reduction in photosynthetic rate is proportional to the amount of light reduction in the water column due to turbidity. Flocculation and aggregation of temporary suspensoids can also mechanically trap phytoplankton and carry the cells to the bottom (Brehmer, 1965; Gunnerson and Emergy, 1962). Some zooplankton may also be adversely affected by turbidity by the reduction in primary production.

Siltation can be detrimental to benthic biota by burying or blanketing these organisms with sediment, which, if excessive, could cause their mortality by asphyxiation, and by depressing feeding, growth, and egg and larval development rates (Emery and Stevenson, 1957; Brehmer, 1965; Davis, 1960; Dodgen and Baughman 1949; Loosanoff, 1961). Saila et al. (1968), however, have observed in the laboratory that at least one benthic species (i.e., adult lobsters) can tolerate concentrations of suspended material as great or greater than those resulting from dredge spoil dumping with no adverse effects.

Turbidity can also affect finfish. At high turbidity concentrations, Ingle et al. (1958) found that several estuarine fishes suffered morality probably due to suffocation brought about by clogging of the opercular cavities and damage to respiratory structures. Resistance to disease, reproduction, and behavior of finfish can also be affected by increased turbidity (EIFAC, 1964). To the contrary, Flemer et al. (1967) could find no alteration in the abundance and distribution of striped bass, winter flounder silversides and menhaden larvae and others due to suspended and deposited sediments during dredging and overboard shallow spoil disposal operations in the Upper Chesapeake Bay. Furthermore, Ingle et al. (1955) have noted that some fish species exhibit an avoidance reaction to increasing turbidity levels, thereby preventing movement into a potentially adverse environment. There will be no intake and discharge construction related effects in Ninigret Pond. Factors considered include (1) temporal and spatial distribution of the various life stages, (2) mobility, (3) behavioral characteristics, and (4) feeding habits. Because tunnels will be utilized for the cooling water system, construction related impacts will be limited to those associated with installing the intakes and diffusers in Block Island Sound.

In Block Island Sound, the disruption and removal of bottom sediment in the immediate construction area during installation of the circulating water system will primarily affect benthic biota. Bottom sediment disruption will temporarily interfere with the area's usage as habitat while organisms associated with sediment removed during dredging may be destroyed. However, no permanent detrimental benthic impact from circulating water system construction is anticipated. The system will be located in areas of relatively low benthic population density. Furthermore, benthic species in the proposed construction area are found throughout the region, and upon completion of construction, the environs disrupted are expected to be recolonized and should readily return to their pre-construction state.

4.1.2.2 The Impacts of Operation

Impacts associated with the operation of the cooling water system of a power plant may be divided into three distinctly different areas: (1) the entrapment or impingement of nekton, (2) the entrainment of and subsequent in-plant effects on planktonic organisms, and (3) the effects of the thermal plume once it is released from the plant. In this document, each of the areas is considered separately and the cumulative effects are then addressed.

Entrapment/Impingement. Entrapment is characterized by the drawing in of free swimming aquatic organisms into the cooling water system. Impingement occurs when entrapped organisms larger than three-eighths of an inch are ultimately prevented from passing through the traveling screen barrier. Organisms which fall into this category are usually fish and occasionally invertebrates such as crabs and lobsters. Fish return systems are not considered practical for NEP 1 and 2 (see ER Section 10.10). However, Applicant is proposing both an advanced offshore intake design (velocity cap) and a location which minimizes the potential for entrapment.

Therefore, an important consideration in evaluating the impact is whether or not the potential for entrapment and impingement is environmentally acceptable. Constraints on the location of the intake are discussed in Section 5.0 of this document and include the requirement for sufficient water depth to prevent exposure of the structure during storm conditions and its positioning close enough to shore to minimize the potential for interference with commercial fishermen. The potential for entrapment and the resultant impact is dependent on several operational and environmental variables. From an operational standpoint, the design, location and capacity of the intake determine its entrapment potential. Environmentally, factors such as the particular species involved, their age, size, swimming speed, behavior, temporal and spatial abundance when associated with physical factors such as water temperature are also taken into consideration.

While offshore velocity cap intakes have been installed and are said to be effective in reducing the entrapment and ultimate impingement of marine fishes and macroinvertebrates (see ER Section 5.1.4.2) at electric generating stations in California and Florida, this type of intake design has not been utilized in coastal New England waters. It is, therefore, difficult to predict (based on regional operational data) the effect of NEP 1 & 2 on the entrapment and subsequent impingement of indigenous fish species.

The potential effects of the proposed NEP 1 & 2 intake system were, however, based on a comparative study of the performance of extant coastal velocity cap intakes by Coastal

Zone Consultants (1979). This study examined the operational velocity cap intakes in southern California and Florida with respect to design criteria, operational conditions and the faunas exposed to them. The NEP 1 & 2 Representative Important Species were paired with ecologically similar species occurring in Florida and/or southern California. The life histories of the paired species were examined in detail, and the entrapment records of the California and Florida equivalent species were studied. From this information, estimates of the relative entrapment potential for the NEP 1 & 2 RIS were prepared.

During backflushing, water will be recirculated through the condensers in order to provide the 120°F necessary to kill biofouling organisms, primarily mussels, in the intake tunnel. As a result of recirculation flow, the volume of cooling water drawn in and discharged will be reduced from the normal flow. The reduction in water utilization is a constant 50% of the normal circulating water flow requirements provided cool service water is available from the unit not being backflushed. Under these conditions, entrainment mortality during backflushing also will be reduced by 50% as a result of the reduced flow requirement. Despite the reduction in water consumption, it is anticipated that the rate of entrapment of finfish will increase during backflushing as a result of the high intake velocity through the diffuser nozzles and the absence of a velocity cap. Because of the relatively short time involved, however, the increased entrapment mortality is not judged to be important.

Effects in the Discharge Plume. Temperature is among the most influential ecological mediators of biological systems affecting a poikilotherm's temporal and spatial distribution, as well as their metabolism and behavior. Although mammals and birds have partially solved the problem of temperature directed effects by their internal compensatory maintenance of a nearly constant body temperature (i.e., homothermic condition), other taxonomic groups experience relatively great variation in their internal temperature in conformance to the temperature of their surrounding environment (i.e., poikilothermic condition). Of course, poikilotherms have undergone considerable adaptation to the varying temperatures of their particular environment and are generally capable of withstanding most naturally encountered temperature fluctuations. Within tolerable temperature ranges, there are great differences in the rates of biochemically based metabolic processes which can influence such things as an organism's development, maintenance, growth, reproduction and behavior.

Naturally occurring background temperatures vary temporally (diurnal and seasonal) and spatially. Ambient temperature fluctuations may be extremely small in deep ocean waters whereas, nearshore water temperatures can vary by several degrees, daily as well as seasonally. As discussed earlier in Section 2.1, the temperature in Block Island Sound typically ranges from 34°F in the winter to 70°F in the summer. Diurnal and semi-diurnal temperature fluctuations of 2 to 3°F are typical of the area. In the spring and summer a vertical thermal stratification of as much as 6°F exists in the water column. The rest of the year the water column is nearly isothermal.

While a species has evolved the ability to survive ambient temperature fluctuations, there are both upper and lower temperatures and temperature fluctuations beyond which active life can only exist for a short time period. Within temperature tolerance ranges, the degree of activity is again governed by the temperature. Thus, temperature limits that range for existence and governs the capacity to be active within that range.

The discharge of waste heat to the aquatic environment may have a bearing upon such normal activities described above. What degree there will or will not be an impact will have to be determined by an evaluation of all variables that enter into the organism/water temperature interface. In order for one to predict the ecological affects of aquatic waste heat disposal, one must know: (1) the location, quantity, and water temperature of the circulating water discharge, (2) the affect of the discharge on the natural thermal state of the receiving water body, and (3) the ability of the organism to tolerate such a change above normal background temperature levels.

A description of the NEP 1 and 2 heat dissipation system is given in Section 3.4 of the Environmental Report and Section 3.0 of this document. At full load and rated flow, the cooling water temperature will be raised approximately 37°F as it passes through the condenser. Transit time between the condenser and the point of discharge is estimated to be 14.5 minutes.

Cooling water is discharged into the Atlantic Ocean by means of a submerged multiport diffuser. As a result of the hydrodynamic characteristics of the heated discharge it is expected the plume will have some contact with the sea floor before it ascends to the surface. Based on analytical predictions presented in Section 3.2, approximately two acres of the ocean bottom could experience, at most, a maximum induced temperature increase of 6°F. Due to the rather nominal rise in temperature that an organism might experience and to the comparatively small size of the bottom area contacted, no appreciable impact is anticipated however.

Heated water will exit the diffuser ports at an initial velocity of 18 fps. This initial velocity will be reduced quickly, however, as the ambient water mixes with the discharge jets. Within 250-400 feet of the diffuser nozzles, ambient water will be entrained at a ratio of 6 to 1 causing a corresponding reduction in the temperature rise of the heated water to approximately one-sixth of its initial discharge value. It will take only a few minutes for the discharge water to reach the surface and for the water temperature to be attenuated to approximately 6°F above ambient.

Generally the surface plume temperature rise isotherms, areas and location vary as a function of tidal current and phase. As indicated in Section 3.2, changes in tidal current significantly affect the thermal plume characteristics. Results from a hydrothermal physical model study (Table G.3.2-1 and Figure G.3.2-6) indicate that the surface maximum temperature rise, which occurs at slack tide, is about 6°F and occupies less than 1 acre. As indicated in Table G.3.2-1 once the tidal current is above 0.5 fps the maximum surface temperature rise is less than 5°F.

Having reached the surface, a plume flow away zone is created and the remaining jet momentum is dissipated by entraining additional water. Beyond this region temperature decay of the thermal plume occurs primarily by diffusion and by surface heat loss to the atmosphere. Both of these natural processes is slow and requires a variable amount of additional time to reach ambient temperature conditions.

From the standpoint of plant operation, marine organisms will be subjected to thermal effects either (1) by being entrained and passed through the cooling water systems where they will experience the full temperature differential of 37°F on the discharge side of the condenser, or (2) by being entrained in or interacting with the heated plume once it is discharged. In order to reduce the number of organisms entrained, Applicant has selected a low volume of cooling water flow and the resultant high temperature increase of 37°F. While the low flow will reduce entrainment, the high temperature increase is expected to cause almost complete mortality of those organisms that are entrained; this is considered preferable to the alternative of a cooling system with higher flow and lower temperature rise. Regardless of the cooling systems temperature rise, it is expected that a substantial mortality of entrained organisms will occur as a result of mechanical and hydraulic stresses. Therefore, to minimize overall entrainment mortality, it is considered necessary to minimize the cooling water flow. This is accomplished by selecting a cooling system with a high temperature rise.

In contrast to the foregoing, aquatic organisms may encounter short term or localized temperature stresses within the thermal plume of the station's cooling water system discharge. Here there may be a temperature maximum greater than those naturally present

$$N_o = \frac{N_t}{e^{-Zt}}$$

where:

N_o = number of larval sand shrimp at hatching

N_t = number of larval sand shrimp at time t

Z = instantaneous mortality rate (0.0967/day)

t = time in days

Based on an estimated average density of larval sand shrimp at hatching, and assuming 100% plant load, an equivalent of 6.387×10^9 Stage I sand shrimp would have been entrained in 1978. To determine the number of adults that would have been lost through entrainment of these larvae, the following assumption was made. If the population is in equilibrium, the fecundity of a female will be reduced to two breeding adults in one generation or

$$S = 2/F$$

where:

S = survival from egg to adult, and

F = fecundity of a breeding pair during their life.

Survival from egg to adult is a product of survivorship from egg to larvae and larvae to adult. For conservatism survivorship from egg to larvae was assumed to be 100%. Haefner (1976) provided a fecundity relationship of $Y = 2611 + 0.0077 (X-156516)$

where

Y = number of eggs per female

X = cubed length in mm.

He found egg bearing females ranging in size from 16-70 mm. Smith (1950) never found adult sand shrimp greater than 30 mm. Beach seine data from Ninigret Pond for 1978 showed that 76% of adult Crangon were less than 40 mm (YAEC, 1979). Using a mean length of 30 mm for ovigerous females a fecundity of 1614 eggs per female was calculated. This provided a survivorship from hatching to adult of 0.124%.

Based on estimates generated by Applicant, the projected entrainment of larval sand shrimp at hatching would result in the loss of 7.92×10^6 adults.

The weight of these adults lost due to entrainment was estimated from the length-weight relationship provided by Wilcox and Jeffries (1973).

$$\text{Log } W = 0.040L + 1.0$$

where:

W = weight (mg)

L = Length (mm)

Based on Applicant's estimate, the projected loss of adult shrimp would weigh 1.256×10^6g (2763 lbs).

Smith (1950) estimated the standing stocks of C. septemspinosa in Block Island at 0.239 g/m^2. Assuming an area of 400 sq mi, the estimated loss of adult shrimp represent 0.5% of the standing stock of sand shrimp in Block Island Sound in 1949.

Smith also estimated that fish consumed 5.5g of food/g of fish/year and that sand shrimp comprised 7.2% of the stomach contents of fish. Therefore the amount of adult C.

profile.

Since all the representative species (except eelgrass) are poikilotherms (cold blooded), temperature is an integral factor in their presence or absence at the site. In order to identify the correlation between the presence or absence of a species with temperature, the relative temporal abundance of eggs, larvae, and adults found at Station BIS-A (Figure G.2.2-1), which is the most representative of the discharge location, is plotted below each temperature profile. It should be pointed out that these temporal abundance profiles are relative only within a particular life stage and, therefore, one should not compare the relative size of one life history stage with another. The number in the largest block represents either the number of organisms/100 cubic meters during the period of greatest abundance of eggs and larvae or the number of adult individuals captured during four otter trawls tows for any one month.

The last data input parameters are the temperature tolerance values derived from the literature. This information is presented in one of three ways:

a. A specific temperature related event (e.g., upper lethal limit, incipient lethal temperature, avoidance response temperature, temperature preferenda, etc.) based on a particular acclimation temperature;

b. A specific temperature related event where no corresponding acclimation value was provided; or

c. General background temperature information, such as the organisms' spawning temperature, preferred temperature, growth temperature, etc.

Where acclimation temperatures are provided, a specific temperature event is plotted by relating the acclimation value to a naturally occurring surface water temperature found at the NALF site. An example is provided (Figure G.4.1-1) for an adult with an upper lethal temperature limit of 77°F based on an acclimation temperature of 58°F. Commencing at Point A (58°F), a horizontal line is extended from the organism's given acclimation temperature to a location on the temperature profile which corresponds to that date when such a temperature was observed at the NALF site (Point B). A perpendicular line is then drawn up to that temperature found by the author to be the animal's upper lethal temperature limit (Point C).

In some cases, the actual test acclimation temperature is higher than the average maximum surface temperature observed at the site (i.e., 70°F in August). In order to denote such an occurrence, the acclimation temperature is placed in parentheses (Point D) and a dashed vertical line is drawn to its corresponding temperature related event (Point E). For this example, the author acclimated the organism at 77°F and found it has an upper temperature tolerance of 88°F.

In those instances where no acclimation temperatures are provided for a given temperature related event, or where information such as spawning temperature, optimal growth values, etc., are given, the various values are plotted on the right hand side of the figure. In this example, an upper lethal temperature for larvae was observed at 74°F whereas a spawning range is given for the species between 56-67°F.

Having plotted all such data points a general relationship can then be obtained between the a given species' life history stage, observed temperature tolerance and projected impact with the surface temperature maximum induced by plant operation.

<u>Effects Within the Plant.</u> Applicant has designed the cooling water system in such a manner that the cooling water flow volume (hence the number of entrained organisms subject to in-plant effects) is minimized. In order to achieve this low flow, it is necessary to raise the Delta T; at NEP 1 & 2, 37°F is the highest practical temperature consistent with engineering and environmental considerations.

The predicted annual entrainment of eggs and larvae of the representative species is presented in Table G.4.1-2. From this table, it can be seen that the vast majority of total entrainment of ichthyoplankton will be incurred by relatively few species. In descending order of abundance, the largest sources of ichthyoplankton were: cunner, Atlantic mackerel, anchovy, and winter flounder. Because of the importance of these species, Applicant commissioned Stone and Webster Engineering Company to model mathematically the entrainment effects of power plant operation on the populations of these species (Stone and Webster, 1976).

The other selected representative fish species have lower densities than the above four, and, in several cases, their ichthyoplankton are not even present. For these species, available information on the population statistics have been gathered. Depending on the available information, the effects of in-plant mortality have been correlated to: (1) the loss of a certain number of females, (2) the projected loss to the adult fishery, and (3) the commercial harvest.

In modeling the effects of entrainment on several of the species, the assumption has been made that if the population is in equilibrium, the fecundity of a female will be reduced to two breeding adults in one generation. This may be represented by the equation presented in Horst (1975):

$$2 = S \times F \qquad (1)$$

where:

S = survival from egg to adult, and

F = the fecundity of a breeding pair during their life.

Transposing,

$$S = 2/F \qquad (2)$$

From this consideration, the probability of an egg reaching adulthood may be calculated. S is also equal to the product of survivorship of the egg to larvae (S_e) times survivorship from larvae to adult (S_l) or,

$$S = S_l \times S_e \qquad (3)$$

and

$$S_l = S/S_e = 2/S_eF \qquad (4)$$

This equation provides a prediction of the probability of a given larvae reaching adult.

The number of adults lost as a result of entrainment is predicted by summing the effects as predicted by multiplying S and S_l times the total egg entrainment and the total larvae entrainment, respectively.

Total Impacts. The total impact section of the seventeen representative species will summarize the effect of each major factor (i.e.,entrapment, entrainment and thermal plume) and assess the aggregate impact on the population. Other sublethal effects are addressed in Section 4.3.

4.2 Impact Assessment

4.2.1 Atlantic Menhaden (Brevoortia tyrannus)

4.2.1.1 Life History.

The Atlantic menhaden is a widely distributed migratory species which is found along the entire Atlantic se. ard between 27°N and 45°N. The majority of the population winter in offshore waters south of Cape Hatteras and moves northward in early spring

(Nicholson, 1971). They return to southern waters in the fall months, i.e., October-December. The menhaden is one of the most abundant fishes found along the coast.

Juvenile and adult menhaden are non-selective plankton feeders. Comb-like gill rakers filter out plankton as the fish swims with its mouth open.

Bigelow and Schroeder (1953) reported that menhaden spawn at sea and that the chief production was south of Cape Cod. While most of the eggs are probably spawned at sea, there is evidence that, in southern New England, significant spawning takes place in large estuaries (Marine Research, Inc., 1974). In New England, spawning may occur from May to October (Reintjes, 1969). Investigations by Marine Research, Inc. in areas of Narragansett Bay during 1973 revealed the presence of menhaden eggs in ichthyoplankton collections as early as mid-April, with maximum abundance around mid-June. The eggs are pelagic and usually hatch within 48 hours (Kuntz and Radcliffe, 1917). There is no evidence that Ninigret Pond and adjacent waters of Block Island Sound are particularly significant spawning areas for menhaden, although its eggs and larvae were found to occur in both areas during the summers of 1974 and 1975. The temporal abundance of menhaden eggs and larvae (1974-1975) is depicted in Figure G.4.2-1; the spatial abundance is depicted in Figures G.4.2-2 through G.4.2-5.

On the average, menhaden weigh approximately one-half pound as one-year-olds and nearly a pound as three-year-olds. The growth rate declines after age three. They may enter the fishery, principally along the south Atlantic coast, when less than one year old. The majority become sexually mature in their third year (Olsen and Stevenson, 1975).

Menhaden have supported an important commercial fishery from Cape Kennedy, Florida to Cape Ann, Massachusetts, although regional scarcity resulted in no New England landings during the 1963-1968 period (Olsen and Stevenson, 1975).

U. S. fishermen catch more pounds of menhaden each year than any other species (Henry et al., 1965). Menhaden are not processed for human consumption. They are usually reduced to meal which is rich in protein and which is used as a food supplement in animal feed. Additionally, the oil derived from menhaden is used in paints, soaps, lubricants and a variety of other commercial and industrial products.

Aside from its own commercial value, the menhaden also serves as a principal forage species for such important predators as bluefish and striped bass.

4.2.1.2 Impacts of Construction. Adult menhaden can be found in the area of the site from March until December. Schools of adult menhaden are not only transitory, but are sufficiently mobile to avoid suspended sediments and turbidity. Increases of suspended sediments and turbidity in the immediate area of construction could adversely affect some eggs and larvae floating through the construction site. However, because the most intensive menhaden spawning in southern New England takes place in the large bays and estuaries, such as Narragansett Bay, few eggs and larvae are present, and the effects of construction on eggs and larvae in Block Island Sound is expected to be very minor. Under these circumstances, no appreciable harm to the Atlantic menhaden populations is anticipated as a result of construction.

4.2.1.3 Impacts of Plant Operation

Entrapment. Menhaden are often impinged on the intake traveling screens of power plants. Along the northeast coast, there have been several instances of substantial intake impingement of menhaden (Young, 1974). These impingement cases, however, occurred at facilities with shoreline intakes. Menhaden appear to be vulnerable to entrapment at shoreline intakes.

Based on their comparative study, Coastal Zone Consultants (CZC) (1979) concluded that the entrapment potential for this species at NEP 1 & 2 ranged from medium to high based on the following reasons: (1) Its RIS counterpart, the northern anchovy (*Engraulis* mordax) is entrapped in relatively high numbers by velocity caps in southern California; (2) Atlantic menahden are seasonally present for over 6 months in southern New England. The young-of-the-year should be particularly abundant in October, while the adults may be abundant throughout the summer; (3) This species is planktivorous and remains in schools at least into early evening. However, CZC (1979) also identified factors which may tend to minimize entrapment of menhaden. These factors included: (1) Atlantic menhaden are wary; and adults, especially, may avoid the intake structure; (2) The young remain in the estuary much of the time and move to the nearshore waters at the onset of migration. (3) Brevoortia tyrannus and B. smithi are both present in the vicinity of the operating velocity cap intake at St. Lucie Generating Station in Florida yet impingement of these species has not been reported.

The critical swim speed for menhaden has been reported by Wyllie et al. (1976). Utilizing their data, the average critical swim speeds for menhaden of 3.7 to 7.1 inches in length was calculated to be 1.4, 2.3, 2.3, 2.8, and 1.5 fps at water temperatures of 41, 50, 59, 68-69.8, and 75.2-77°F, respectively. Thus the potential for menhaden entrapment is not considered a significant problem since the fish generally have a swimming capability greater than the intake velocity of 1.5 fps.

Since no known regional operating experience on the entrapment rate of menhaden at submerged offshore intakes is available, the entrapment mortality of menhaden predicted for two nearby nuclear power stations (i.e., Pilgrim Station and Millstone Station) with shoreline intakes was examined to place any potential menhaden entrapment losses at NEP 1 and 2 in perspective. The significance of predicted menhaden entrapment losses at Pilgrim and Millstone Stations was assessed by population simulation modeling (Stone and Webster, 1975; Horst, 1976).

The estimated number of menhaden which will be annually impinged on the Pilgrim Station Units 1 and 2 intake screens was estimated to be 18,567 fish (Stone and Webster 1975).

This annual entrapment of menhaden at Pilgrim Station is expected to cause a reduction in the menhaden population of 0.00073 percent over a 50 year period of plant operation. Since the effect of menhaden impingement at Pilgrim was negligible, Stone and Webster (1975) concluded that the menhaden population should not be adversely affected.

The number of menhaden annually impinged on the intake screens of Millstone Units 1, 2 and 3 was estimated to be 1018 fish (Horst, 1976). The mortality coefficient derived from the annual impingement loss given above was of such small magnitude (i.e., 0.0000005) that it was not used by Horst in his population simulation model. Instead, a greater than average menhaden mortality incident that occurred at Millstone Unit 1 was used to derive the intake mortality coefficient for the simulation model. This incident occurred in the fall of 1971 when about 50 million juvenile menhaden and blueback herring were killed at the Unit 1 intake. Extrapolating the Unit 1 mortality to all three Millstone Units results in a notable mortality of 210 million fish. The resulting mortality coefficient for entrapment losses of this magnitude (used in the population simulation model) is 1,740 times larger than the normally expected intake mortality and represented a worst-case incident. As a result of his analysis, Horst (1976) concluded that no detectable change in the population dynamics of the Atlantic menhaden population would result from the operation of Millstone Station.

The analyses discussed above clearly demonstrate that within the range of annual intake-entrapment losses of 1000 fish to 210 million fish, no significant impact occurred to the Atlantic menhaden population. Since any projected annual intake-entrapment loss of menhaden at NEP 1 and 2 would probably fall on the low side of the range of losses discussed above, and since the NEP 1 and 2 intake structure incorporates features of design (e.g., offshore velocity cap) which have proven extremely successful in minimizing the entrapment of fish, it is concluded that entrapment of menhaden at the NEP 1 and 2 intake should not appreciably harm the Atlantic menhaden population.

Within the Discharge Plume. As one might expect from a species found in commercial quantities as far south as Florida, the menhaden has considerable tolerance for high temperatures. In fact, Bigelow and Schroeder (1953) report that menhaden do not appear in the Gulf of Maine until the water reaches 50°F or more. Temperature tolerance data for menhaden are depicted in Figure G.4.2-6.

Meldrim and Gift (1971) reported that the preferred temperature of adult menhaden was 70°F with some indication of an avoidance response at 84.2°F. Battelle Columbus Laboratories (1971-72) reported that the 24 hour TLM temperature was 86°F for adults. At New England Gas and Electric Company's Canal Station, menhaden young of the year appeared stressed at 87°F and were killed when the temperature reached 94°F (Fairbanks et al., 1971). At the New Jersey Oyster Creek Station, menhaden survived temperatures of 92°F but were killed at 99°F (Smith, 1974).

Lewis and Hettler (1968) determined that test temperatures above 33°C (91°F) caused mortality in young menhaden. How soon they died depended in part on acclimation time, temperature, salinity, D.O., and gill condition. Hoss et al., (1974) reported that larvae acclimated at 10 and 15°C (50 and 59°F) for 3-7 days had a respective upper lethal temperature of 28.9 and 29.7°C (84.0 and 85.5°F).

The NEP 1 and 2 thermal discharge may interact with this species' nearshore migratory activities anytime during late spring or early fall. During this period, adult and juvenile menhaden could experience a surface water temperature between 53 and 75°F. Based on the results obtained by the various investigators cited, such a temperature range is well within the temperature tolerance capabilities of this species.

As a result of ichthyoplankton studies conducted by Applicant in Block Island Sound, menhaden larvae and eggs were found at the site from as early as May to as late as October. Observations made by Hoss et al., (1973) generally indicate that the larval stage of this species would be able to tolerate an induced surface temperature maximum in excess of the expected $6^{o}F$.

Since menhaden eggs are buoyant (Bigelow and Schroeder, 1953) there is a possibility that they may be entrained in Applicant's thermal plume. It would be reasonable to assume however, that minimal thermal impact would be incurred since spawning and subsequent development of eggs occurs in more southerly waters along the eastern seaboard; areas where water temperatures equal or exceed those predicted in Block Island Sound (NOAA, 1973).

<u>In-Plant Effects.</u> The eggs and larvae of the Atlantic menhaden will be subject to entrainment through the NEP 1 and 2 cooling water system, but to differing degrees. Atlantic menhaden eggs were collected from the location of the proposed intake at Station BIS-A on only one sampling day during the entire 1974 and 1975 study period. Thus, due to their limited occurrence, the potential for significant impact to the menhaden population as a result of egg entrainment is minimal. Menhaden larvae, however, were collected from the proposed intake location during late May through late July 1975, and primarily from mid-June through mid-August 1974. Average larval densities for these time periods are depicted in Figures G.4.2-4 and G.4.2-5. Therefore, due to their longer temporal occurrence, the evaluation of entrainment effects will focus on menhaden larvae.

If the plant had been operating at 100% capacity, the estimated number of menhaden eggs and larvae annually entrained through the NEP 1 and 2 cooling water system would have been 0 eggs in 1974 and 8.592×10^6 eggs in 1975, and 2.027×10^7 and 3.789×10^7 larvae in 1974 and 1975, respectively. Average annual menhaden egg and larval entrainment estimates for the two study years are 4.296×10^6 eggs and 2.908×10^7 larvae. Making the very conservative assumption that all of the projected entrained eggs would have survived to the larval stage, then an estimated 3.338×10^7 larvae would annually be affected by entrainment at NEP 1 and 2.

The significance of larval entrainment losses of the magnitude cited above to the Atlantic menhaden population can be assessed by comparing the above larval entrainment estimates to those predicted for the Pilgrim (Cape Cod Bay) and Millstone (Long Island Sound) nuclear power facilities. The significance of predicted menhaden larval entrainment losses at each of these nearby power facilities was assessed by population simulation modeling (Stone and Webster, 1975; Horst, 1976). Since the menhaden population potentially affected by NEP 1 and 2 larval entrainment is identical to the menhaden population modeled for Pilgrim and Millstone entrainment, and if the predicted larval entrainment losses are of similar magnitude for each of the power facilities, then determinations as to the significance of larval entrainment losses made at Pilgrim or Millstone should also be valid for NEP 1 and 2.

The number of menhaden larvae annually entrained through the Pilgrim Station Units 1 and 2 cooling water system was estimated to be 1.53×10^8 larvae (Stone and Webster, 1975). Assuming 100 percent larval mortality, this magnitude of larval entrainment at the Pilgrim facility was predicted to cause a reduction in the menhaden population by only 0.00275 percent over a 50 year period. Since the effect of larval entrainment at Pilgrim was negligible, Stone and Webster (1975) concluded that the menhaden population should not be adversely affected.

The maximum number of menhaden larvae annually entrained through Millstone Station Units 1, 2, and 3 (based on field data) was predicted to be 4×10^7 larvae (Horst, 1976). Since this entrainment prediction resulted in a very small larval mortality coefficient, Horst based his population simulation model on highly conservative assumptions. The larval mortality coefficient used in his model was 58 times larger than the actual entrainment mortality and represented a worst case situation. Utilizing two different simulation strategies (density independent and density dependent), he predicted that the menhaden population would be reduced in size by only 0.08-1.1 percent after 50 years of power plant related mortality. Thus, it was concluded that, even when intentionally overestimating the mortality associated with the power station, no detectable change in the dynamics of the Atlantic menhaden population would result from the operation of the Millstone nuclear power facility.

Given that the estimated number of menhaden larvae entrained at Pilgrim Units 1 and 2 and Millstone Units, 1, 2 and 3 is over 4.5 and 1.2 times greater, respectively, than the predicted number of larvae entrained by NEP 1 and 2, and given that the Pilgrim Station and Millstone Station entrainment losses had negligible effects on the menhaden population, it is concluded that the Atlantic menhaden population will not suffer appreciable harm as a result of larval entrainment at NEP 1 and 2.

Total Impacts. Based on historical occurrences at other power plants in southern New England as well as the comparative study conducted by CZC (1979), Applicant believes that the menhaden may be frequently entrapped. However, a significant difference between NEP 1 and 2 and all existing New England power plants is that NEP 1 and 2 will have an offshore, velocity cap intake.

This feature should reduce entrapment potential to something less than that observed at other exiting plants. Furthermore, the average critical swim speed of menhaden is generally greater than the intake velocity. Thus, the menhaden swimming capability would allow the fish to swim away from the intake and avoid entrapment. As model studies on the effects of existing plants (notably Millstone and Pilgrim) indicate entrapment effects have resulted in no appreciable harm to the menhaden population, Applicant believes that this conclusion must also hold for NEP 1 and 2.

The menhaden is an extremely temperature tolerant species which is known to be capable of living in waters on the order of 15-20^{o}F warmer than the maximum temperature expected in the thermal plumes of NEP 1 and 2. Additionally, gas-bubble disease, which is a temperature related phenomenon, should not contribute to any plant related mortality because of the multiport diffuser; a detailed discussion of this phenomenon is presented in ER Section 5.1.4.4. As a result of the above, it is expected that the menhaden population will suffer little if any, mortality as a result of temperature or temperature related phenomena.

The impact of entrainment of eggs is not judged to be a source of concern since eggs have been taken in the vicinity of the proposed inlet only once in two years. The number of larvae which may be lost within the cooling water system is an order of magnitude less than Pilgrim Station and roughly the same as for Millstone. Models predicting the effects of entrainment at these two plants indicated that the impacts would be insignificant.

Considering the high temperature tolerance of the menhaden and the acceptable results of population models at two other southern New England power plants which predict impacts greater than are expected at NEP 1 and 2, Applicant believes that the total effect of the operation of the proposed plants cooling water system will result in no appreciable harm to the effected population.

4.2.2 Bay Anchovy (Anchoa mitchilli)

4.2.2.1 Life History.

The bay anchovy is a small fish, seldom exceeding 9 cm (3.5 inches) in length, with a range extending from Maine to Texas. Its occurrence north of Cape Cod is relatively rare (Bigelow and Schroeder, 1953). It appears to be found in greatest abundance near river mouths and off sandy beaches, although this may be due to its apparent preference for estuarine areas of spawning. Relatively little has been written about this species, which is of no direct commercial value, but which, on the basis of sheer abundance, must play a significant role in the marine food chain.

The Narragansett Bay ichthyoplankton survey conducted by Marine Research, Inc., during 1973 (Marine Research, Inc., 1974) indicated that the bay anchovy is primarily an estuarine spawner, since the great majority of the eggs were observed in collections made near the head of the Bay. Observations in the area of Ninigret Pond and Block Island Sound during 1975 would tend to agree with this, since egg concentrations at certain stations within the Pond were generally higher than those in the Sound by at least two orders of magnitude. On the other hand, anchovy egg concentrations in Ninigret Pond during 1975 were low compared with those observed in the upper regions of Narragansett Bay during 1973, indicating that Ninigret Pond is probably not of great significance as a spawning area for this species.

Kuntz (1913) reported that this species spawns in the waters off Beaufort, North Carolina from June to August. In Narragansett Bay during 1973 (MRI, 1974) anchovy eggs were collected as early as the first week in June and by late August the eggs had disappeared from the collections. These two studies indicate that the spawning season of this species may be roughly the same over a wide geographic range. Peak egg abundance in Narragansett Bay occurred about the third week in June, while larval abundance reached a maximum during the second week in August. (It should be noted that, during 1973, the larvae of bay anchovies were more abundant than any other single species in Narragansett Bay, comprising nearly 50% of the total population (Marine Research, Inc., 1974)).

During 1974 and 1975, spawning was initiated in Ninigret Pond by late May or by the first week in June, terminating by early September (1974) or by early August (1975). Highest concentrations were found from mid-June to mid-July, particularly in the northerly and relatively estuarine area known as Fort Neck Pond. The facts that larval concentrations appeared to be much higher in the Sound than in the Pond and that, on one occasion at least, anchovy larvae were found in relatively high concentrations at all stations between Charlestown Beach and Block Island itself, might indicate the major source of larvae to be other than Ninigret Pond. It is perhaps possible that these larvae originated from Narragansett Bay.

The temporal abundance of the anchovy ichthyoplankton is presented for Station BIS-A (Figure G.2.2-1) in Figure G.4.2-7, and the spatial distribution within the study area is presented in Figures G.4.2-8 through G.4.2-11.

4.2.2.2 Impacts of Construction.

Adult anchovy have sufficient mobility to avoid construction activity, however, increases of suspended sediments and turbidity in the immediate area of construction may adversely affect eggs and larvae transported through the construction site. Because of the wide range of this species' spawning area, the rapid development of larvae, and the relatively low numbers, these effects are expected to be minimal. Under these circumstances, no appreciable harm to the bay anchovy population is anticipated as a result of construction.

4.2.2.3 Impacts of Plant Operation

Entrapment. Bay anchovies are a potential candidate for entrapment since (1) they are a coastal species, (2) their average critical swim speed capability is less than the intake velocity, (3) they are not restricted to a specific stratum in the water column, (4) their planktivorous feeding habit, (5) they are nocturnally active, (6) larger anchovies tend to move to deeper water, and (7) entrapment of A. compressa occurs at velocity cap intakes in California. According to Gordon (1974), the bay anchovy in Rhode Island is found in coves, bays and river mouths from May through October. The greatest amount of impingement will probably occur from August when young-of-the-year begin to reach impingible size through October when the exodus from inshore waters is largely completed. The critical swim speed for bay anchovy has been reported by Wyllie et al., (1976). Utilizing their data, Applicant calculated the average critical swim speeds for anchovy ranging in length from 3.2-3.7 inches and found these swim speeds to be 0.7 and 1.0 fps at test water temperatures of 50 and 59°F, respectively.

Section 5.1.4.2 of the Environmental Report discusses the experience and experimental results of Southern California Edison with the velocity cap intake and the anchovy Engraulis mordax. Although it is likely that some bay anchovies will be entrapped, the numbers are expected to be low because of habitat preferences of the adult and because of the velocity cap design. The location of an offshore intake should reduce entrapment of the species well below that expected of an estuarine, shoreline intake. Consequently, no appreciable harm to the anchovy population is anticipated as a result of entrapment.

Within the Discharge Plume. The anchovy is a ubiquitous species found in coastal waters from Maine to Texas. It is found in decreasing numbers however, north of Cape Cod. Similar to the menhaden, the bay anchovy is primarily a warm water fish which migrates into New England waters during the warmer months (Bigelow and Schroeder, 1953). The fact that it is abundant in subtropical estuaries where water temperatures may exceed the maximum surface temperature predicted in NEP 1&2's discharge plume (NOAA, 1973) indicates that bay anchovy eggs must be capable of surviving high ambient water temperatures.

Houde (1974), conducted experiments on the "critical period" of the bay anchovy in order to determine the post hatching time interval during which larvae must either establish themselves as active feeders or else risk starvation. In experiments conducted in water temperatures of 24 and 32°C (75.2 and 89.6°F), survival of larval anchovy was achieved when fed 40 to 16 hours, respectively, after development of eye pigmentation.

Interestingly enough, the temperatures which were used by Houde were equal to or exceeded the maximum surface temperature anticipated at NEP 1 and 2 by as much as 14°F (Figure G.4.2-12). Since survival was found even at the highest experimental temperature of 89.6°F, no impact is expected for those early life history stages of the bay anchovy found in the thermal plume of NEP 1 and 2.

In preference and avoidance experiments conducted by Meldrim and Gift (1971), adult A. mitchilli showed a general water temperature preference anywhere from 5°F below to 10°F above the induced surface temperature projected at the site. Of particular relevance is that the highest preference temperature found for bay anchovy (i.e., 86°F) exceeds the warmest temperatures observed by Applicant in Block Island Sound. In this instance, the preferred temperature exceeded the expected surface maximum water temperature by 10°F. More importantly, however, is that in the two cases, where avoidance tests were conducted, anchovy responded to temperatures well in excess of those predicted by the Applicant. Such information indicates that the adult should be able to satisfactorily tolerate surface water temperatures incurred from plant operation.

In-Plant Effects. The bay anchovy is one of the four species which were modeled by Stone and Webster (1976). They analyzed this species with the model which is presented in Section 4.1.2.3. In this application, the slightly conservative assumption was made that the anchovy does not spawn more than once. The survival from egg to larvae was estimated to be 0.072 (based on five years worth of egg to larvae ratios from Chesapeake Bay). According to Stevenson (1958) the mean egg production of the bay anchovy is 3.43×10^4 eggs; however, only 7% or 2.4×10^3 of these are actually spawned. The latter number was, therefore, utilized by S&W as an estimate of fecundity.

In their model, S&W calculated an entrainment rate of 9.919×10^6 eggs and 6.064×10^8 larvae based on the 1974 field data. The small difference between S&W's estimate and Applicant's estimate (Table G.4.1-2) results from technique differences in numerical integration: S&W utilized Simpson's rule while Applicant utilized the trapezoid rule. Using the conservative assumption that all Anchoa sp. eggs and larvae were Anchoa mitchilli and assuming no density dependent compensation mechanism, the above entrainment losses were predicted to result in the loss of approximately 7×10^6 adults. Using the same model as S&W and the entrainment rates presented in Table G.4.1-2, Applicant predicts that if NEP 1 and 2 had operated at full load during 1974 and 1975, the losses to the adult population would have been 6.08×10^6 and 6.03×10^6 individuals in 1974 and 1975, respectively. The assumption of full load is, of course, conservative when the life of the plant is considered. A more reasonable load factor would be on the order of 80%; this would produce an annual entrainment loss of approximately 4.8×10^6 adults. Because no good quantitative studies have been conducted on this commercially unimportant species, it is not possible to place the above numbers in perspective. However, when one considers the relative abundance of anchovy ichthyoplankton in Block Island Sound and areas such as Narragansett Bay, it must be concluded that the former area is not particularly important to this species as a spawning area. If the area has comparatively low ichthyoplankton numbers, it follows that the adults lost also constitute a small portion of the population. Applicant, therefore, concludes that there will be no appreciable harm associated with the entrainment of this species.

Total Impacts. The eggs of anchovy are present in low numbers in Block Island Sound (as might be expected for a species which has a short incubation period and spawns some distance away) and that the larvae and adults are certainly tolerant to any temperatures which may be encountered in the surface plume. It is also believed that while the entrapment potential for this species is judged to be medium to high, the offshore location of the NEP 1 & 2 intake, as well as the fact that the adults have a preference for bays and estuaries, should significantly produce entrapment of this species well below that of a shore line intake.

Because the anchovy is a forage species of little commercial importance, and no good quantitative studies have been conducted on this species, the conservatively predicted entrainment loss of 7×10^6 adults cannot be directly addressed. However, because the ichthyoplankton density of this species in Block Island Sound is low compared to nursery areas such as Narragansett Bay, the loss due to entrainment is expected to result in no appreciable harm to the anchovy population as a result of plant operation.

4.2.3 Silver Hake or Whiting (Merluccius bilinearis)

4.2.3.1 Life History.

The silver hake, or whiting, is a strong, swift swimmer and does not confine itself to a specific stratum in the water column. They are found at depths ranging from the tide line to 400 fathoms (Bigelow and Schroeder, 1953). Silver hake often swim together in large numbers but they do not school in definite bodies.

Silver hake range from Newfoundland to South Carolina. Maximum abundance occurs within the area from Cape Sable to New York (Bigelow and Schroeder, 1953). It winters in relatively deep water, moving inshore in late spring and remaining throughout the summer. It prefers warmer water than any of the other members of the cod family (Olsen and Stevenson, 1975), although seldom occurring in water warmer than 18°C (64-65°F).

The silver hake is a well armed voracious predator. Their diet includes: alewife, butterfish, cunner, herring, mackerel, menhaden, scup, silversides, smelt, squid and even young silver hake. Silver hake are often seen driving schools of herring ashore (Bigelow and Schroeder, 1953).

Bigelow and Schroeder (1953) report that the Gulf of Maine is the principal nursery area for silver hake. It is probable that the eggs and larvae of this species which are found in Block Island Sound represent a relatively small fraction of the population as a whole; they were certainly not an important part of the ichthyoplankton sampled during the current study. The largest egg concentrations were collected in mid-June; however, eggs were present in the plankton from late May through August. The eggs are buoyant and hatch within a period of several days. Bigelow and Schroeder (1953) report that the fry move into deep water by autumn; however, during recent years, large numbers have been observed in upper Mount Hope Bay during late fall. By the following spring, the young silver hake range from 5 to 16 cm (2-6.5 inches) in length. According to Bigelow and Schroeder (1953), silver hake remain offshore until three years of age, when they enter the commercial catch. At this time, they may average 27.5-35 cm (11-14 inches) in length. The temporal and spatial abundance of silver hake ichthyoplankton are depicted in Figures G.4.2-13 through G.4.2-17.

The silver hake is an important component of the commercial fishery. In Rhode Island, they constituted 10% of the total landings by weight. Principal fishing areas include the coast of New Jersey, the general area between Montauk Point (Long Island) and Martha's Vineyard Island (including Block Island Sound), and the inshore waters east and north of Cape Cod (Saila and Pratt, 1973).

In Block Island Sound during 1975, silver hake were found at the otter trawl sampling stations off Charlestown Beach during the months of May, June and July. It was noted that this species occurred in appreciably higher concentrations at the 80-foot depth contour than in the shallower water, 30-40 feet deep (Table G.2.3-3). The catch records of two commercial draggers fishing in slightly deeper water in Block Island Sound during 1975 indicate the presence of silver hake during every month of the year except August.

4.2.3.2 Impacts of Construction.

Although silver hake can be found in the area from late spring through the summer, the adults remain offshore in deep water. Increases of suspended sediments and turbidity in the immediate area of construction could adversely affect some eggs and larvae floating through the construction site. However, because the density of these life stages are comparatively low in the construction area, these effects are expected to be insignificant. The adults are mobile and able to avoid any areas of distrubance. Under these circumstances, no adverse effects on silver hake populations are anticipated as a result of construction.

4.2.3.3 Impacts of Plant Operation

Entrapment. Silver hake will be potentially vulnerable to entrapment since they are oceanic and pelagic. Silver hake have not been found in large numbers in Block Island Sound as far inshore as the proposed intake location. Monthly otter trawl sampling from April 1974 through March 1975 near Station A, the intake location, failed to catch a single silver hake. Additionally, gill nets set for six to eight hours at Station BIS-A (Figure G.2.2-1) on ten separate occasions from September 1974 through March 1975 yielded only six silverhake. From May 1975 through March 1976, a commercial dragger made twice monthly sets near the proposed intake and at a point offshore (near Station BIS-C). The total catch of silver hake offshore was 330 compared to only 12 near the proposed intake. This data strongly indicates that silver hake do not occur in numbers near the intake, and, therefore, will rarely be subjected to entrapment.

For those few silver hake that do occur near the intake, entrapment is not believed likely. According to Bigelow and Schroeder (1953), silver hake are strong, swift swimmers. In addition it is anticipated that this species will be adequately protected by the velocity cap intake particularly since there is no entrapment record of its counterpart species, the Pacific hake (Merluccius productus) at operating velocity cap intakes in California. The impact of entrapment on the silver hake population is, therefore, expected to be insignificant.

Within the Discharge Plume. The silver hake is a cold water fish as are all members of the family Gadiae. Bigelow and Schroeder (1953) report that the adults are not found in abundance above 64°F. Because of their swimming ability adults are not expected to be affected by the plume.

Most eggs are apparently spawned at water temperatures between 45-55°F; however, the eggs are buoyant and apparently incubate most successfully at temperatures of 55-60°F (Bigelow and Schroeder, 1953). During 1974 and 1975, applicant has observed eggs and larvae at temperatures of 49.1-76.6°F and 56.3-73.4°F, respectively, at some locations in Block Island Sound. The temperatures of peak abundance for egg and larvae were roughly 62.6-71.6°F and 59-68.9°F, respectively. If we make the very conservative assumption that each of the two early life stages will not survive if exposed to temperatures above those observed, then both the eggs and larvae will be viable throughout the major period of presence and only a very small number will be killed at the end of the spawning season.

Additionally, it must be noted that most of the Block Island Sound eggs and larvae were found at the offshore stations. Furthermore, the densities found anywhere were low, indicating that Block Island Sound is not an important spawning area. The Gulf of Maine is probably this species' most prolific nursery area (Bigelow and Schroeder, 1953).

It is, therefore, concluded that the thermal discharge will have little or no effect on the silver hake population.

In-Plant Effects. Silver hake eggs occurred at the location of the proposed intakes for approximately 84 days and 56 days during 1974 and 1975, respectively. Silver hake larvae occurred for 49 and 56 days, respectively, during the same period.

Based on the calculated densities of silver hake eggs and larvae and assuming a 100% plant load during their period of occurrence, 3.054×10^7 eggs and 8.614×10^5 larvae would have been entrained in 1974 and 1.108×10^8 eggs and 4.281×10^6 larvae would have been entrained in 1975. Entrainment may be compared to either the equivalent number of females necessary to produce the number of eggs and larvae entrained or to the number of sexually mature silver hake that would have developed from the entrained eggs and larvae. The model utilized to evaluate entrainment losses with respect to the adult population is the same as that presented in Section 4.1.2.2..

Based on two years worth of larvae/egg ratios collected by Applicant at Charlestown, the survivorship from egg to larva (S_e) is 0.033. In the model, F represents the fecundity of a breeding pair during their life. Since the available data does not allow the prediction of a lifetime fecundity, this analysis conservatively assumes that an individual female spawns only once; Sausken and Serebryakov (1968) present an average fecundity value of 343,000 for 25-30 cm females. As adults average 14 inches (35.6 cm) (Bigelow and Schroeder, 1953) this fecundity is probably conservatively low. From this information, it is calculated that the survivorship from egg to adult is:

$$S = \frac{2}{343,000} = 5.8 \times 10^{-6}$$

and survivorship from larvae to adult is

$$S_1 = \frac{5.8 \times 10^{-6}}{0.033} = 1.8 \times 10^{-4}$$

The loss due to entrainment, therefore represents

$$(3.054 \times 10^7)(5.8 \times 10^{-6}) + (8.614 \times 10^5)(1.8 \times 10^{-4}) = 332 \text{ adults}$$

during 1974 and

$$(1.108 \times 10^8)(5.8 \times 10^{-6}) + (4.281 \times 10^6)(1.8 \times 10^{-4}) = 1413 \text{ adults}$$

during 1975.

If the projected loss is compared only to spawning females, the 1974 and 1975 entrainment projections equate to 166 and 707 individuals, respectively.

If the average weight of a mature silver hake is assumed to be one pound, then the equivalent loss of gravid females from entrainment in 1974 and 1975 is equal to 0.003% and 0.01% of the 1975 Rhode Island commercial silver hake landings (5,347,000 pounds). Similarly, the number of silver hake that would have developed from the entrained eggs and larvae is equal to 0.006% and 0.02% of the Rhode Island silver hake landings in 1975.

These numbers are considered to be very conservative, but even if values by two orders of magnitude higher were assumed, no appreciable harm to the silver hake population is predicted as a result of entrainment.

If is, therefore, believed that the impact of entrainment on the population of silver hake will be insignificant.

Total Impacts. While the silver hake is an important commercial species in the deeper waters of Block Island Sound, neither the adult nor ichthyoplankton is common in the vicinity of the proposed intake and discharge. This lack of abundance by itself is enough to conclude that the operation of NEP 1 and 2 will not have a significant effect on the Block Island Sound population.

Additionally, the eggs and larvae have been observed in Block Island Sound at temperatures approaching those expected in the thermal plume, and the adults are quite capable of avoiding both the plume and the intake currents. Furthermore, there is no record of its counterpart species, the Pacific hake, being entrapped at operating velocity cap intakes in California. It is, therefore, concluded that there will be no appreciable harm to the silver hake population as a result of plant operation.

4.2.4 Striped Bass (Morone saxatilis)

4.2.4.1 Life History.

On the Atlantic coast, the range of the striped bass extends from the St. Lawrence River to Louisiana (Merriman, 1941). Its center of abundance is the mid-Atlantic Bight region (Cape Cod to Cape Hatteras) where 80 percent of the commercial catch is taken and where most of the recreational fishing for this species takes place (Saila and Pratt, 1973).

The striped bass is a migratory species that may travel considerable distances along the coast during spring and fall. The majority of bass caught along the shores of southern New England during late spring, summer and early fall originate from the Chesapeake Bay area, where they hatched and where the majority return each fall. According to Chapoton and Sykes (1961), large bass tend to winter along the coast of North Carolina. According to Merriman (1941), both the spring and fall migrations are triggered by water temperatures of approximately 7°C (45°F). These populations are supplemented to a certain extent by fish originating in the Chesapeake (Saila and Pratt, 1973).

The striped bass is a carnivore, although not particularly discriminate in its feeding habits. It is evident from Raney's (1952) review of the subject that smaller fish constitute the bulk of its diet, with such species as silversides, menhaden, mummichogs and anchovies being particularly prominent. However, various invertebrates such as prawns, crabs, snails and clams are also included

This is an anadromous species that spawns in the major tributaries draining into the mid-Atlantic. Major spawning areas include the rivers entering Chesapeake Bay, Pamlico and Albemarle Sounds in North Carolina, and, to a lesser extent, the Delaware and Hudson Rivers and smaller rivers to the north. Bass reportedly spend their first two years in the estuary in which they hatched. The males tend to mature somewhat more rapidly than the females, reaching sexual maturity by the end of their second or third year, whereas the majority of females do not become mature until their fifth year. Bass have been known to attain a weight of 125 pounds, although such fish are exceptional (Bigelow and Schroeder, 1953).

Charlestown Beach is reportedly a favored area for recreational striper fishing, which is done both from the shore and from boats working off the beach. The results of gill netting in Ninigret Pond during 1975 indicated that bass were present as late as November. Although bass have been known to winter over in New England estuaries, there is no evidence that they have done so in Ninigret Pond during the past few years.

4.2.4.2 Impacts of Construction.

The adults are found in the area from spring until fall, but they have sufficient mobility to avoid the construction activity. However, it is possible that because of their feeding habits and food preferences, they may be attracted to the site during construction to take advantage of aquatic organisms dislodged during construction. Because no eggs or larvae are present, they will not be affected. Under these circumstances, no appreciable harm to the striped bass population is anticiapted as a result of construction.

4.2.4.3 Impacts of Plant Operation

Entrapment. The pelagic striped bass is a possible candidate for entrapment since this migratory species adheres to the coastline during its movements. The striped bass is, however, not expected to be entrapped more than occasionally for the following reasons.

According to Bigelow and Schroeder (1953), striped bass do not migrate until they are two years old. Juvenile striped bass, which would be most vulnerable to entrapment (CZC, 1979), do not occur in Block Island Sound. Fish older than two years potentially could be entrapped. The average size of two-year old striped bass in the vicinity of Block Island Sound is 11 to 11.5 inches (Bigelow and Schroeder, 1953). Bibko et al. (1974) have reported that striped bass 3.5 to 8.6 inches in length have average swim speeds ranging from 1.6 to 2.8 fps. Since the striped bass that would be found in the region of the intakes should be approximately 11 inches or greater in length, their swim speeds would probably be greater than those for the smaller individuals reported above by Bibko et al. (1974). Thus, striped bass in Block Island Sound are believed to be strong enough to avoid or escape from the intakes, and Applicant is unaware of any significant entrapment problem with this species at other power plants in New England. Furthermore the west coast counterpart, Cynosicion nobilis, was entrapped by velocity cap intake in low numbers in 23% of the samples evaluted by CZC (1979). They determined that only 156 individuals were impinged on 121 sample dates.

The impact of entrapment on the striped bass population is, therefore, expected to result in no appreciable harm.

Within the Discharge Plume. The importance of the striped bass (Morone saxatilis) as a sport fish is undoubtedly the reason for the large amount of available information on its thermal tolerance (Figure G.4.2-18). Tagatz (1961) has shown that adults can tolerate abrupt changes between saltwater and freshwater at temperature differences between 45 and 80°F. Similarly, juveniles tolerate temperatures between 55 and 69°F. Meldrim and Gift (1971) in their temperature shock studies quickly increased test tank temperatures from 79 to 94°F, held this temperature for fifteen minutes, and then returned the fish to ambient conditions. This temperature regime was survived by all test subjects but there were some mortalities in two similar studies in which bass were acclimated at 66°F before the +15°F temperature pulse. Another aspect of this investigation gathered data on the ability of striped bass to avoid areas of elevated water temperature. Maximum upper avoidance temperatures of 93 and 94°F were found for bass acclimated to 81°F, while those acclimated to 41°F in winter avoided 55°F waters. Observations made by Dorfman and Westman (1970) indicate juvenile bass may survive and even feed at 95°F for short periods whereas Talbot (1964) cites Merriman (1941) who indicates that striped bass in New England can tolerate maximum temperatures of 77 to 80°F. Gift and Westman (1971) in their study increased water temperatures from an initial acclimation temperature of 68°F by 0.6 $\pm$0.1°F/hr until 80 $\pm$2°F was reached. Thereafter, the temperature was raised 2.5 $\pm$0.5°F/hr until an avoidance breakdown response was realized (avoidance breakdown is defined in Mihursky and Kennedy, 1967, as CTM). The results of their study indicate that striped bass ranging in length from 48.3-55.9 cm had an upper avoidance breakdown temperature of 86°F.

As discussed in the species' life history characteristics, the majority of bass caught along the shores of southern New England during late spring, summer, and early fall originate from the Chesapeake Bay area, where major stock recruitment to existing populations takes place. Inasmuch as spawning and development of juveniles up to two years of age takes place in these more southerly waters, the plant discharge will in no way affect these stages in the species' life history. The possiblity of interaction with the NEP 1 and 2 thermal discharge could arise during the species' migratory activities anytime during late spring or early fall. During this six to seven month interim, striped bass could encounter a plant induced surface water temperature, anywhere from a low of 53°F to a high of 75°F. This is certainly well within their temperature tolerance capabilities.

<u>In-Plant Effects.</u> Because no striped bass ichthyoplankton are present, there will be no in-plant effects.

<u>Total Impacts.</u> The only striped bass which will be potentially susceptible to effects resulting from operation of the NEP 1 and 2 cooling water system will be age two or older. These individuals may be subject to entrapment. Because they are fast swimmers

which have apparently not been entrapped in significant numbers at other power plants in New England (nor are their ecological counterparts entrapped in great numbers in California), it is believed that they will not be entrapped in large numbers at the proposed plant.

It is concluded that the striped bass population will not suffer appreciable harm as a result of the operation of NEP 1 and 2's cooling water system.

4.2.5 Bluefish (Pomatomus saltatrix)

4.2.5.1 Life History. The bluefish is a widely distributed species that supports an active recreational fishery from Maine to Florida. Depending upon the time of year, it may occur along the edge of the outer continental shelf, at depths of 100 fathoms or more, or may be found well within coastal estuaries.

The wintering grounds of bluefish that occur in the inshore waters of southern New England are not known with certainty, since adults have been captured during winter both in the deep waters at the end of the shelf as well as along the coast of Florida (Saila and Pratt, 1973). By March and April, bluefish appear off the Carolinas, off Delaware in April, and off New Jersey and New York in April and May. They usually first enter the waters of southern Massachusetts in early June and, in recent years, move eastward of Cape Cod and into the waters of Maine later in the summer.

When water temperatures drop to 12-15°C (54-59°F) in fall, the bluefish depart the coastal waters of southern New England. According to Lund and Maltezos (1970), adult fish move offshore, while young of the year and Age I fish migrate southward along the coast.

Bluefish spawn offshore in early summer, a major spawning ground apparently lying 30-80 miles off the Virginia-North Carolina coast (Norcross et al., 1974). The larvae are roughly 2 mm in length at hatching. Juvenile fish gradually work their way inshore during late summer and fall, and form schools of "snappers". At this time the fish may range from 10 to 200 cm (4-8 inches) in length. When one year of age, bluefish average 20-30 cm (8-12 inches) in length (Bigelow and Schroeder, 1953); they probably become sexually mature when three years of age.

Bluefish grow rapidly and feed voraciously upon a variety of forage species. Included in their diet are menhaden, mackerel, herring, hake, butterfish, and squid (Olsen and Stevenson, 1975), as well as sand lance and silversides.

As indicated above, the bluefish is an offshore spawner, and neither its eggs or larvae have been observed in the ichthyoplankton collections from Block Island Sound or Ninigret Pond. However, large numbers of young of the year enter Ninigret Pond in late summer and remain into November.

4.2.5.2 Impacts of Construction. Both the "snappers" and adults are found in the vicinity during the warmer months; however, they have sufficient mobility to avoid construction activity. Because no eggs or larvae are present, they will not be affected. Under these conditions, it is concluded that construction activities will have little or no effect on the bluefish.

4.2.5.3 Impacts of Plant Operation

Entrapment. Because the bluefish is pelagic and migrates close to shore, it is a possible candidate for entrapment. Swim speed studies, however, indicate that the 1.5 fps intake velocity proposed for NEP 1 and 2 is sufficiently low to adequately protect even the young bluefish which appear in southern Rhode Island during late summer and fall.

Wyllie et al., (1976) conducted numerous swim speed tests with young bluefish (NEP 1 and 2 Environmental Report, Table 5.1-1). For bluefish in the size range of 3.1-7.5 inches, they observed critical swim speeds of 1.6-3.2 fps with an average value of 2.1 fps.

Olla and Studholme (1971) studied the effect of temperature on the average daily swimming speed of adult bluefish which were 55-65 cm long. They observed daily averages on the order of 1-1.5 fps when acclimated to a temperature of approximately 20°C (68°F). As the temperature either increased or decreased from the acclimation temperature, the average swimming speed increased to approximately the same value (2.6-3.0 fps) at temperatures of approximately 12°C and 30°C (54°F and 86°F). It appears that swimming speed increases as a result of stress and that adult bluefish are capable of sustained daily average speeds of at least 3 fps; burst speeds are certainly higher still.

During their comparative entrapment study for NEP 1&2, CZC (1979) indicated that although yearling bluefish are present throughout the winter in the vicinity of the velocity cap intake at St. Lucie, Florida, no bluefish have been impinged at that plant.

As a result of the swim speed capability of both adult and juvenile bluefish as well as the lack of entrapment of this species at an operating velocity cap intake in Florida, Applicant believes that bluefish will very rarely be impinged.

Within the Discharge Plume. According to Bigelow and Schroeder (1953) bluefish are never found in any numbers where water temperatures fall below 58-60°F. As reported in the life history section for the bluefish, it is believed that spawning takes place in early summer apparently off the Virginia-North Carolina coast. As a consequence, no thermal impact upon the egg and larval life history stages is anticipated.

Any interaction that occurs between the plant thermal discharge and the bluefish will involve the juvenile and adult life history stages. Due to the migrational characteristics of this species, however, such interaction is expected only during the late spring and the early fall (Figure G.4.2-19). Gordon (1974) has personally observed bluefish in Rhode Island waters from June to late November. During the six to seven month interim, bluefish could encounter a plant induced surface temperature, anywhere from a low of 58°F to a high of 75°F.

Much has been written concerning the temperature tolerance of the juvenile or "snapper" life history stage of the bluefish. Most if not all of the published literature indicates that the bluefish is a very hardy species from the standpoint of thermal tolerance. In temperature preference studies conducted by Meldrim and Gift (1971), juvenile bluefish ranging in size from 78-125 mm were acclimated between 65-75°F. Corresponding preference temperatures were observed between 72° and 83°F. When 53-62 mm fish were acclimated at 72°F, an avoidance response was observed at 89°F. In testing responses of some estuarine fishes to an increasing thermal gradient, Gift and Westman (1971) found that 7.9 cm (average) bluefish had a mean avoidance temperature of 86.5°F and a mean avoidance breakdown response at 92.0°F. Similar results were observed for somewhat larger fish (13.9 cm) where respective mean avoidance and avoidance breakdown temperatures of 88° and 92.5°F were found.

Olla and Studholme, (1971) tested the effects of temperature on the behavior of marine finfish species, which indicated juvenile bluefish swimming activity was found to increase significantly as water temperatures rose above 27°C (81°F). Swimming speeds continued to increase until reaching a maximum at 32-33°C (89.6-91.4°F). Loss of equilibrium occurred between 34.5-35.6°C (94.1-96.1°F). Interestingly, Olla and Studholme (1971) interpret an increase in swim speed when temperatures were raised to a point as a response, at least in part, to a manifestation of avoidance behavior to thermal regimes which departed significantly from their preferred temperature. Their swimming behavior results coincide quite closely to the avoidance response temperature noted earlier by Gift and Westman (1971) and Meldrim and Gift (1971). In addition preference studies conducted by Wyllie et al. (1976), showed juveniles were acclimated from 64.4°F to 77°F. Preference temperature results ran from a low of 71.6°F (acclimation temperature: 68°F) to a high of 79.7°F (acclimation range: 71.6-77.0°F. These same authors observed an avoidance response at 87.2-89.6°F when acclimated to 68°F. Finally, in a most recent study in which preference and avoidance responses were once again tested, juvenile bluefish were found tolerant of water temperatures well in excess of those anticipated as a result of plant operation. Preference studies conducted by Terpin et al. (1977), indicates that juvenile bluefish acclimated to water temperatures from 50 to 73.4°F show water temperature preferences from a low of 64.9°F when acclimated at 50°F, to 77.9°F when acclimated at 73.4°F. In avoidance studies, juvenile bluefish (108-195 mm) were acclimated to a temperature range of 59-77°F. A low avoidance temperature of 86.7°F was observed for a corresponding acclimation temperature of 59°F while the high was found to be 95.5°F at an acclimation of 77°F. Again, these results indicate that juvenile bluefish can easily tolerate the surface maximum temperature induced by the plant.

Olla and Studholme (1971) subjected adult bluefish (55-65 cm) to swimming tests at varying temperatures above and below their 19-20°C (66-68°F) acclimation temperature. At a temperature of 39.8°C (85.6°F) they observed a significant change in the adult's average swimming speed and schooling ability which they interpreted as indicative of stress or an avoidance response. It is interesting to note that this avoidance response exceeds the highest induced surface temperature expected at the Applicant's thermal discharge by 10°F.

In summary, the published thermal tolerance studies relative to the juvenile and adult life history stages of the bluefish indicates that this species would be very tolerant of any surface temperature change that NEP 1 and 2 could induce.

Entrainment. Because bluefish do not spawn in the nearshore waters of southern New England, this species will not be subjected to entrainment.

Total Impacts. Because eggs and larvae of the bluefish are not present in Block Island Sound, entrainment of this species is not an issue. Likewise, because all affected life stages are highly motile, there should be no construction-related effects. While both the juveniles and adults will be subject to thermal plume interaction and possible entrapment, Applicant has documented that the species is too tolerant of high temperatures to be affected by the thermal plume and too fast to be frequently entrapped.

Consequently, Applicant believes that there will be no appreciable harm to the bluefish populations from the operation of the circulating water system of NEP 1 and 2.

4.2.6 Scup (Stenotomus chrysops)

4.2.6.1 Life History. Scup is a moderately important commercial and recreational species between southern New England and Cape Hatteras. Cape Ann, Massachusetts is the northern boundary of the scup's usual range; however, they are found infrequently as far north as Eastport, Maine (Bigelow and Schroeder, 1953). In the vicinity of Rhode Island, it appears that the fish arrive in three distinct cohorts, the first arrivals weigh 1-1/2 to 2-1/2 pounds, the next 3/4 to 1 pound, and the latest arrivals weigh 1/4 to 1/2 pounds. The size definition of these groups is more clearly evident in some years than in others (Neville and Talbot, 1964). During Applicant's studies, scup first appeared in April and were an important part of the commercial catch from May through November.

Scup move offshore and southward with the chilling of coastal waters in the fall. The extent of this movement is a function of the climatic conditions of the particular year. These fish and those entering the winter fishery along the mid-Atlantic states are believed to be substantially of the same stock (Neville and Talbot, 1964).

Young-of-the-year fish were identified at the site during experimental trawls of late summer and fall of 1975. Relatively few scup eggs and larvae have been observed in the ichthyoplankton collections, suggesting that this sector of Block Island Sound is not a particularly favorable spawning area. The temporal and spatial distribution of the eggs and larvae are presented in Figures G.4.2-20 through G.4.2-24.

Scup are primarily bottom feeders which prefer smooth to broken ground. They feed on small crustaceans, worms, sand dollars, hydroids, squid and other similar prey (Bigelow and Schroeder, 1953).

Prior to 1900, the scup was an important component of the trap fishery. Since then, the trap fishery has declined and most scup are now taken by otter trawl. The majority of the total harvest is by sport fishermen utilizing hook and line (Gusey, 1976).

4.2.6.2 Impacts of Construction. Schools of adult scup are sufficiently mobile to avoid suspended sediments and turbidity; however, it is possible that they may be attracted to the construction area in Block Island Sound to feed on dislodged marine organisms. In the immediate area of construction, eggs and larvae could be affected; however, relatively few scup eggs and larvae have been observed in Block Island Sound. This suggests that the area is not a favorable spawning area. Under these circumstances, no appreciable harm to the scup population is anticipated as a result of construction.

4.2.6.3 Impacts of Plant Operation

Entrapment. Scup, since they are an inshore fish during the warmer months (Gussey, 1976), will be potentially vulnerable to entrapment.

Entrapment of scup is expected to be minimal however, (particularly during daylight hours) because of the following reasons. The location of the proposed intake does not appear to be in an area which might be considered prime habitat for scup. Secondly, they are strong-swimming fish capable of sustained swimming speeds in excess of five body lengths per second and even higher burst speeds. For example, Wyllie et al. (1976) have shown that this species has a critical swim speed of 1.8-2.3 fps which would allow these fish to avoid or escape the intakes. In addition, scup tend to hug the bottom during daylight hours thereby reducing the likelihood of diurnal capture by a midwater intake structure. Also scup are exceedingly wary fish; they are seldom seen by SCUBA divers despite their great abundance (this is in marked contrast to easy observation of sargo and walleye surfperch in California). Lastly, scup are not conspicuous in the impingement sample of coastal generating stations with conventional shoreline intakes (CZC, 1979). Consequently, the impact of entrapment is not expected to result in appreciable harm to the scup population.

Within the Discharge Plume. Bigelow and Schroeder (1953) report that scup are so sensitive to low water temperatures that large numbers have been known to perish in sudden cold spells in shallow water. Neville and Talbot (1964) and Thompson et al., (1971), both describe an avoidance response to water temperatures of 45°F or below.

The likelihood of thermal impact upon the adult life history stage of this species is anticipated to be minimal for several reasons. First, the range of this species implies that they exist in waters where temperatures equal or exceed those anticipated as a result of plant operation (NOAA, 1973). Second, adults can move from an area should it prove unsuitable.

Similar to the adults, any impact upon the early life history stages of this species resulting from the thermal plume is expected to be negligible. Incubation of scup eggs is reported to occur at water temperatures which are almost equivalent to the warmest temperatures projected at the site; scup eggs are buoyant with incubation occurring in 40 hours at 72°F (Bigelow and Schroeder, 1953). Additionally, very low numbers of eggs and larvae were found in the ichthyoplankton.

In-Plant Effects. Scup eggs were present at the location to the proposed intake for 91 and 56 days in 1974 and 1975, respectively. Scup larvae for the same periods occurred for 42 and 44 days, respectively.

If NEP 1 & 2 had been operating at full load during the period when scup eggs and larvae were present, 2.946×10^7 eggs and 2.169×10^6 larvae would have been entrained in 1974. During 1975, 1.299×10^8 eggs and 7.429×10^6 larvae would have been entrained.

The entrainment can be equated to the number of sexually mature scup that would have developed from the entrained eggs and larvae by assuming that, during her life, a single female produces only two offspring which reach sexual maturity. The calculations are the same as described in Section 4.1.2.2.

The fecundity of the scup was estimated in the Jamesport 316 demonstration to be 30,000 eggs. This estimate is based on a relationship between maximum egg size and minimum body weight. This estimate is considered conservative. For comparison, P. A. Isaacson of the New York Public Service Commission, in testimony before the New York State Board of Electric Generation, Siting and Environment, Case 80003, estimated the lifetime fecundity of scup to be 250,000 and the annual fecundity to be 144,000. His estimates were based on the analysis of three fish.

The average spawning life of the scup is estimated to be 1.25 years by assuming an 80% annual mortality (Finkelstein, 1971). Therefore, based on the conservative fecundity estimate of 30,000 eggs, the average sexually mature female scup produces 37,500 eggs during her spawning life.

Since the scup egg has a relatively short incubation time of two to three days (Bigelow and Schroeder, 1953), the egg to larval ratio is considered an estimate of the egg-to-larval survivorship. The average egg-to-larval ratio for 1974 and 1975 for all Block Island Sound Stations is 10 to 1. The average egg to larval ratio for Station A is 15.5 to 1. The best estimation of the actual egg-to-larval ratio is based on the maximum number of stations. However, since the higher egg-to-larval ratio adds conservatisms to the calculation, it will be used. The larval entrainment in 1974 and 1975 is, therefore, equivalent to 3.36×10^7 and 1.15×10^8 eggs, respectively.

Based on the total spawning life fecundity, the predicted egg and larval entrainment, and the assumption that only two sexually mature scup will develop from the lifetime spawn, the entrainment by NEP 1 and 2 during 1974 and 1975 would have resulted in a loss of 3,360 and 13,100 scup, respectively. If the average scup is assumed to weigh 1 pound, then the entrainment is equal to 3,360 and 13,100 pounds of scup for 1974 and 1975 respectively.

The Rhode Island commercial scup landing for 1975 was 5,357,000 pounds. However, the average Rhode Island commercial scup landing for the years 1971, 1973 and 1975 was 3,802,000 pounds. Since the lower number adds to the conservatism, it will be used. The number of scup potentially lost due to entrainment in 1974 and 1975 is, therefore, equivalent to 0.08% and 0.3%, respectively, of the average commercial scup landings.

These estimates are considered conservative, but even if the value is an order of magnitude greater, the loss of scup is predicted to result in no appreciable harm to the population.

Total Impacts. The scup is a warm water species which exists seasonally in New England. It naturally exists in waters warmer than will be found within the thermal plume, and there should be, therefore, no impact from this source.

Entrapment is likewise expected to present no significant problem: (1) because of the relative scarcity of scup inshore; (2) because of their relative strong swimming capability, (3) because they apparently have not proven vulnerable to entrapment at other power plants in New England, (4) because of their preference for the bottom during daylight hours thereby reducing the likelihood of capture by mid water intake, and (5) because scup are exceedingly wary fish.

Scup eggs and larvae are present in relatively low densities in Block Island Sound. Because this is not an important nursery area, entrainment will be equivalent in effect to less than one-half percent of the Rhode Island commercial scup landings.

It is concluded that the scup population will not suffer appreciable harm as a result of the operation of NEP 1 and 2's cooling water system.

4.2.7 Cunner (Tautogolabrus adspersus)

4.2.7.1 Life History. The cunner is a small, predominately coastal fish which, in New England waters, is found from the tide mark seaward among rocks, pilings and algal fronds (Bigelow and oeder, 1953). The range of the cunner extends from the Gulf of St. Lawrence to the Chesapeake Bay (Johnsen, 1925; Bigelow and Schroeder, 1953). It is a ubiquitous species of little direct commercial or recreational value and one generally regarded as a nuisance to fishermen.

The cunner is an omnivorous species. As larvae, the food consists chiefly of small crustaceans copepods, amphipods and isopods. According to Shumway and Stickney (1975), the diet of the adult cunner in Narragansett Bay consists primarily of the barnacle (Balanus balanoides) and two species of bivalve mollusks, the Atlantic sea mussel (Mytilus edulis) and the soft shell clam (Mya arenaria). Other forms represented in the cunner's diet included various species of macroscopic algae, sponges, coelenterates, polychaete worms, crustacea, mollusks, bryozoans, ascidians, and small fish.

In Block Island Sound, Labrid-Limanda eggs (the cunner, tautog and yellowtail flounder eggs were generally grouped because of the difficulty in differentiating them) occurred in the collections primarily during the period 22 May - 24 July 1974, and 20 May - 23 July 1975 (Figure G.4.2-25). Peak abundance of eggs occurred in the Pond at the sampling station nearest the breachway, suggesting that some if not most, of these had orginated in the Sound and were swept into the Pond by the tide. In Block Island Sound, the eggs were found in highest concentrations at the sampling stations nearest shore and east of Ninigret Pond's breachway (Figures G.4.2-26 and G.4.2-27).

Labrid-Limanda larvae were extremely rare in the Ninigret Pond collections, particularly in comparison with those from Block Island Sound. Larvae were generally abundant between Charlestown Beach and Block Island and comprised a high percentage of total larvae during the summer months.

At the age of one year, cunner are approximately 5 cm (2 inches) in length. After two years, they are approximately 10 cm (4 inches) and after three years, 15 cm (6 inches). At the age of six years, length may average 25 cm (10 inches) (Bigelow and Schroeder, 1953). Observations by Serchuk and Cole (1974) in the Weweantic River estuary in Massachusetts suggest a somewhat lower rate of growth, i.e., fish three and six years old average 12.5 cm and 20.4 cm in length, respectively.

The temporal and spatial distribution of cunner eggs and larvae (Labrid-Limanda group) are depicted in Figures G.4.2-25 through G.4.2-29.

4.2.7.2 Impacts of Construction. Cunner are mobile enough to avoid construction activities; however, it is possible that they will be attracted to the site during construction to feed on the displaced bottom organisms. It is, also, possible that increased suspended sediments and turbidity in the immediate area of construction may adversely affect eggs and larvae passing through the construction site. However, because of the short time interval and area involved, and because the cunner is not of great commercial or recreational value, and because of its great abundance in Block Island Sound, no appreciable harm to this species is anticipated as a result of construction.

4.2.7.3 Impacts of Plant Operation

Entrapment. The cunner is one of the species which may be entrapped regularly in relatively low numbers since they are an abundant coastal fish closely associated with rocks, pilings and underwater structures, and small cunners are not strong swimmers. Underwater site inspection revealed that cunner do inhabit the area of the proposed intake. The level of entrapment is not readily predictable since no density statistics are available for cunner at the intake site. The impact is, however, expected to be highly localized since cunner are non-migratory, and according to Bigelow and Schroeder (1953), they never depart from the bottom or rocks about which they make their home. Since the bottom in the vicinity of the intake is characterized by non-continuous rocky outcrops, only those cunner inhabiting the immediate area of the intake will be readily vulnerable to entrapment. Those living in the surrounding areas should be less likely to be entrapped, becoming vulnerable only when they move into and repopulate the intake area. Other factors which would suggest that entrapment of cunners should not be very significant include: (1) there has been a low entrapment of their counterpart species, the opaleye, in southern California, (2) cunners are inactive at night and not available in the winter, (3) the largest cunners tend to inhabit deeper waters, (4) cunners are grazers and are well adapted to wave surge conditions (CZC, 1979).

The impact on the cunner population is, therefore, predicted to be insignificant.

<u>Within the Discharge Plume.</u> As reported earlier, the cunner is a ubiquitous species found in abundance along the Rhode Island coastline.

Haugaard and Irving (1943) reported that the cunner can tolerate water temperatures as high as 29-30°C (84.2-86°F) after existing at a field temperature of 18-22°C (64.4-71.6°F). They also reported that test fish acclimated to winter temperatures of 1-3°C died when test temperatures exceeded 25-26°C (77-78.8°F). DeSylva (1969) corroborates the summer test observation made by Haugaard and Irving by reporting an upper lethal temperature of 84.2°F.

Based on field data collected at the site, Applicant observed that cunner spawn during the months of May-August at temperatures ranging from 15°C (59°F) to 20°C (68°F), whereas Bigelow and Schroeder (1953) describe a somewhat broader spawning range of 55-72°F. Hatching usually occurs within two days at temperatures of 70-72°F (Bigelow and

Schroeder, 1953).

From a temperature tolerance standpoint, the cunner appears to be a hardy species able to withstand test temperatures as high as the mid to upper-seventies during the winter and the mid-eighties during the warmest summer months. This species' upper temperature tolerance makes it well suited to withstand the six degree surface temperature increase anticipated within the boundary of the mixing zone. The temperature information on the cunner is presented in Figure G.4.2-30.

In-Plant Effects. An extensive analysis predicting the effects of entrainment losses on the local cunner population was conducted by Stone and Webster Engineering Corporation (1976). The model utilized by S&W in their predictions was a density-independent eigen value model which incorporates a Leslie population projection matrix. The biological interpretation of the eigen value is the finite population growth rate.

In their analysis, S&W assumed an annual entrainment rate of 8.07×10^9 eggs and 4.7×10^8 larvae. The small differences between S&W's entrainment rates and those presented in Table G.4.1-2 result from S&W's use of the Simpson rule for numerical integration and Applicant's use of the trapezoid rule. In their model, S&W predicted that entrainment would result in an annual population reduction rate of .0008. The very conservative assumption was then made that this species has no density dependent compensatory mechanism and the loss rate was applied additively for each of the years that NEP 1 and 2 operated. It was also assumed that all Labrid-*Limanda* eggs were cunner. If the egg ratios of the three species involved have the same ratio as their larvae, then only 72% of the eggs are cunner (Table G.2.2-8). Under these conditions, the net effect after 40 years of continuous operation at 100% load (approximately 80% load is expected) would be a 3.03% reduction in the population size. Considering the conservatism built into the model, it must be concluded that the effects of entrainment of cunner ichthyoplankton into the NEP 1 and 2 cooling water system will be negligible.

Total Impacts. The cunner is a species which may be regularly entrapped in small numbers and entrained in fairly large numbers. The small number of adults lost will not be likely to significantly affect the large ubiquitous population. A mathematical model developed by Stone and Webster Engineering Company conservatively predicted a loss rate of adults due to ichthyoplankton entrainment. This model predicts that the affected population will be reduced in size by a factor of 0.08% during one year assuming no population compensatory mechanism. It is important to emphasize that the 0.08% annual population size reduction is a very conservative upper limit, because without density dependent compensatory mechanisms, extinction is inevitable in all species. Additional conservatisms built into this model are (1) the assumption that all Labrid-Limanda eggs are cunner, and (2) the plant will always operate at 100% load.

The analysis of thermal tolerance information indicates that temperatures expected in the thermal plume will not adversely affect the cunner.

Applicant believes that the cunner population will not be subjected to appreciable harm by the operation of NEP 1 and 2's cooling water system.

4.2.8 Sand Lance (Ammodytes americanus)

4.2.8.1 Life History. The genus Ammodytes is a circumpolar and, at least in the Atlantic, the taxonomy is uncertain. It appears that the European species, A. tobianus, is a distinct species, however, there is such great similarity in the western Atlantic species A. americanus and A. dubius, and the European species A. marinus that all three may in fact, simply be races of one species (Reay, 1975). It, therefore, seems reasonable to consider the biology of these other "species" since little detailed work has been conducted on A. americanus. The American sand lance (A. americanus) is found along the North American Atlantic coast from Cape Hatteras to the Gulf of St. Lawrence and may be found as far north as Hudson Bay (Bigelow and Schroeder, 1953).

The principle economic importance of A. americanus in New England is indirect. They are a major bait or forage species for a variety of predators such as cod, mackerel, silver hake, striped bass and bluefish. Whales and porpoises consume great numbers of them (Bigelow and Schroeder, 1953) as do various seabirds, notably the terns which nest along our coast. In Europe, sand lance, primarily A. marinus are marketed for human consumption, and a similar fishery is under study by the National Marine Fishery Service (R. Livingstone, Personal Communication). Initially, such a fishery would probably focus on the larger, offshore species, A. dubius.

Sand lance are generally found associated with clean sand or fine gravel substrates, and avoid rocky, muddy or coarse gravel bottoms. Kuhlmann and Karst (1967) studied the behavior of A. tobianus in inshore waters of the Baltic. They observed fish emerging from the sand in small groups at dawn. These groups then merged to form large schools in excess of 1000 individuals which swam approximately 1000 meters to the sea-grass feeding grounds. The school returned to the sandy habitat around mid-day and spent the afternoon close inshore.

Sand lance do not have teeth and are planktivorous. Richards (1963) observed that 10 species of pelagic crustaceans comprised most of the diet of Long Island Sound A. americanus. His findings are consistent with those of Covill (1959) who described the food of post-larvae from the same area.

Most A. marinus become sexually mature at age two and essentially all individuals are mature at age three. Macer (1966) reported that 5%, 80%, and 98% spawned at the respective ages of one, two and three. Ammodytes americanus spawns in the winter and early spring. The eggs are demersal and adhesive, and the larvae occur in Block Island Sound from December through mid June (Figure G.4.2-31).

Larvae are more plentiful nearshore (Figures G.4.2-32 and G.4.2-33), and are found throughout the water column (Norcross et al., 1961). The oldest reported age of A. americanus is 9 years (Macer, 1966).

Applicant obtained length and weights from a random sample of 155 adult A. americanus (61 females, 94 males) obtained in Newburyport, Massachusetts during the month of October (just prior to the spawning season). The length-weight regression equation for this species was

$$\text{Weight (g)} = 0.0697\ \text{Length (cm)}^{1.7152}$$

The average weight of the sample was 5.05 g, and the average length was 12.15 cm. Scott (1968) reported that the average length of A. americanus he collected in Newburyport was 12.7 cm.

4.2.8.2 Impacts of Construction. Adult sand lance are sufficiently mobile to avoid the construction area, and the large amount of time spent in the sand implies that they are capable of tolerating highly turbid conditions and should not be harmed by any turbidity increase. Because the eggs are demersal and adhesive, those few which may be in the construction area will be lost. It is also expected that a comparatively small number of larvae will be affected. Under these circumstances, no appreciable harm to this species is anticipated as a result of construction.

4.2.8.3 Impacts of Plant Operation.

Entrapment. The potential for sand lance entrapment is judged to be low to medium and is expected to be highly seasonal.

Fishery statistics indicate that the sand lance is highly seasonal in its susceptability to capture. Data presented by Reay (1975) indicates that virtually the entire North Sea catch takes place from April through August. The literature generally supports the unavailability of free-swimming sand lance during the winter months and yet Macer

(1966) and Cameron (1958) were able to obtain some specimens year round. In spite of their absence from the catch, the presence of larvae in the winter adequately demonstrates that adults are present even though they may spend little time in the water column. Winslade (1974) concluded that A. marinus spent most of the time from August through April buried in the sand. As a result of the above plus the diurnal patterns described by Kuhlmann and Karst (1967), and Winslade (1974) it is believed that the sand lance will only be a potential candidate for entrapment during daylight hours of the warm months.

Kuhlmann and Karst (1967) estimated that A. tobiunus usually swam at a speed of 30 cm/sec (roughly 1 fps), and that they were capable of short escape bursts to speeds of 300-500 cm/sec (9.82-16.37 fps). Wyllie et al. (1976) determined that the critical swimming speed (essentially a predicted sustained swimming speed) for one 13.3 cm Ammodytes sp. from a New Jersey estuary (therefore, probably A. americanus) was 0.93 fps. It is therefore, evident that the burst swim speed of the sand lance should easily permit this fish to escape the 1.5 fps velocity at the lip of the proposed intake.

Due to the burst swimming speed, the short period of time during which the sand lance will be subjected to entrapment and its performance for water over unobstructed sand bottoms and its failure to be attached to reef-like structures, it is expected that this species will only be impinged occasionally. Therefore, there will be no appreciable harm to the local population of sand lance as a result of NEP 1 and 2's operation.

Within the Discharge Plume. As a result of their investigation of sand lance larvae along the inner continental shelf waters off lower Chesapeake Bay, Norcross et al. (1961) theorized that spawning takes place before bottom temperatures reach $9^{o}C$ ($48^{o}F$).

Since the eggs are demersal and adhesive, the possibility exists for a portion of the discharge plume to interact with sand lance eggs. If a worst case analysis were made whereby sand lance eggs were assumed intolerant of a 6°F temperature rise then approximately two bottom acres could be affected. Inasmuch as the area that could be affected is small relative to other sand lance spawning sites, any associated impact is considered inconsequential as a result.

Applicant collected sand lance larvae in Block Island Sound from mid-December through mid-June (Figure G.4.2-31). Water temperature profiles during the last collection containing sand lance larvae were 9.9°C bottom to 14.1°C surface on June 4, 1975 and 12.2°C bottom to 14.0°C surface on June 17, 1976. It is, therefore, certain that Block Island Sound sand lance larvae are naturally found in water whose temperature exceeds 12.2°C (54.0°F). On the warmer of these two days (June 17, 1976) the integrated water temperature (bottom to surface) at the sample (and intake) location was 13.2°C (55.8 °F). If for the sake of conservatism, it is assumed that any larvae subjected to temperatures greater than 13.2°C will not survive, then a worst case analysis of the effects of the 6°F temperature rise may be made.

Six degrees Fahrenheit less than 13.2°C is 9.9°C (49.8°F). Based on surface water temperatures at the time of actual collections, Applicant calculates that 99.7% and 99.8% respectively of the 1975 and 1976 sand lance would have metamorphosed prior to the "critical" value of 9.9°C. In view of this fact and considering the small area involved (i.e., $\leq$1 surface acre) and conservatism in the calculation, it is believed that sand lance population will not be adversely affected by the surface discharge plume.

Adults, of course, are able to choose their own temperature preferenda and will not reside in the plume if the water is too warm.

<u>In-Plant Effects.</u> Because *A. americanus* has demersal adhesive eggs, entrainment will not affect this life stage. Sand lance larvae, on the other hand, were present at the location of the proposed inlet for an estimated 194 days in the winter of 1974-75 and

218 days during the winter of 1975-76. The estimated number of larvae which would have been entrained during these two years is 1.763×10^8 and 4.577×10^7 respectively if 100% plant load is assumed.

The University of Rhode Island, Marine Experiment Station is currently conducting studies on the biology of Ammodytes americanus for Applicant. Fecundity is being determined by counting all eggs from fish captured in October from Newburyport, Massachusetts. Calculations on counts from ten females ranging in total length from 10.8 to 15.6 cm has resulted in the following length fecundity regression equation:

$$\text{Fecundity} = -15098.34 + 1629.56\ (\text{Length, cm})$$

Within this size range, the data appears linear; the r^2 of the data set was 0.81.

The above regression was then applied to the total lengths of 61 randomly selected female sand lance in order to estimate the fecundity of the "average" individual. From this analysis, it was determined that the average female is 11.86 ± 1.12 cm total length and has a fecundity of 4232. In spite of the fact that sand lance live for many years, Applicant will conservatively assume for this analysis that they spawn only once.

The model utilized to analyze the effects of entrainment was previously described in Section 4.1.2.2. Briefly, this model assumes that, on the average, a female will produce only two offspring which reach the age of reproduction.

As an estimate for the survivorship of sand lance eggs (S_e) is not available, a series of analyses will be presented based on S_e values of 0.01 and 0.50, the true value probably falls somewhere between these two and closer to the high value. From these values, the survivorship expectation of a given larvae (S_1) may be calculated with the equation.

$$S_1 = \frac{2}{(\text{Fecundity})(S_e)}$$

Thus, when S_e - 0.01, S_1 = 0.047 and when S_e = 0.50, S_1 = 0.00095. The projected number of adults which may be lost as a result of entrainment is calculated by multiplying S_1 times the entrainment estimate. The predicted losses of adults is described by the following matrix:

		1974-75	1975-76
S_e	0.01	8.286×10^6	2.151×10^6
	0.50	167,485	43,481

Thus, the annual estimate of adults lost as a result of entrainment falls somewhere between 43,000 and 8,300,000 per year.

It is also possible to back calculate the e ivalent number of females whose spawn would be lost as a result of entrainment by dividing the numbers in the above matrix by two. Thus, the spawn of between 22,000 and 4,150,000 females is expected to be lost to entrainment.

Utilizing the length-weight equation presented in the life history section, it is calculated that the average reproductive female sand lance weighs approximately 4.8 grams. Thus, 4,150,000 females would weight 19,920 kg while 8,300,000 lost adults (average weight 5.05 g) would weigh 41,915 kg. To put this upper limit of weight lost to the population in perspective, these numbers may be compared to the catch of the European sand lance fishery.

Bertelsen and Popp Madsen (1958) reported that the average peak catches for a 75 vessel North Sea fishing fleet during late May and early June was 2,500 kg per hour. The vessels averaged 10,000 kg/day/km^2. Macer and Burd (1970) referenced catch rates up to 15,000 kg/hour. Compared to catch rates like these and considering the great conservatism in the calculations, the effect of NEP 1&2 must certainly be viewed as very small.

Total Impacts. Some sand lance eggs may be found in the vicinity of the construction activities in Block Island Sound; these eggs will be lost. Construction is, however, a small area and short duration impact. Sand lance larvae are expected to be entrained frequently, however, based on the projected loss to the population, there will be no appreciable harm to the species. Likewise, the effect of the thermal discharge should be trivial because: 1) the eggs will not be present, 2) the larvae are thermally tolerant and 3) if they are not thermally tolerant, the adults are capable of leaving (if they even encounter the plume). Entrapment of this species is likely to be an infrequent event because of the amount of time the adults spend buried in the sand, their high burst swimming speed, and their preference for water over unobstructed sand bottoms and its failure to be attracted to reef-like structures.

It is believed, therefore, that the operation of NEP 1 and 2's circulating water system will result in no appreciable harm to the sand lance population.

4.2.9 Atlantic Mackerel (Scomber scombrus)

4.2.9.1 Life History. The Atlantic mackerel is a far-ranging species found on both sides of the Atlantic Ocean. On the western side of the Atlantic, its range extends from the Gulf of St. Lawrence to North Carolina (Bigelow and Schroeder, 1953). It is oceanic rather than estuarine in habit and usually travels in dense schools anywhere from the surface to depths of 200 fathoms.

Mackerel become sexually mature when two years of age and an average female produces 360,000-450,000 eggs (Sette, 1943). For the 1932 year-class, Sette (1943) estimated that, for every million eggs laid, only four fish survived to an age of three months. Sette further estimated a total mortality rate of 0.0012 (0.12%) per day between the age of three months and three years.

According to Sette (1943), the most important spawning area for this species is along the coast of the southern New England and mid-Atlantic states. Within this region "...the area of densest distribution occupies about the inner half of the shelf off New York..." In 1973, mackerel spawning was most intensive in the area of Narragansett Bay during the third and fourth weeks of May (Marine Research, Inc., 1974). As noted in this report, spawning was most intensive near the mouth of the Bay, indicating the preference of this species for an oceanic habitat.

During 1974 and 1975, spawning was intensive in Block Island Sound throughout the month of May (Figure G.4.2-34). Few eggs and even fewer larvae were found in the Ninigret Pond collections; those that did occur in the Pond were found at the sampling stations nearest the breachway. Larval abundance reached a peak in the Sound near mid-June in both years. It was noted during 1975 that the concentration of both eggs and larvae increased in an offshore direction; larval densities were found to be significantly higher at sampling stations located well offshore than at those located inshore (Figures G.4.2-35 through G.4.2-38).

According to Bigelow and Schroeder (1953), mackerel average 22.8 cm (9 inches) in length after one year, 27.9 cm (11 inches) after two years, and 35.5 cm (14 inches) in length after three years. The diet of post-larval mackerel includes pelagic amphipods, copepods, squid, launce, and pteropods (Sette, 1943), as well as molluscan larvae, polychaete worms, fish eggs, medusae and ctenophores, and a variety of small fish

(Bigelow and Schroeder, 1953).

In spite of the fact that mackerel are comparatively unimportant to the Rhode Island commercial fishery (approximately 1% of the total pounds and less than 1% of the total dollars in 1975), this species constitutes the largest single component of the ichthyoplankton in Block Island Sound (Tables G.2.2-6, G.2.2-7 and G.2.2-8). Because of the susceptibility of ichthyoplankton to plant induced entrainment mortality and the relative importance of mackerel to this component of the ichthyoplankton in Block Island Sound (Tables G.2.2-6, G.2.2-7 and G.2.2-8). Because of the susceptibility of ichthyoplankton to plant induced entrainment mortality and the relative importance of mackerel to this component of the environment, Applicant has had the effect of entrainment modeled by Stone and Webster Engineering Company.

4.2.9.2 Impacts of Construction. The mackerel is an offshore spawner whose ichthyoplankton decreases in abundance towards the shore (Figures G.4.2-35 through G.4.2-38). Because the adult mackerel have great mobility and can avoid construction activity, and because the eggs and larvae are concentrated offshore, and considering the small area and short time involved, no appreciable harm to the mackerel population is anticipated as a result of suspended sediments and turbidity caused by construction activity in Block Island Sound.

4.2.9.3 Impacts of Plant Operation

Entrapment. Atlantic mackerel are potentially vulnerable to entrapment since they are a pelagic, migratory species and are found throughout the water column in inshore waters. It is not believed that Atlantic mackerel are serious candidates for entrapment because of the following reasons. Gill netting monthly from September 1974 through March 1975 and commercial otter trawling twice monthly from April 1975 through March 1976 at the location of the proposed intake, both failed to catch a single Altantic mackerel. Since the otter trawl is not particularly selective for Atlantic mackerel, it is conceivable that schools of mid-water mackerel went undetected. However, concurrent with each otter trawl set, echo soundings were made and at no time was a sizeable school of mid-water fish observed. This evidence suggests that Atlantic mackerel do not regularly occur near the proposed intake and, hence, will not be frequently entrapped.

Additionally, mackerel are an extremely fast and powerful swimmer and it is anticipated that they will be able to avoid or escape from the intake currents. According to Bigelow and Schroeder (1953), mackerel less than one year old can sustain a speed of six knots (10 fps) while circling inside a live car. Yearlings exhibited a sustained speed of 11.5 knots (19 fps). In addition, Atlantic mackerel quickly become visually oriented. Also, the west coast ecological counterpart, the chub mackerel (Scomber japonicux) is rarely entrapped at coastal California power plants with velocity cap intakes.

Since substantial numbers of Atlantic mackerel are not expected to be entrapped, no significant impact on the mackerel population is predicted.

Within the Discharge Plume. The mackerel prefers relatively cold water, wintering along the edge of the continental shelf at temperatures of approximately 7°C (44-45°F), and is seldom found in water with temperatures exceeding 20°C (68°F) (Bigelow and Schroeder, 1953).

Adult mackerel make their annual appearance in Block Island Sound from the month of May through July - months with rapidly increasing water temperature (i.e., 46°F - 68°F). Spawning is most intensive in waters with temperatures ranging between 48 and 57°F (Sette, 1943). Mackerel eggs develop normally between 52-70°F (Bigelow and Schroeder, 1953). Altman and Dittmar (1966) cite the work of Moore (1940) who determined the upper tolerance limit of the embryo of mackerel to be 69.8°F. By the time water temperatures reach 70°F in the warmest part of the surface plume (approximately July 1), the major spawning and larval life stages will have been concluded. In 1974, only 0.18% of the eggs and 1.47% of the larvae at Station BIS A were found after this date.

The likelihood of an impact on this species as a result of Applicant's thermal plume is anticipated to be negligible when one considers the following: (1) the ability of the adult to select its preferential temperature as a result of its mobility, (2) the greater relative abundance of mackerel eggs and larvae further offshore, (3) the small numbers of eggs and larvae which will be affected, and (4) the short time frame during which these stages will be effected.

Temperature data for the mackerel is presented on Figure G.4.2-39.

<u>In-Plant Effects.</u> Mackerel represented the most abundant egg and larval components of the ichthyoplankton collected during Applicant's baseline studies (Tables G.2.2-6, G.2.2-7 and G.2.2-8). Consequently, a sophisticated mathematical model was developed in order to predict the effects of entrainment on this species (Stone and Webster, 1976).

The structure of the model is essentially that utilized by ICNAF (Lett et al. 1975). Stone and Webster made minor modifications to the model in order to allow flexibility in analyzing the effects of varying mortality rates and power station induced mortality. Input parameters include the population age distribution, age-specific mean weight, age-specific fishing mortality rates, age-specific instantaneous natural mortality rates, age-specific growth rates, a density dependent stock-recruitment function, and entrainment mortality.

The entrainment mortality is a major source of conservatism in S&W's model. Entrainment mortality was overestimated because only the peak population egg and larval productions, as estimated by the stock-recruitment function, were used to determine the percent of the spawn which was lost due to entrainment. If S&W had utilized the total annual production, the losses from entrainment mortality would have constituted a smaller fraction of the population.

A sensitivity analysis was conducted to determine (1) the effect of using various mortality rates and recruitment assumptions to estimate population size, (2) the effect of varying the various components of the stock-recruitment function, (3) the effect of varying certain density-independent variables (instantaneous natural mortality, instantaneous fishing mortality and age of recruitment), and (4) the effect of entrainment mortality.

The model was run for a total of 80 years with and without the presence of NEP 1 and 2. The modeled population underwent fairly large oscillations in size both with and without entrainment mortality included. Depending on the selected input values for the various parameters in the equations, this model conservatively predicts that after 40 years of continuous operation at 100% load (approximately 80% load is expected), NEP 1 and 2 will have caused a reduction in the mackerel population size of 0.9-3.4%. These numbers represent 6.7 and 20.7 of the natural oscillations predicted by inclusion of the respective input parameters. A sensitivity analysis on the model demonstrated that population size changes of this magnitude could potentially be caused by rounding errors in the stock and recruitment function.

Stone and Webster concluded that the model did not predict an effect of sufficient magnitude to disrupt the normal pattern of the population. While some effect was predicted, the conservatism in the model tended to magnify the effect.

Total Impacts. It has been demonstrated that effects on the mackerel population resulting from either thermal plume mortality or entrapment of adults is negligible. Population reductions caused by entrainment of the eggs and larvae of mackerel superficially appear high (0.9-3.4% after 40 years of plant operation at 100% load versus the expected 80% load factor). However, when compared to natural fluctuations and considering the conservatism S&W built into the model to ensure that the effects of the plant do not exceed the predicted value, these numbers are indeed small.

Applicant, therefore, concludes that the operation of NEP 1 and 2's cooling water system will result in no appreciable harm to the mackerel population.

4.2.10 Butterfish (Peprilus triacanthus)

4.2.10.1 Life History. The butterfish is a relatively small (6-9 inch) fish that appears along the Rhode Island coast in the spring. According to Bigelow and Schroeder (1953), butterfish stay near the surface when inshore but are found at depths up to 115 fathoms when offshore. It is primarily a warm-water fish and is found from Newfoundland to Florida. It is more abundant south of Cape Cod than to the north. Butterfish appear along the Rhode Island coast in April, probably having moved in from offshore (Bigelow and Schroeder, 1953), and they depart the inshore waters by late fall. Horn (1970) has separated Atlantic Coast butterfish into two distinct populations: an offshore, southern population that lives over mud bottoms and deep water and an inshore population, to which the Rhode Island fish belong, that extends all along the coast in shallower waters over sandy bottoms.

Bigelow and Schroeder (1953), state that spawning takes place a few miles offshore. This was also observed in Block Island Sound during these studies -the largest concentrations of ichthyoplankton were found at the stations 2-4 miles offshore. Offshore, most of the spawning activity took place in June and July while the concentrations of eggs and larvae were found inshore in July and August. Catch data from a 45' stern trawler (Table G.2.3-3) supports the thesis that the adults are primarily found offshore. The temporal and spatial distribution of butterfish eggs and larvae are presented in Figures G.4.2-40 through G.4.2-44.

As the summer progresses, young butterfish become plentiful in otter trawl catches off

Charlestown. According to Horn (1970), different size-classes of butterfish move independently during the summer months but move together offshore in deep water during the colder part of the year.

Young butterfish are regularly found in association with jellyfish medusae. Horn (1970) reports jellyfish to be the principal food of the juveniles until the fall of their first year, by which time they have reached a length of about 10 cm (4 inches). Older fish continue to feed in part on medusae, but small fish, squid, crustacea, and worms by that time have become important components of the diet.

Butterfish are a moderately valuable commercial species in southern New England whose numbers have declined in recent years as a result of heavy foreign fishing pressure (Olsen and Stevenson, 1975).

4.2.10.2 Impact of Construction. Increases in suspended sediments and turbidity in the immediate area of construction could adversely affect eggs and larvae floating through the construction site. However, because of the wide distribution of this species and its extensive spawning habitat, no significant effects are expected. The adult butterfish have sufficient mobility to avoid the construction site. Under these circumstances, no appreciable harm to the butterfish population is anticipated as a result of construction.

4.2.10.3 Impacts of Plant Operation.

Entrapment. The butterfish, since it is a coastal fish and not restricted to a specific stratum, has a medium to high entrapment potential (CZC, 1979). This entrapment potential is based on the facts that (1) the butterfish is largely planktivorous, (2) the ecologically similar species, *Peprilus simillimus*, is entrapped by velocity cap intakes in considerable numbers in southern California despite its apparently low abundance there, and (3) it may be particularly susceptible to entrapment during storm conditions. Entrapment of this species can be expected in May when immature, year-old fish arrive in coastal waters, and again in early fall when young-of-the-year reach impingible size (CZC, 1979).

There are, however, several factors which will tend to minimize entrapment of butterfish at the proposed NEP 1&2 intake location. Chief among them include the fact that butterfish do not occur inshore near the site of the proposed intake in particularly large numbers as compared to their numbers of offshore waters. Sampling inshore by a commercial otter trawl, twice monthly, from April 1975 through March 1976, yielded 882 butterfish (Figure G.2.2-2). Sampling at the offshore location with the same gear and for the same time span, yielded 6,428 butterfish. The location of the intake in boulder-strewn area is therefore, not considered to be a preferred butterfish habitat. In addition, swim speed tests with butterfish have been performed by Wyllie et al., (1976). Based on their data, the average critical swim speed for butterfish 3-3.5 inches in length is 1.8 fps which would allow this species to avoid or escape the intakes. Furthermore, the species, with its short life span, has a history of sporatic population peaks and declines, as a result, in some years few will be available for entrapment. Consequently, the potential for significant entrapment impacts is judged minimal.

<u>Within the Discharge Plume.</u> The butterfish is a warm water species which migrates into New England waters during the warmer months of the year. In this area, they have been reported at temperatures ranging between 4.4 and 22.8°C (40 and 73°F) (Horn, 1970; Fritz, 1965; Schaefer, 1967). Colton (1972) reported a minimum spawning temperature of 15°C (59°F). The eggs are buoyant and hatch in less than 48 hours at a temperature of 65°F. They probably will not develop unless the water is comparatively warm. The later statement is supported by the fact that Bigelow and Schroeder (1953) have taken a considerable number of eggs but only two larvae north of Cape Cod.

As with other species which migrate from the south, it is reasonable to assume that butterfish have a tolerance or even a preference for relatively warm temperatures. The information presented by Bigelow and Schroeder (1953) certainly suggests that the eggs and larvae will not be adversely affected by a temperature of $6^{\circ}F$ above ambient. The adults should certainly not be affected by the plume as they may avoid it in the event it is stressful.

In-Plant Effects. Butterfish eggs occurred for 154 days and 107 days, respectively, during 1974 and 1975. The larvae occurred for 105 and 76 days during the same respective periods. If NEP 1 and 2 had operated at full load during this period and assuming that the ichthyoplankton are uniformly distributed throughout the water column (the eggs have an oil globule and are buoyant), then 2.832×10^7 eggs and 6.621×10^6 larvae would have been entrained in 1974, and 8.889×10^7 eggs and 1.876×10^7 larvae, in 1975.

The entrainment of eggs and larvae can be equilibrated to the number of sexually mature fish that would have developed from the entrained forms in the same manner as described in Section 4.1.2.2.

The fecundity and survivorship of the butterfish is not documented and, therefore, an estimate of the fecundity is necessary. The fecundity of the butterfish is estimated by assuming that the volume of each ovary is approximately two cubic centimeters. Since the diameter of a butterfish egg is approximately 0.7 to 0.8 millimeters (Bigelow and Schroeder, 1953), it is conservatively assumed that each egg occupies one cubic millimeter of space in the ovary. The fecundity of an average butterfish is, therefore, predicted to be 4,000. This fecundity appears drastically small for a species with pelagic eggs, when compared to other species, and is considered conservative.

The average spawning life of the butterfish is also not documented and is, therefore, conservatively assumed to be one year. During its breeding life, it is, therefore, predicted that the average butterfish will lay 4,000 eggs.

The incubation period for butterfish eggs is a relatively short 48 hours (Bigelow and Schroeder, 1953), and, therefore, the egg to larval ratio is assumed to be a measure of the egg ' larval survivorship. The average egg to larval ratio for all Block Island Sound Stations for 1974 and 1975 is 3 to 1, while the average egg to larval ratio at Station A is 4.5 to 1. The best estimator of the actual egg to larval ratio is based on the maximum nur-ber of samples. However, since the higher egg to larval ratio adds conservatism, it will be used. The larval entrainment in 1974 and 1975 is, therefore, equivalent to 2.98×10^7 and 8.44×10^7 eggs, respectively.

Based on the calculated egg and larval entrainment and the assumed fecundity and spawning life, the operation of NEP 1 and 2 would have resulted in a loss of 29,000 and 86,700 butterfish in 1974 and 1975, respectively.

According to Bigelow and Schroeder (1953) butterfish average six to nine inches in length and weigh approximately four ounces. Based on this weight, the loss due to the entrainment of eggs and larvae is equivalent to 7,250 and 21,680 pounds of butterfish for 1974 and 1975, respectively.

The Rhode Island commercial butterfish landing in 1975 was 1,899,000 pounds. The average commercial butterfish landing for the years 1971, 1973 and 1975 was 1,433,000 pounds. Since the smaller number adds to the conservatism, it will be used. The loss due to the entrainment of eggs and larvae in 1974 and 1975 is, therefore, equivalent to 0.5% and 1.5% of the average commercial butterfish landing.

Considering the great conservatism built into the above calculations, it is concluded that the entrainment of butterfish eggs and larvae by NEP 1 and 2 will result in no appreciable harm to the population.

<u>Total Impacts.</u> Utilizing very conservative techniques, it can be concluded that the

combined impact of entrainment and entrapment on this species will be in the range of 1-2% of the Rhode Island commercial landings. If the true impact could be calculated, it would very likely be equivalent to a fractional portion of 1% of these landings. No impact is expected as a result of thermal effects within the discharge plume.

It is, therefore, concluded that no appreciable harm will result on this species resulting from the operation of NEP 1 and 2's cooling water system.

4.2.11 Winter Flounder (Pseudopleuronectes americanus)

4.2.11.1 Life History. The winter flounder is a species of considerable importance to both the commercial and recreational fisheries of New England. It is a benthic fish that is found in large numbers in the inshore area and is taken in commercial quantities from Nova Scotia to New Jersey, although its range reportedly extends from Labrador to Georgia (Bigelow and Schroeder, 1953).

Areas of maximum abundance are Nantucket Shoals, Georges Bank, Gulf of Maine and Cape Cod Bay, Block Island Sound, and Long Island Sound. Members of the offshore populations, often referred to as "lemon sole", tend to attain a larger size than do those from inshore. They attain lengths up to 60 cm (25 inches).

The inshore populations of winter flounder - often referred to as "blackbacks" in the more southerly portions of their range - are generally found in depths of 1 to 30 fathoms. These fish seldom exceed 50 cm (20 inches) in length. Although occasional pattern of movement seems to be that of inshore-offshore migrations in response to temperature (Perlmutter, 1947; Saila, 1961). According to McCracken (1963), 12 to 15°C (54 to 59°F) is the preferred temperature range.

Winter flounder range from the Gulf of St. Lawrence to the Chesapeake Bay in substantial numbers and infrequently as far south as Georgia (Bigelow and Schroeder, 1953). Adult winter flounder feed on small shrimp, amphipods, ascidians, seaworms, bivalves, squid, holothurians and hydroids (Bigelow and Schroeder, 1953).

Winter flounder become sexually mature when two to three years of age. Typically, adult fish move shoreward in the fall to spawn in relative shoal bays, inlets and estuaries (Saila, 1961; Jeffries and Johnson, 1974). Spawning in southern New England waters usually occurs during mid to late winter. Unlike most other species of flatfish, the eggs of the winter flounder are both adhesive and demersal. Hatching of the eggs south of Cape Cod may occur in February, reaching a peak during March and early April; in the colder waters north of Cape Cod, hatching may be at a maximum in early May.

Pearcy (1962) described the larval flounder as nonbuoyant and as displaying a mixed planktonic-benthonic behavior. Older larvae characteristically are found in greater abundance near the bottom than are the younger forms, and their ability to stratify enhances the likelihood of their being retained within an estuarine system even though the net water flow is seaward. At metamorphosis, which may occur two months or so after hatching, the left eye of the little flounder moves over the right side of the head as it assumes its flattened shape, giving its right-handed appearance.

The winter flounder is a species of considerable importance to both the commercial and recreational fisheries of New England. It is taken in commercial quantities from Nova Scotia to New Jersey. During the years 1971-1975, the annual commercial landings of winter flounder in Rhode Island have averaged around 4 million pounds. The value of the 1973 Rhode Island commercial catch was $877,000 (Olsen and Stevenson, 1975). It has been estimated (Deuel and Clark, 1968) that approximately 26 million pounds of flounder are caught by sport fishermen in southern New England each year.

The high percentage of tagged fish recaptured in the area of release, in conjunction with information on spawning behavior and early life history (see below), led Perlmutter

(1947) to conclude, that in southern New England at least, "...young blackback flounders are the product of local spawning..." and "...stock of adult fish drawn upon by the sport and commercial fisheries remain highly localized...".

Because winter flounder were common in both the ichthyoplankton and trawl samples, and because Ninigret Pond, like the other salt ponds on the Rhode Island coast, is a nursery area for this species, Applicant has had the effect of entrainment modeled by Stone and Webster Engineering Corporation (1976).

The temporal and spatial distribution of winter flounder eggs and larvae are presented in Figures G.4.2-45 through G.4.2-47.

4.2.11.2 Impacts of Construction. Adult winter flounder have sufficient mobility to avoid the construction area and the larvae are present in such relatively low numbers (compared to Ninigret Pond) that no appreciable harm is anticipated as a result of short term construction activities.

4.2.11.3 Impacts of Plant Operation

Entrapment. The winter flounder, because of its affinity for the bottom and because of the protruding lip of the velocity cap intake, is not expected to be vulnerable to entrapment. Support for this judgement can be devised from the California velocity cap experience with the dim~~d turbot (assumingly close ecological equivalent to winter flounder) which has shown that even the original velocity cap designs are effective in minimizing entrapment of benthic flatfish (CZC, 1979).

Additionally, winter flounder do not congregate in large concentrations near the location of the proposed intake. Twice monthly otter trawling from April 1975 through March 1976 (Figure G.2.2-1) produced only 125 fish inshore. Otter trawling offshore during the same period netted 1,393 fish. The proposed intake locations is, therefore, not considered to be prime habitat for winter flounder.

Swim speed tests with winter flounder have been performed by Wyllie et al., (1976). Utilizing their data, the average critical swim speed for flounder 3.5-7.9 inches in length was calculated to be 1.5-1.6 fps. Furthermore, the endurance of winter flounder was investigated by Beamish (1966). He found that winter flounder 7.4-9.1 inches in length could endure velocities of 2.5 and 4.4 fps for periods up to approximately 25 and 5 minutes, respectively. Consequently, it appears that winter flounder could escape or avoid the NEP 1 and 2 intakes.

Due to the low densities of winter flounder near the intake location and the bottom dwelling nature and swimming speed capability of the species, the entrapment of winter flounder is not expected to occur frequently. Therefore, no appreciable harm on the winter flounder population is expected.

Within the Discharge Plume. Much has been written concerning the temperature tolerance of the juvenile and adult life history stages of winter flounder. Winter flounder become sexually mature at two to three years of age, with spawning taking place during winter and early spring. Thompson et al., (1971) reported that incubation takes 15-18 days at a temperature of 37-38^{o}F.

Hoff and Westman (1966) conducted temperature tolerance tests on 8.6-11.3 cm juveniles. When acclimated at 7, 14, 21 and 28^{o}C (44, 57, 69.8 and 72^{o}F) and tested at the respective temperatures of 20, 23, 26 and 29^{o}C (68, 73, 78.8 and 84.2^{o}F) for one hour, no mortality was observed.

Huntsman and Sparks (1924) subjected P. americanus adults to tests in which temperatures were increased at the rate of 1^{o}C per five minutes until they succumbed. The incipient lethal temperatures for this demersal species was found to range between 82.2 - 87.1 ^{o}F. Testing the adult stage, McCracken (1963) describes their ability to orient to certain isotherms during seasonal migratory movements. From this investigation, he postulated an upper incipient lethal temperature of 27°C (80.6°F).

Gift and Westman (1971) in their study increased water temperatures from an initial acclimation temperature of 68°F by 0.6 ± 0.1°F/hr until 80 ± 2°F was reached. Thereafter, the temperature was raised 2.5°F ± 0.5°F/hr until avoidance response and avoidance breakdown temperatures were realized (avoidance breakdown is defined in Mihursky and Kennedy, (1967) as CTM or critical thermal maximum). The results of their study indicate initial avoidance behavior for one year olds at 75.5°F with an avoidance breakdown at 87°F. The authors go on to cite an upper thermal tolerance limit for one year olds at 88.3-89.17°F. Again, it is necessary to point out that due to the nature of their experimental method, the upper tolerance limits presented in Gift and Westman's investigation do not provide indications of exact lethal temperatures, but rather provide a measurement of the relative thermal tolerance of the winter flounder. Meldrim and Gift (1971) give a discrete preference temperature of 67°F when the adult is acclimated at 10°F less (i.e., 57°F). Frame (1973) describes a growth temperature range for one year old flounder between 53.6 and 60°F.

From the standpoint of plant operation, possible impact to this representative demersal species as a result of an induced 6°F temperature rise is expected to be insignificant. Such a position is based on several factors.

a. The eggs of this species are demersal and adhesive, with the majority of spawning taking place in coastal salt ponds such as Ninigret Pond. Therefore, the probability of this life history stage being involved with the thermal discharge or being affected by a design surface maximum within the boundary of the mixing zone is relatively small.

b. The literature demonstrates rather conclusively that the juveniles can tolerate water temperatures well in excess of those anticipated once the plant is operational. Temperature tolerance limits for periods when juveniles are known to occur at the site (i.e., winter and spring) exceed the projected surface maximum temperature by anywhere from 3 to 18°F.

c. As presented in Figure G.4.2-48, adult flounder are found throughout most of the year at the proposed site. Of particular relevance is that a majority of the temperatures from temperature tolerance studies conducted coincide quite closely with the warmest water temperatures that the adult would experience during the month of August. In all instances, the upper thermal tolerance limits exceed the anticipated surface maximum of 76°F that would be experienced within the boundary of the mixing zone. Impacts as a result of thermal stress are, therefore, not anticipated. Irrespective of this species' temperature tolerances, it must be kept in mind that we are dealing with a demersal species which, in all likelihood, will have minimal interface with the thermal discharge.

<u>In-Plant Effects.</u> The winter flounder is the only one of the representative important species discussed in this document which is believed to have a nearby and relatively important nursery area. This area is the Ninigret/Green-Hill Pond complex. The mathematical model which Stone and Webster (1976) used to predict the effects of entrainment on the winter flounder is a self-regenerating dynamic pool model originally developed by Hess, Sissenwine and Saila (1975). It incorporates a density-dependent stock and recruitment function which predicts age 1 recruits from the previous year's spawn. Input values include estimates of age-specific fecundity for each of the 12 year classes, natural and fishing mortality, survival from egg to age 1, standing crop and entrainment mortality. The model only addresses the effect of entrainment on the Ninigret Pond population and does not consider the populations remote from the site.

In their analysis, Stone and Webster conservatively predicted that 1.5% of the original larvae produced in Ninigret Pond would be entrained. The conservatisms in this prediction and its subsequent impact assessment include the following assumptions:

a. The larvae are randomly distributed throughout the water column;

b. The entire Pond is uniformly remixed on each tidal cycle;

c. The plant will operate continuously at 100% load; and

d. No larvae are in the "ambient" water of Block Island Sound, i.e., larvae from other sources do not metamorphose in Ninigret Pond.

The assumption that the larvae are randomly distributed throughout the water column is contrary to the findings of other investigators. Howe (1974) found that larvae were eleven times more abundant in the bottom water than in the near surface waters of Nantucket Sound. Pearcy (1962) reported that in the Mystic River estuary (Connecticut) winter flounder larvae were about six times as abundant near the bottom as they were near the surface. In that estuary, this distributional pattern resulted in an estimated loss rate less than one third of that which would have been expected had the larvae been randomly distributed.

The effect of uniform mixing of the Pond's water on each tidal cycle is certainly conservative and not supported by any evidence. Raytheon Company (1975) reported that currents in the Pond were dominated by local winds and that flushing of the western basin was irregular. Furthermore, from Figures G.4.2-46 and G.4.2-47, it is obvious that the larvae are found in greater concentrations at points distant from the breachway - a situation not possible under the assumption above.

The assumption of 100% load is obviously conservative when the 40 year plant life is considered. This number will probably be on the order of 80%.

The assumption that larvae from other sources do not have an opportunity to contribute to the population of Ninigret Pond is clearly conservative. During 1975 and 1976, Applicant observed that depending on the year and station, larvae were present in Block Island Sound for one or two months after they were no longer present in productive areas of the Pond. Furthermore, data from Station BIS-P (Figure G.2.2-1) clearly demonstrates that larvae are arriving in the study area from other sources.

A fifth assumption, which is very likely conservative, is that all of the larvae flushed from the Pond have the same probability of survival and subsequent recruitment into the local population as those which remain in the Pond. Pearcy (1962) states "Larval mortality in offshore waters is thought to be higher than that in the estuary." Lawrence (1975) reported that winter flounder larvae required 49 days to metamorphose at 8°C and 80 days, at 5°C, only three degrees lower. Larvae did not survive to metamorphose when held at 2°C. The importance of this data is apparent when it is correlated with the ambient water temperatures during the presence of the larvae and with life table statistics before and after metamorphosis. During the months of April and May 1974 and 1975, when winter flounder larvae were most abundant in Block Island Sound, the water in Ninigret Pond was on the order of 5-6°C warmer than it was in the Sound.

Saila (1976) utilizing information presented by Pearcy (1962) developed a mathematical model which maintained a stable population through time. This life table, along with Z values (instantaneous mortality rate) is presented below:

Age	Survivorship	Z/Day
Larvae		
Hatch to 26 days	0.004536	0.2075
27-60 days	0.2995	0.0355

Juvenile		
3-12 months	0.03546	0.0109
12-24 months	0.3491	0.0029
Subsequent years	0.33	0.0030

From this table, it can be seen that the instantaneous mortality rate is more than 3 times as high for second semester larvae as it is for juveniles. It is, therefore, of definite survival advantage to metamorphose as early as possible. Since it is 5-6°C warmer in the Pond than in the Sound, it is reasonable to conclude, based on Lawrence's information, that something greater than an extra month is required for metamorphosis in the Sound. As previously noted, the thesis of prolonged larval retention in the Sound is circumstantially supported from field data: the larvae are collected for an extra 1-2 months in the Sound.

Winter flounder apparently metamorphose at one of the smallest sizes for pleuronectids (Bigelow and Welsh, 1925; and Kyle, 1898; as referenced in Pearcy, 1962). Demersal adhesive eggs, early metamorphosis, and a benthic preference all increase the probability of larval retention within an estuary. These adaptations have been "selected-for" in the life cycle of the winter flounder presumably because of their value in increasing survival. It, therefore, seems reasonable to postulate that larvae which are flushed from Ninigret Pond have a lower survival rate than those retained within the nursery area.

With these five conservative assumptions in their model, Stone and Webster predicted that 5.4×10^6 larvae would be entrained from Ninigret Pond's 1975 larval population. Over a period of 40 years, they predict that the 0.015 entrainment mortality rate would result in a decrease in the population of Ninigret Pond of about 9%. A sensitivity analysis was applied to the various parameters of the stock and recruitment function, age-specific fecundity, and age-specific survival. This analysis revealed that the predicted population size decrease is less than might be expected from a 10% change in the most sensitive of the model parameters.

Considering the highly conservative assumptions inherent in their calculations, the fact that small errors in estimating the parameters could have produced this effect, and the five fold variation in Rhode Island winter flounder landings (Stone and Webster, 1976, Figure 8.5-2), it seems unlikely that operation of NEP 1 and 2's cooling water system will result in a measurable change in the size of this population.

During 1975, Applicant predicted that if the plant had operated at full load, 4.577×10^8 larvae would have been entrained (Table G.4.1-2). If we assume that Stone and Webster's predictions of larval density as a result of flushing from Ninigret Pond are not conservative, but realistic, then their estimated 5.4×10^6 larvae would only account for 1.2% of the larvae entrained by the plant. As larvae may originate from many sources (e.g., Narragansett Bay and the Niantic River), additional analysis is required, and the subsequent discussion will address the effects of the entrainment of larvae from all sources.

The survival curve for a cohort of winter flounder will follow the general equation:

$$N_t = N_o e^{-Zt} \quad (1)$$

Where

N_t = number at time t

N_o = number at time 0

Z = instantaneous mortality rate

There will be a separate curve for each age group represented in the above survivorship table. As larvae are not frequently captured after age 53 days (Pearcy, 1962), we can calculate the survival curves for the larvae in our samples based on the first two lines in the previously presented survivorship table.

If it is assumed that, over a spawning season, the age frequency distribution of the entire larval population is equivalent to the age frequency distribution of the larvae that a given cohort experiences throughout its occurrence, then equation (1) defines the age frequency distribution of the population. If it is assumed that all age classes of the larval population which are 53 days old or younger are entrained at a rate commensurate with their relative abundance, then equation (1) also identifies the age frequency distribution of the entrained larvae. The number of larvae entrained (E) is then defined by the equation:

$$E = N_o \int_o^{26} e^{-0.2075t}\,dt + N_{26} \int_{26}^{53} e^{-0.0355\,(t-26)}\,dt \qquad (2)$$

If it is assumed that 100,000 larvae per day enter the subpopulation which is destined to be totally entrained, then N_o = 100,000 and, from the survivorship table, N_{26} = 453.6.The solution to equation (2) then comes:

$$E = 479,678.6 + 7881.3 = 487,559.9 \qquad (3)$$

In this example, E represents that fraction of 5,300,000 larvae (53 days x 100,000 larvae/day) which had survived until they were entrained. It is, therefore, assumed that the number of larvae which are entrained by NEP 1 and 2 will represent approximately 9% of the production of some number of females (488,692.3 divided by 5,300,000).

From Table G.4.1-2, Applicant estimates that if NEP 1 and 2 had operated at 100% load during 1975, 4.577×10^8 winter flounder larvae would have been entrained. In order to entrain that many larvae, it would have been necessary for 5.086×10^9 eggs to hatch. Assuming a hatching rate of 53% (average of 33-73% from Scott, 1929 as referenced in

Saila, 1976), the 5.086 x 19^9 hatching eggs represent an initial spawning of 9.595 x 10^9eggs. Assuming a fecundity of 366,700 eggs for the average female of 348 grams (Saila, 1961), the projected entrainment represents the spawn of 26,170 females which weigh a total of 20,070 pounds.

Projecting the calculations forward instead of backwards, we find from the survivorship table that of the 5.086 x 10^9 eggs which hatched, only 28,226 age 3 adults (breeding age) will enter the population. Three year old winter flounder average 227.3 grams (Hess, Sissenwine, and Saila, 1975). The projected loss, therefore, will weigh approximately 14,164 pounds.

During the period from 1971 through 1975, the Rhode Island commercial winter flounder landings averaged 4,000,000 pounds (U.S.D.C. 1974, 1975 and 1976). The adults whose spawn is lost and the projected loss of three year olds, therefore, represents 0.50% and 0.35%, respectively, of the average Rhode Island landings.

Because of the low magnitude of entrainment losses when compared to the Rhode Island landings, Applicant believes that the effected winter flounder populations will not suffer appreciable harm as a result of larval entrainment.

Total Impacts. The winter flounder is a species which will not be entrapped with any great frequency. It is thermally tolerant and should not be affected by the thermal plume. The eggs are demersal adhesive and are, therefore, not subject to entrainment. The only potential for an impact will be from the entrainment of larvae.

The larvae of winter flounder are concentrated inside Ninigret Pond in densities which greatly exceed those found in Block Island Sound, and only an estimated 1.5% of the Pond's larvae will be entrained in the unlikely event that a series of very conservative assumptions proved correct. Additionally, there is reason to believe that those larvae which are flushed from an estuary have a reduced probability of survival and any predicted entrainment effects would again be overestimated. Even if all of the conservative assumptions are true and the larvae in the Sound have an equal probability of survival, entrainment losses would equal a fractional percentage point of the Rhode Island commercial landings.

Consequently, Applicant believes that the operation of the heat dissipation system of NEP 1 and 2 will not result in appreciable harm to the winter flounder population.

4.2.12 Blue Mussel (*Mytilus edulis*)

4.2.12.1 Life History. On the western side of the Atlantic, the range of the blue mussel extends from polar regions southward to North Carolina (Miner, 1950). Although it often occurs in greatest concentrations, and appears to grow best near the area of the low tide mark (Loosanoff and Engle, 1943), in areas of abundance it may be found both within and beyond the intertidal zone forming dense colonies on rocks, pilings, sand bars, and other surfaces by attachment with its byssal threads.

As is true of other bivalve mollusks, the mussel is a prolific spawner, capable of releasing many millions of eggs (Field, 1922). Spawning is usually triggered by rising temperatures. In Southern New England, the major spawning effort usually occurs in late spring; however, the larvae have been observed in the water column year round. The duration of the larval period is variable but is approximately 14 days (Loosanoff and Davis, 1963). During this time, the planktonic larvae are essentially at the mercy of water currents and may be transported considerable distances from the area where spawning occurred. The temporal and spatial distributions of *Mytilus* larvae are presented in Figures G.4.2-49 through G.4.2-51.

The metamorphosing larva, or pediveliger, may be quite selective in its choice of attachment, exploring the surface of the substrate by means of its foot and tentatively attaching itself by means of its byssal threads. The ability to disengage itself from the substratum by severing the byssal threads, and to reattach at a new location by secreting additional threads, is retained throughout its life (Field, 1922).

The growth rate of the mussel is variable, depending upon temperature, current, and other environmental factors. In areas favorable for growth, they may reach a size of 60-65 mm (2.5 inches) in one year (Davies, 1969).

During the summer of 1974, juvenile mussels were found in abundance in Block Island Sound, forming dense colonies on the bottom. Heavy mussel sets were not observed at the same locations during the summer of 1975.

Although of limited commercial value at the present time, the mussel is of significance as an important source of food for many species, most particularly the tautog (<u>Tautoga onitis</u>) and cunner (<u>Tautogolabrus adspersus</u>) (Bigelow and Schroeder, 1953). Because of its tendency to form dense colonies and thereby cover or obstruct underwater objects such as cooling water intakes, the mussel may also become a serious pest in some areas.

The mussel is prized as a food item throughout much of Europe. However, it has failed to arouse much interest in the average American consumer and, therefore, does not command as high a market price as other bivalves such as oysters, clams and scallops. Because mussels can be cultured in exceptionally high concentrations to yield significant quantities of valuable protein (Bardach et al., 1972), interest in this species as a potential food source has been increased in this country in recent years.

4.2.12.2 <u>Impacts of Construction.</u> It is possible that the suspended sediments and turbidity could adversely affect mussel larvae passing through the construction site. Additionally, those mussels present in the construction area will be lost as a result of dredging and overboard disposal of spoil. Although significant sets of juvenile mussels have occurred in Block Island Sound in the area of proposed construction, natural conditions are evidently unfavorable for mussel development and maturity: Applicant has found very few adults in the area. Under these circumstances, no appreciable harm to the blue mussel population is anticipated as a result of construction.

4.2.12.3 Impacts of Plant Operation.

Entrapment. With the exception of those mussels which are either killed or which release their byssal threads during backflushing operations, no mussels will be entrapped.

Within the Discharge Plume. As a result of its importance as a biofouling organism of intake pipes at electric power plants, the thermal tolerance of the blue mussel has received considerable attention. During Applicant's studies, dense concentration of juvenile mussels were found in Block Island Sound.

As described earlier, this bivalve species is a prolific spawner, capable of releasing millions of eggs. Spawning usually occurs in late spring when water temperatures reach approximately 60°F. (Engle and Loosanoff, 1944).

The duration of larval planktonic development is approximately 14 days (Loosanoff and Davis, 1963). Lough (1974) reported optimal water temperatures for larval survival and growth between 11 and 14°C (52-57°F) at a salinity range of 22.5-36.5 o/oo. Brenko and Calabrese (1969), on the other hand, found more than 70% survival of Mytilus edulis larvae tested for 16 to 17 days at almost all salinities (15-40 o/oo) at temperatures ranging from 5 to 20°C (41-68°F). Erratic survival at 25°C (77°F) indicated that this temperature approached the upper limit for survival. At 30°C (86°F), there was essentially no survival at any salinity tested.

Most Mytilus pediveliger larvae settle to the bottom from mid-June through mid-July in Connecticut when corresponding water temperatures ranged between 59.0 and 69.8°F.

Gonzalez (1973) found juvenile mussels were intolerant of sustained temperatures above 27°C (80.6°F). Such a temperature coincides quite closely to the water temperature which identifies the boundary of their zoogeographical range. Hutchins (1947) found the southern limit of distribution corresponds with a monthly maximum temperature of 80°F. Read and Cummings (1967) explain the restrictions over this species natural range by an upper limiting temperature of 80.6°F. The same authors, however, state that according to their experimental evidence, some individuals can survive temperatures as high as 85°F

Henderson (1929) recorded the upper tolerance temperature level of Mytilus to be 105.4°F. The 24-hour median tolerance was conservatively estimated at 84.2°F. Pearce (1969) claims a behavioral perturbation rendoring Mytilus more susceptible to predation at temperatures approximating 75.2°F. Gonzalez (1973) through field observations and laboratory studies reported extensive M. edulis mortality immediately adjacent to a power plant discharge. He noticed that feeding ceased at 77°F, and mortality was reported when the water temperatures increased above 80.6°F. Widdows (1973) found that the heart beat of adult mussels became erratic, and the rate of water filtration declined at 25°C (77°F) or above. Based on observations made by the various investigators, adult Mytilids appear to be able to tolerate temperatures from 80°F to sligntly above 100°F for short periods of time (Figure G.4.2-52). Gonzales (1973) points out, however, that sustained water temperature approximating the lower end of this higher-temperature-limitation range (i.e., 80°F) does cause mortality. Such an observation is confirmed by Hutchins (1947) and Read and Cummings (1967) who indicate that the natural range of this species is definitely influenced by naturally occurring water temperatures of 80°F or above. The thermal discharge of NEF 1 and 2 is not expected to cause appreciable harm to the adult population of Mytilus for two reasons:

a. The expected peak plume temperature of 75-76°F are within their tolerance limit, and

b. Within the proposed discharge area there is a limited amount of substrate (i.e., rocks) where blue mussels can attach; consequently, any interaction between the thermal plume and any sublittoral community of M. edulis is expected to be small.

Due to the somewhat temperature sensitive nature of the larvae, the planktonic stage of this species may be affected to a limited degree. The overall impact is expected to be negligible, however, due to the small area of the mixing zone relative to the area of Block Island Sound, the species prolific nature, and the short residence time an organism would experience in the mixing zone.

The thermal tolerance information available for Mytilus edulis is presented in Figure G.4.2-52.

In-Plant Effects. Blue mussel larvae occurred for 314 days during both the 1974 and 1975 period and the 1975 through 1976 period. If NEP 1 and 2 had operated at full capacity during the period of occurrence, 6.393×10^{11} and 2.799×10^{11} mussel larvae would have been entrained during 1974-1975 and 1975-1976, respectively.

Perchon (1968) indicated that mortality over 99.9% was normally compensated for by bivalves in general. Applying this mortality assumption, the above larval entrainment estimates would be equivalent to 6.393×10^{8} and 2.799×10^{8} adult mussels for (1974-75 and 1975-76 respectively).

Quarterly benthic sampling in Block Island Sound from May 1974 through March 1976 indicates that sets of adult blue mussels do not become successfully established in this area. The entrainment of blue mussel larvae is, therefore, not expected to have a measurable impact on local mussel populations since these entrained larvae do not appear to normally contribute to a local sustained adult population. However, mussel larvae passing through this area may contribute to adult populations far removed from the vicinity of NEP 1 and 2. The potential impact of mussel larvae entrainment on such populations can be evaluated by reviewing the entrainment impact on mussel populations at another nearby coastal nuclear power facility (i.e., Pilgrim Station, Cape Cod Bay).

Stone and Webster (1975) estimated that 2.31×10^{12} mussel larvae would be entrained through Pilgrim Station Units 1 and 2. Applying the same mortality assumption given above, they determined that the mussel larvae entrained at Pilgrim Station might have produced 2.31×10^9 adults. Based on densities of adult museels in the vicinity of Pilgrim Station, they estimated that the loss of 2.31×10^9 adults would be equivalent to 121 acres that could theoretically be devoid of mussels. This estimate was considered conservative since no detectable change in mussel density in the vicinity of Pilgrim Station has occurred as a result of Unit 1 operation even though theoretically one would predict that 32 acres should be devoid of mussels as a result of Unit 1 operation. Based on their analyses, Stone and Webster (1975) concluded that the Pilgrim Station impact on the adult mussel population would be negligible.

Since the mussel entrainment estimates for Pilgrim Stations Units 1 and 2 are approximately 3.6 to 8.2 times greater than those predicted for NEP 1 and 2, and since mussel larval entrainment losses of this magnitude have been previously shown to have negligible impact on adult mussel populations, it is concluded that mussel larval entrainment at NEP 1 and 2 should likewise result in no appreciable harm to the adult mussel populations.

<u>Total Impacts.</u> The mussel is a thermally tolerant species which will not be subject to entrapment. Large numbers of mussel larvae will be entrained through the cooling water system of NEP 1 and 2. This number is approximately the same as the numbers which are taken at Pilgrim Unit 1, a plant which has not effected the local mussel population. Because of this and the low survivorship rates of the larvae, plus the inability of adults to survive in large numbers in the local area, it is believed that there will be no appreciable harm to this species.

4.2.13 Hard Clam (Mercenaria mercenaria)

4.2.13.1 Life History. The hard clam - also referred to as the "littleneck", the "cherrystone" and the "quahog", depending upon its size - is a widely distributed bivalve mollusk, its range extending from the Gulf of St. Lawrence to the Caribbean (Pratt and Campbell, 1956). Its inability to reproduce at temperatures below 20°C limits its distribution north of Cape Cod to coves and estuarine areas where localized warming may permit spawning.

Because of its high degree of tolerance to a wide range in temperature and salinity, variations in substrate, and levels of pollution, the hard clam may be the most abundant animal of its size in estuarine areas such as Narragansett Bay (Pratt and Campbell, 1956).

The hard clam spends its post-larval existance buried beneath the bottom sediment, moving only short distances from its original point of settlement. In Narragansett Bay, Stringer (1959) found it to be most abundant in sediments composed of mud, sand and shell. Since it is a filter feeder, extending its short siphon upwards to the water-sediment interface and pumping its food - in the form of phytoplankton and particles of detritus - from the surrounding waters, its rate of growth is generally faster in relatively firm sediment where water currents typically are greater than over a soft mud bottom.

Sexes in the hard clam are separate and fertilization of the egg is external. Spawning usually occurs when water temperatures reach 23°C (73-74°F) or more in early summer; temperature appears to act as the major stimulant to the release of eggs and sperm. Since the presence of sperm often stimulates the release of eggs, spawning may also be in response to a chemical stimulus contained within the sperm (Nelson and Haskin, 1949).

The fertilized egg is slightly negative buoyant. However, cleavage and embryological development proceed rapidly and by the end of 24 hours the embryo has developed into a shelled, free-swimming veliger larva. During the next 7-14 days, depending upon temperature the larvae equipped with a ciliated velum has limited mobility but presumably is at the mercy of water currents, with little control over its distribution.

At the time of metamorphosis, the larva develops a muscular "foot". The velum disintegrates, and the larva settles to the bottom where now equipped with a byssal gland it alternatively attaches itself to sand grains then crawls by means of its foot in search of a suitable substrate for burying. This exploratory period may continue for days or weeks. Ultimately the little clam burrows into the sediment by the use of its byssal gland and if the area is favorable remains there for the remainder of its life.

The growth rate of the hard clam is dependent upon and directly related to temperature as well as to salinity, current, and availability of food. In the waters of southern New England, it generally requires a period of two to three years for a hard clam to attain a length of five cm (2 inches); the rate of growth is inversely proportional to the size of the clam. Turner (1953) found that salinity in the range of 23-28 ppt and temperature of approximately 23^{o}C were optimum for growth. Hard clams may become sexually mature by their second year.

Experiments by Davis (1960) indicated that the percentage of fertilized clam eggs capable of developing normally declined at silt concentrations of 0.75 g/l; no eggs developed normally at concentrations of 3.0-4.0 g/l. Silt concentrations above 1.0 g/l retarded the development of clam larvae. A salinity of 27 ppt was optimum for development of eggs and larvae; salinities of 17.5 ppt or below resulted in reduced survival.

The hard clam is of major economic importance in southern New England and along the middle Atlantic coast where it may be found from the low water mark seaward to depths of 50 feet (Olsen and Stevenson, 1975). It is the basis of a valuable fishery in Rhode Island. Commercial landings in Rhode Island during the period 1971-1973 averaged 960 thousand pounds of meat, with an average annual value of 925 thousand dollars. Ninigret POnd supports a modest commercial and recreational clam fishery.

4.2.13.2 Impacts of Construction. No adult quahogs were found in Block Island Sound during Applicant's baseline studies, and larvae were found in very limited numbers. Therefore, no appreciable harm to the quahog population is anticipated as a result of construction.

4.2.13.3 Impacts of Plant Operation

Entrapment. The hard clam will not be subject to entrapment.

Within the Discharge Plume. The hard clam is both a euryhaline and eurythermal species which is widely distributed from the Gulf of St. Lawrence to the Caribbean. Because of its high degree of tolerance to a wide range of temperature, salinity, variations in substrate, and levels of pollution, the hard clam may be the most abundant animal of its size in estuarine water such as Narragansett Bay (Pratt and Campbell, 1956). At the proposed site, this bivalve is only found in Ninigret Pond where it provides a modest commercial and recreational fishery. As a result of its thermal tolerance and location relative to the thermal discharge, no thermal impact to the adult is anticipated.

Davis and Calabrese (1964) reported the effects of temperature and salinity on the growth of eggs and larvae of M. mercenaria. At 27.5 ppt salinity (the highested tested and closest to the salinities observed in Ninigret Pond and Block Island Sound) eggs survived temperatures between 17.5 and 30.0°C (63.5 and 86°F) whereas, the mean length for 12 day old larvae was greatest at 30°C (86°F). In Ninigret Pond, significant concentrations of Mercenaria larvae were observed when the surface temperature was 80.6°F, the highest temperature observed. It is, therefore, concluded that the peak temperature of 75-76°F expected in the thermal plume will not adversely affect Mercenaria larvae.

In-Plant Effects. During Applicant's baseline studies, hard clam larvae were collected in relatively low numbers in Block Island Sound. A direct comparison of their density in the Sound with densities elsewhere is more difficult than in the case of the oyster as a result of the problems associated with distinguishing the larvae of this species. The larval hard clams were not identified in the 1974 collections. During 1975, a conservative maximum density of $1452/m^3$ was observed on August 19. The estimate is conservative because it also includes Modiolus and Mytilus as well as Mercenaria: most of the larvae were probably Mytilus.

Carricker (1959) reported a density of 10,000 hard clam larvae/m^3 in Home Pond on Gardner's Island, New York and Landers (1954) reported densities of $7500/m^3$. In Ninigret Pond, Applicant observed densities of Mercenaria (not including Mytilus and Modiolus) in excess of $16,000/m^3$.

Because of the comparatively low density of larvae in Block Island Sound, it is unlikely that this species will suffer any appreciable harm as a result of the operation of NEP 1 and 2's cooling water system.

Total Impacts. The hard clam is a thermally tolerant species which will not be subject to entrapment and whose larvae exist in Block Island Sound in low numbers. No appreciable harm to this species is expected as a result of the operation of NEP 1 and 2's cooling water system.

4.2.14 Long-finned Squid (Loligo pealei)

4.2.14.1 Life History. The long-finned squid, also known as the winter squid, bone squid or common squid, is commonly found from Cape Cod to Cape Hatteras (Olsen and Stevenson, 1975). According to Summers (1969), squid may be found on the continental shelf at depths of 28-366 m (92-1200 ft), with major concentrations at 110-183 m (360-600 ft). In Block Island Sound, squid have moved into the area of Charlestown Beach in significant numbers by May and remain into December. During this time, they may comprise a significant percentage of the catch by local trawlers fishing out of Point Judith (Table G.2.3-2). Otter trawl sampling at two stations off Charlestown Beach during 1975 indicated that squid were significantly more abundant at a depth of 80 ft than at depths of 30-40 ft (Table G.2.3-3).

The squid moves inshore each spring to spawn in shallow water, i.e., from the shore to a depth of 90 m (295 ft) (Rathjen, 1973). The eggs are contained in a series of gelatinous strings containing 150-200 embryos each (McMahon and Summers, 1971). Time between deposition and hatching varies indirectly with temperature but ranges roughly between two to four weeks during late spring and early summer in southern New England. Summers (1971) reported that eggs appear to approach 100% hatch in nature. In Block Island Sound during 1977, newly hatched juvenile squid were first observed on June 28, 1977. Maximum abundance of juveniles was observed from July 5 through July 14, 1977 with secondary peaks in mid-August and mid-September (Raytheon, 1978). The temporal abundance of squid juveniles is presented in Figure G.4.2-53; the spatial distribution within the study area is presented in Figures G.4.2-54.

The squid grows rapidly, many becoming sexually mature after one year; the majority die before completion of their second year. The adult squid averages 160-180 mm in length (Summers, 1971).

The squid is an active predator, feeding upon small crustaceans as a juvenile and later upon small fish (Rathjen, 1973). It in turn is fed upon by striped bass, bluefish and other swift-moving predators.

4.2.14.2 Impacts of Construction. Squid have great mobility and can easily avoid the suspended sediments and turbidity associated with construction activity. Additionally, they are more abundant offshore than near the construction area (Table G.2.3-3). Effects on the eggs and juveniles are not expected to be significant because of the small area involved and the short incubation time. Under these circumstances, no appreciable harm to squid populations is expected as a result of construction activities.

4.2.14.3 Impacts of Plant Operation

Entrapment. Squid, since they are pelagic and occur near the location of the proposed intake (Table G.2.3-3), are potentially vulnerable to entrapment. However, the potential for significant entrapment of Loligo pealei through the proposed velocity cap intake at NEP 1&2 appears to be remote based upon the experience noted at electric generating stations in California and in Florida which are currently using velocity cap intakes (CZC, 1979). This assessment is based upon the following observations: (1) the long-finned squid does occur, although not in abundance, in Florida, but it has not been impinged at the St. Lucie plant; (2) Loligo opalescens, a behaviorally similar congener of the long-finned squid is commonly abundant near all of the velocity cap intakes in California, yet California Fish and Game records show that it is rarely entrapped. It was found to be entrapped in only 9 out of 155 sampling periods between September 1975 and April 1978. The total weight of entrapped squid during this period was less than forty pounds; and, (3) the long-finned squid has an exceptional swimming ability. According to Barnes (1969), squid attain the greatest swimming velocity of any of the aquatic invertebrates. Cole and Gilbert (1970) reported that squid have an average swim speed of 6.5 fps. Furthermore, Loligo is known to feed on young mackerel by swimming backwards into a school and seizing its prey. Since mackerel less than one year old can sustain a speed of six knots (fps) (Bigelow and Schroeder, 1953), it is assumed that squid are able to attain a similar velocity. It is, therefore, expected that the squid will be able to avoid or escape from the intake currents and, hence, no appreciable harm on the population is predicted.

Within the Discharge Plume. McMahon and Summers (1971) reported that the long-finned squid deposits its eggs at temperatures between 10 and 23°C (50 to 73.4°F). These same authors found the rate of development of squid embryos appeared to be directly related to sea water temperature. In their experiment *L. pealei* embryos were readily maintained in the laboratory between 12.0 and 23°C (53.6-73.4°F).

Temporally, Raytheon (1978) reports squid egg clusters observed in Block Island Sound from May to October. Spatially a greater abundance of egg clusters were found at the inshore station than at the two offshore stations. Such findings would indicate the potential exists for some interface between the discharge plume and attached squid egg clusters. Inasmuch as the induced bottom temperature isotherms would approximate natural egg laying temperatures, described in the literature (i.e., 50-73°F), no appreciable thermal impact is expected.

Mean development time for spawning to hatching is related to water temperature. McMahon and Summers, (1971) report squid hatching in approximately 27 days at 12.0-18.0°C (54-64°F), 19 days at 15.5-21.3°C (60-71°F) and 11 days at 21.5-23.0°C (71-74°F). Raytheon (1978) also found that the majority of squid juveniles were collected only when water temperatures ranged between 15°C to 21°C (59-70°F). Even though juvenile squid were collected from June to October, the majority of juveniles were observed in July when mean surface and bottom temperature reached 18.9°C (66°F) and 15.7°C (61°F) respectively.

The five month interim (i.e., June-October) when juvenile squid are found in Block Island Sound coincides with an induced surface temperature range of 63-75°F. When such results are compared with the juvenile development temperature range presented in McMahon and Summers (1971) it seems rather improbable that the Applicant's thermal discharge would affect this early life history stage.

Summers (1969) reported a pronounced reduction in squid bottom catches at temperatures less than 8°C (46.4°F), while Serchuk and Rathjen (1974) found highest concentrations of squid in water of 10-12°C (50-53.6°F) during the spring and 10-14°C (50-57.2°F) during the fall. Adult squid were observed in the vicinity of Applicant's proposed discharge site during the months of May-November, coincident with a surface temperature range of 46-70°F. Similar to the findings of Serchuk and Rathjen (1974), peak abundance occurred in October, corresponding to a temperature range of 54 to 57°F. Should similar temporal tendencies occur during plant operation, adult squid would experience an induced surface temperature from a low of 52°F to a high of 76°F. Even though there is the possibility that squid may contact the surface discharge during their seasonal inshore activities, thermal impact is expected to be negligible since the geographical range of this species implies existence in waters equal to or warmer than those anticipated as a result of plant operation (NOAA, 1973).

In-Plant Effects. Squid eggs are laid in gelatinous strings on the bottom and, therefore, are not subject to entrainment. No intermediate planktonic larval form, as in the gastropods or pelecypods, is produced (Barnes 1969) and juvenile squid hatch directly from the egg.

During 1977, juvenile squid occurred at the location of the proposed intake for approximately 133 days. Based on calculated average densities and assuming 100% plant load during their period of occurrence, 1.983×10^6 squid juveniles (all ages) would have been entrained in 1977.

To determine the number of one year old squid that would have resulted from this entrainment, this entrainment estimate was converted to the equivalent number of squid juveniles at hatching by applying the procedures discussed below.

Length-frequency data obtained on squid juveniles collected during the 1977 survey were used to develop a method for aging juveniles. From each weekly collection of squid, the largest juvenile was selected and its age was estimated. During the time period of 28 June through 14 July 1977, the hatching date for this oldest individual was assumed to be one week older than the first occurrence in the samples. After 14 July 1977, the largest squid in the sample was assumed to have hatched at the mid-point of the major hatching period (5 July through 21 July 1977). A linear regression line was then fitted to the data utilizing the standard least squares technique. Inspection of the regression revealed that the equation overestimated the age of recently hatched juveniles, but that the confidence limits on the value of the intercept included the known length at hatch point (2 mm mantle length; Arnold, 1965). The regression line was, therefore, rotated around the grand mean of age and length and forced through the point age = 0, mantle length = 2mm. The resulting equation for estimating the age of squid juveniles is:

$$\text{Age} = -3.28 + 1.64\ (\text{Length})$$

where:

Age is in days and

Length is mantle length in millimeters

The above equation was then applied to the squid juvenile data, and age-frequency distributions by survey were developed. Age-specific totals of squid juveniles for all surveys were calculated and regressed to the general form $N_t - N_o e^{-Zt}$ for time intervals from hatching to each age represented. The regression coefficients, Z, from these analyses provided estimates of total instantaneous mortality rates. Several of the estimated total mortality rates for various age squid juveniles are presented in the following table:

	Age	Survivorship	Z/Day
Juveniles			
	Hatch - 12 days	0.0044	0.452
	Hatch - 79 days	0.0029	0.072
	79-365 days	0.0807	0.0088
	Hatch - 12 months	0.0002	0.0229
Adults			
	12-24 months	0.19	0.0045

The age-specific total mortality rates were then used to determine the equivalent number of squid juveniles at hatching for each survey by applying the equation:

$$N_o = \frac{N_t}{e^{-zt}}$$

where: N_o = number of squid juveniles at hatching

N_t = number of squid juveniles at time t

Z = total instantaneous mortality rate, and

t = time in days.

These estimated numbers of equivalent squid juveniles at hatching (N_o) for each survey were then divided by the actual numbers of juveniles collected to derive a correction factor for transforming the mixed-age squid juvenile densities to the estimated densities of juveniles at hatching. These densities of squid juveniles at hatching were then used to evaluate the impact of entrainment.

Based on the projected average densities of juveniles at hatching, and assuming 100% plant load, an equivalent of 3.798×10^7 squid juveniles at hatching would have been entrained in 1977. From the data of Vovk (1974) and Raytheon (1978), Applicant developed the following length-fecundity relationship for squid:

$$F = -4147.80 + 636.56 \text{ ML}$$

wehre: F = fecundity, and

ML = mantle length in centimeters

Summers (1971) reported on the age, growth, and age class structure of a squid population in the inshore region of Menemsha Bight in southern Vineyard Sound. Summers suggested that approximately one-fourth of the egg deposition around June was carried out by two year old females and that two year olds probably account for less than one-quarter of the total breeding population and contribute no more than one-third of the brood. He further stated that the squid stock is basically annual but that males may live to 36 months (although more frequently only 24 months) while females have a maximum lonevity of 19 months. During late May (just prior to spawning), Summers reported that 16% of the adults (Applicant assumed 16% of the females) were age 2. From this information plus previously presented fecundity relationships, a Leslie population projection matrix was constructed which desc[illegible]d a stable population (the eigen value or finite population growth rate was 1.00). I[illegible] this model, the survival rate from egg to age 1 was determined by a numerical method presented by Vaughan and Saila (1976). Population values used in the Leslie matrix are presented in the following life table

Age	Fecundity Per Adult	Survivorship	Relative Frequency
0	0	2.3486×10^{-4}	1,000,000
1	3019	0.19	235
2	6520	0	45

From this table, it can be seen that less than 0.03% of squid that hatch woul! be expected to survive to the following year. Assuming a stable population, Summers (1971) estimated that only 0.05% of the hatched juveniles survive to the following year.

Based on the estimates of S_o by Summers (1971) and Applicant, the projected entrainment of squid juveniles at hatching would result in the loss of 18,991 or 8,921 one year old squid, respectively.

The weight of these squid can be estimated by length-weight relationships reported by Tibbetts (1975):

Males: $W = 0.005592L^{1.86345}$

Females: $W = 0.000931L^{2.26429}$

where: W = weight in grams, and

L = length in millimeters.

Summers (1971) found that the average size of one year male and female squid was 180 mm and 160 mm, respectively. Assuming a 1:1 sex ratio, and based on Summers (1971) estimate of S_o the estimated number of one year old squid not recruited to the population due to entrainment would weight approximately 3771 pounds or 1.7 metric tons. Based on Applicant's estimate of S_o, the projected loss of one year old squid would weigh approximately 1771 pounds or 0.8 metric tons.

In their preliminary fishery management plan for squid fisheries of the Northwest Atlantic, NOAA (1977b) assumed (in the absence of evidence to the contrary) that the fishing for long-finned squid off the northeastern USA exploits a single stock distributed from Cape Hatteras to the northern edge of Georges Bank. During 1968 to 1975, minimum stock size esti ates for the affected region (subarea 5 and 6) ranged from 221,100 tons to 97,303 tons (Sissenwine, 1976). The projected loss of one year old squid due to entrainment at NEP 1 and 2 is equivalent to less than 0.008% of the minimum stock size in this area.

Since 1969, squid landings in Rhode Island have ranged from a low of 319 metric tons in 1971 to a high of 1166 metric tons in 1976. In 1976, inshore (0-3 miles) landings of squid in Rhode Island totalled 428 metric tons (Raytheon, 1978). The projected loss of one year old squid due to entrainment is equal to less than 0.5% of recent Rhode Island squid landings.

Because of the low magnitude of entrainment losses when compared to the squid stock size and Rhode Island landings, Applicant believes that squid populations will not suffer appreciable harm as a result of juvenile entrainment.

Total Impacts. The squid is a species which will probably be entrapped and possibly entrained in small numbers. There is no reason, based on experiences at other New England power plants, to suspect anything to the contrary.

Squid eggs are demersal adhesive and are, therefore, not subject to entrainment. The impact of entraining squid juveniles was shown to be less than 0.5% of recent Rhode Island landings, and less than 0.008 % of the minimum stock size estimate of the squid population in the northwest Atlantic.

Very little information is available on the squids' temperature tolerance. However, it is known to live in waters equal to or warmer than will be found in the thermal plume.

It is, therefore, expected that there will be no appreciable harm to this species as a result of the operation of NEP 1 and 2's cooling water system.

4.2.15 Sand Shrimp (Crangon septemspinosa)

4.2.15.1 Life History. The sand shrimp (Crangon septemspinosa (Say), formerly Crago septemspinosus) is an epibenthic decapod species with no direct commercial or recreational value. It is, however, of considerable importance as a source of food for commercial and sport fishes and other organisms higher in the food chain. Price (1962 states that C. septemspinosa "is prominent in diets of numerous carnivores including weakfish, skates and rays." In a study on the benthic invertebrates of Block Island Sound and their relationship to fishes, Smith (1950) found C. septemspinosa in stomachs of skate, sculpin, flounder, sea robin, windowpane, eelpout, whiting and other fish. Crangon ranked fourth and averaged 7.6% of total consumption of invertebrates by fishes. Sand shrimp is found inhabiting various bottom types from Baffin Bay to Eastern Florida and from the nearshore zone to depths of 450 meters (Haefner, 1972; Price, 1962; Whiteley, 1948).

Sand shrimp is a permanent resident in Block Island Sound. Juvenile C. septemspinosa were dominant in fall and adults during late winter early spring at station EB-C in Block Island Sound (Raytheon, 1979). Smith (1950) also collected C. septemspinosa throughout the year in Block Island Sound with most being collected during the winter months. There is evidence of seasonal movements onshore and offshore (Raytheon 1979). However, Wilcox and Jeffries (1973) were unable to collect many individuals from the Pettaquamscutt River in Rhode Island during the winter and spring, and Haefner (1972) reported that C. septemspinosa from Lamoine, Maine appeared in the shallow tidal flat and beach areas in late April or early May and that the larger shrimp began to disappear as early as November with most adults gone by December. Squires (1965) reported an onshore-offshore migration in the Gulf of St. Lawrence. Migration offshore in the warm months instead of the cold months was indicated by Williams (1965) for North Carolina C. septemspinosa. In constrast to the above, Price (1962) did not observe seasonal migrations in Delaware Bay - near the mid-point of the sand shrimp's range.

While this species is generally epibenthic, it does burrow into the bottom (Price, 1962) and is occasionally found in the plankton (Hopkins, 1958), particularly after storms (Bigelow and Sears, 1939). Crangon septemspinosa is apparently omniverous although it has a preference for animal material. Wilcox and Jeffries (1974) reported that 85% of the stomach contents of their specimens was organic debris and that the remaining 15% consisted of sand, crustacean parts, copepods, plant material and polychaetes.

Ovigerous (egg carrying) females were present in trawls collected at EB-C from January through June in Block Island Sound (Raytheon, 1979). At Lamoine, Maine ovigerous females were present from May through September (peak numbers in July and August) (Haefner, 1972) and in all months except December (primarily March to October) in Delaware Bay (Price, 1962). Larvae are planktonic until they attain a length of approximately 4 mm (Tesmer and Broad, 1964).

Larval stages of C. septemspinosa were found in the water column in Block Island Sound year-round with the greatest concentrations occurring from April to November (Raytheon, 1979) (Figure G.4.2-55). The distribution and average density of sand shrimp larvae found during 1978-1979 is shown in Figure G.4.2-56 and G.4.2-57.). Hillman (1964) reported them in Narragansett Bay from May to October.

The largest sand shrimp Price (1962) captured in the Delaware Bay was 70 mm (three and one half years old with 7,500 eggs). The largest individual collected by Wilcox and Jefferies (1973) was approximately 60 mm long.

4.2.15.2 Impacts of Construction. Because of their mobility and the fact that they are able to live within the bottom, sedimentation is not expected to affect sand shrimp present in the vicinity of construction activities. Some larvae will undoubtedly be lost; however, in view of the small area and short time period involved, no appreciable harm to the local population is expected.

4.2.15.3 Impacts of Plant Operation

Entrapment The entrapment potential of the sand shrimp is difficult to assess because of a lack of data at other generating plants having velocity cap intakes. It is likely that the small size of these animals enable them to pass completely through the cooling water system and thus fail to be recorded in impingement data. Little information is available about their swimming capabilities and those behavioral characteristics which would enable one to determine their ability to avoid entrapment.

In California, a similar species, Crago nigromaculatus, was among the most common arthropods collected in the vicinity of the Ormond Beach Generating Station (MBCI, 1972), yet it is not recorded as having been impinged.

Among those characteristics of adult Crangon which argue against its being entraped in significant numbers by NEP 1&2 are: (1) its preference for unobstructed sandy bottoms; (2) its tendency to burrow beneath the sand; and, (3) its benthic habits and nominal absence from the water column. It may become more available for entrapment during periods when storms agitate the bottom substratum and cause the shrimp to become planktonic. It is further possible that the shrimp may be entrapped in large numbers during seasonal migrations if they do not occur among the populations in Rhode Island Sound. Such migrations are known to occur among sand shrimp in Maine but do not occur in the Delaware Bay region.

Within the Discharge Plume. The sand shrimp is eurythermal and has been collected within a temperature range of near freezing (0°C) to the mid to upper 20°C 78-85°F) (Price, 1962; Haefner, 1969, 1976; Vernberg and Vernberg 1970). The available temperature tolerance and thermal characteristics information is presented in Figure G.4.2-58.

Haefner (1972), in his discussion on the biology of the sand shrimp cites Tiews (1969), after Meixner, 1966, 1967) who reported that under optimum feeding conditions Crangon crangon eggs hatch after three weeks incubation at 18°C (65°F); after 4 weeks at 14°C (58°F) and after 10 weeks at 6-10°C (43-50°F). In a cursory study conducted by Price (1961), hatching of C. septemspinosa eggs was observed after 6-7 days at an incubation temperature of 21°C (70°F). Inasmuch as the sand shrimp is strongly bottom oriented, the egg carrying female is not expected to be greatly influenced by the NEP 1&2's discharge plume since she can move from the area should it prove untenable.

Planktonic sand shrimp larvae have been found year-round in Block Island Sound (Raytheon, 1979). Such a temporal occurrence corresponds to an expected induced surface water temperature range of 7.2°-23.9°C (45°-75°F). Sandifer (1973) in examining the distribution and abundance of decapod crustacean larvae in York estuary in adjacent lower Chesapeake Bay, captured sand shrimp larvae between 1.5 and 26.2°C (34° and 79°F). Larvae were most abundant, however, between the temperatures of 15°-20°C (59°-68°F). At stations EB-B and EB-C in Block Island Sound the overall abundance of sand shrimp larvae was higher in near bottom waters than in surface waters (Figures G.4.2-56 and G.4.2-57) with evidence of diel vertical migration (Raytheon, 1979). During the day larvae densities were greater in near bottom waters, whereas at night larval densities appeared to increase near the surface. In contrast, Sandifer (1973) pointed out that sand shrimp larvae were not especially abundant near the bottom in York estuary. Of the larvae he did collect, 59% occurred in the near-surface samples. The natural temperature range for larval development (Sandifer, 1975) encompasses those induced surface temperatures expected from the operation of NEP 1 and 2. Inasmuch as most species characteristic of north temperate waters are capable of existing in temperatures at least a few degrees higher than their natural range for short periods of time, it is believed that there will be no appreciable harm to those larval stages entrained in the plume.

Most of the published thermal tolerance studies conducted on the adult life history stage focuses on temperatures encountered in their natural environment. Haefner (1976) in studying sand shrimp abundance in the York River, Chesapeake Bay estuary, captured sand shrimp in the temperature range of 0.5-24.1°C (33°-76°F). Maximum concentrations were encountered however, in the winter between 5 and 11°C (41°-52°F). He observed that sand shrimp concentration was reduced once the water temperature reached 15°C (59°F). In an earlier paper, Haefner (1969), described the temperature and salinity tolerance of the sand shrimp in the Penobscot River estuary. He reported sand shrimp were never observed at any embayment where water temperatures were in excess of 22°C (72°F) regardless of the salinity. In another study, Haefner (1970) studied the effects of low dissolved oxygen concentrations on the temperature/salinity tolerance of adult sand shrimp. Greatest mortality was observed around 23°C (74°F).

Vernberg and Vernberg (1970) noted that in general, animals with northern affinities (such as the sand shrimp) did not survive high water temperatures as well as those with more southerly displaced limits. Sand shrimp captured in February, were observed to die most rapidly at 25°C (77°F). Meldrim et al. (1974) reported that _C. septemspinosa_ captured in the Delaware River estuary had preference temperatures of 79 and 55°F (26 and 13°C) when acclimated at respective temperature of 43 and 40°F (6 and 4°C).

Adult sand shrimp were found in Block Island Sound year round, corresponding to induced surface temperatures of 7.2-23.9°C (45-75°F).

Based on the observations made by the various investigators, adult sand shrimp appear to be able to tolerate any temperatures which may occur in the thermal plume. Because this species is mobile and eurythermal, interaction with the thermal discharge plume is not expected to harm the sand shrimp.

In Plant Effects. In 1978-1979 sand shrimp larvae were observed in the water column throughout the year with significant abundance levels occurring from March through November (Raytheon, 1979). In Narragansett Bay Hillman (1964) found its frequency of occurrence longer than any other decapod larvae, occurring from May through October. Based on calculated average densities and assuming 100% plant load throughout the year, 2.982×10^9 sand shrimp larvae would have been entrained from May 1978 to May 1979.

To determine the number of adult Crangon that would have been lost through entrainment, all larval stages were converted to equivalent stage I.

During 1978-1979 the average percentage of all larval stages was: Stage I - 32%, Stage II - 13%, Stage III - 8%, Stage IV - 8%, Stage V - 11%, Stage VI - 11%, Stage VII - 12%, and post-larvae - 5%. Since these ratios were not useful to generate a population survival curve, mortality was estimated based on data supplied by Temer and Broad (1964) for sand shrimp larvae cultured in laboratory at 18°-20°C on an Artemia diet. An age-specific mortality rate for larval stages was calculated from the general form

$$N_t = N_o e^{-zt}$$

for time intervals from hatcing to post larval stage. This yielded a mortality of Z=0.0967/day. Hillman (1964) estimated a mortality of 22% from one stage to the next for natural populations of Crangon larvae. However, this rate was not used because he enumerated only five larval stages where in reality there are 7-9 larvae stages of C. septemspinosa (Tesmer and Broad 1964). Consequently, the previous mortality rate was used since it provided a conservative estimate.

The age-specific mortality rate of larval C. septemspinosa was used to determine equivalent numbers of larval stages at hatching by using the equation:

$$N_o = \frac{N_t}{e^{-Zt}}$$

where:

N_o = number of larval sand shrimp at hatching

N_t = number of larval sand shrimp at time t

Z = instantaneous mortality rate (0.0967/day)

t = time in days

Based on an estimated average density of larval sand shrimp at hatching, and assuming 100% plant load, an equivalent of 6.387×10^9 Stage I sand shrimp would have been entrained in 1978. To determine the number of adults that would have been lost through entrainment of these larvae, the following assumption was made. If the population is in equilibrium, the fecundity of a female will be reduced to two breeding adults in one generation or

$$S = 2/F$$

where:

S = survival from egg to adult, and

F = fecundity of a breeding pair during their life.

Survival from egg to adult is a product of survivorship from egg to larvae and larvae to adult. For conservatism survivorship from egg to larvae was assumed to be 100%. Haefner (1976) provided a fecundity relationship of $Y = 2611 + 0.0077\ (X-156516)$ where

Y = number of eggs per female

X = cubed length in mm.

He found egg bearing females ranging in size from 16-70 mm. Smith (1950) never found adult sand shrimp greater than 30 mm. Beach seine data from Ninigret Pond for 1978 showed that 76% of adult Crangon were less than 40 mm (YAEC, 1979). Using a mean length of 30 mm for ovigerous females a fecundity of 1614 eggs per female was calculated. This provided a survivorship from hatching to adult of 0.124%.

Based on estimates generated by Applicant, the projected entrainment of larval sand shrimp at hatching would result in the loss of 7.92×10^6 adults.

The weight of these adults lost due to entrainment was estimated from the length-weight relationship provided by Wilcox and Jeffries (1973).

$$\text{Log } W = 0.040L + 1.0$$

where:

W = weight (mg)

L = Length (mm)

Based on Applicant's estimate, the projected loss of adult shrimp would weigh 1.256×10^6g (2763 lbs).

Smith (1950) estimated the standing stocks of C. septemspinosa in Block Island at 0.239 g/m^2. Assuming an area of 400 sq mi, the estimated loss of adult shrimp represent 0.5% of the standing stock of sand shrimp in Block Island Sound in 1949.

Smith also estimated that fish consumed 5.5g of food/g of fish/year and that sand shrimp comprised 7.2% of the stomach contents of fish. Therefore the amount of adult C.

septemspinosa lost due to larval entrainment would result in the loss of 3.0×10^6g or 6.6×10^3 lbs. of fish per year which is 0.0089% of Rhode Island commercial landings for 1978 (74.513×10^6 lbs).

Because of the magnitude of entrainment losses when compared to projected adult losses of fish in the next trophic level to Rhode Island commercial landings, Applicant believes that sand shrimp populations will not suffer appreciable harm as a result of larval entrainment.

Total Impacts. Since sand shrimp are found throughout the year in Block Island Sound, their thermal tolerance are sufficient so that the thermal discharge plume will not result in any appreciable harm to their populations. Because of their small size they will not be subject to entrapment in any significant quantity. A conservative estimate of the number of adult sand shrimp that would have been lost due to estimated May 1978 to May 1979 entrainment of larval sand shrimp and the resultant loss of their consumers showed that the impact would be small when compared to Rhode Island commercial fishery.

Consequently, Applicant believes that the operation of the heat dissipation system of NEP 1&2 will not result in appreciable harm to the sand shrimp populations.

4.2.16 American Lobster (Homarus americanus)

4.2.16.1 Life History. According to Saila and Pratt (1973), the lobster is the most valuable product of the northwest Atlantic fisheries, with the major fishery extending from Cape Cod to the Gulf of St. Lawrence. According to these authors approximately one-fifth of the total U.S. landings are caught inshore between Cape Cod and New Jersey. As the inshore stocks have declined due to intensive fishing, the effort has concentrated more and more offshore, where lobsters may be potted at depths down to 14,500 feet. During 1974 and 1975, a few adult lobsters were taken in the otter trawl samples collected off of Charlestown Beach; the largest numbers were taken during the late spring, summer and fall. The paucity of lobster pots set within the study area implies that commercial fishermen do not consider that the area contains a significant lobster stock.

The inshore populations are believed to undergo only limited seasonal migrations as a rule, moving offshore into deeper water in late fall and returning closer to shore in the spring. According to Cooper and Uzzmann (1971), members of the offshore populations may undertake more extensive seasonal movements inshore and offshore; the mean dispersal radius of tagged lobsters was 50 km (nearly 30 nautical miles). Saila and Flowers (1968) described lobsters traveling up to 218 km (120 nautical miles).

Lobsters are normally secretive in behavior, seeking shelter in burrows or beneath rocks. They are carnivorous and feed upon a variety of fish and invertebrates, including fellow lobsters. Their cannibalistic tendency makes availability of adequate shelter imperative and may limit population density in certain areas.

The breeding behavior of the lobster in captivitiy has been described by Herrick (1896) and Templeman (1934). Mating can occur only during a relative brief period immediately following molting by the female, and, according to Hughes and Matthiessen (1962), no successful matings have ever been observed at the Massachusetts State Lobster Hatchery 48 hours or more after molting occurred. Russell and Borden (1975) have reported that in Rhode Island Sound there are two optimal periods for molting; these periods are late spring and fall. During the mating process, the male lobster inserts the sperm into the seminal receptacle of the female. The eggs, fertilized as they are extruded approximately 9-12 months later, are attached to the swimmerets of the female beneath her abdomen. They remain in a cluster until hatching after an additional 9-12 month period. The number of eggs extruded varies directly with the size of the female and ranges from 5,000 to 125,000 (Bardach et al., 1972).

All eggs from one female hatch within a week or two depending upon temperature. At 20°C (68°F), all the eggs of a female will hatch within 2-3 days, whereas 10-14 days are required at 15°C (59°F) (Hughes and Matthiessen, 1962).

Hatching of lobster larvae in New England coastal waters generally occurs when water temperatures are approximately 12 to 15°C (54 to 59°F) (Raytheon 1977). The first three larval stages are entirely planktonic and free swimming. By the fourth molt, the larvae resemble the adult yet continue to swim for several days before becoming bottom seeking. By the fifth stage, the lobster is primarily benthic; however, swimming has occasionally been reported (Cobb, 1976).

During its first growing season, the juvenile lobster molts an average of ten times, at the conclusion of which it may average 13.5 mm (approximately one-half inch) in carapace length. Molting frequency declines with age, averaging three to four in number during the second year, three during the third, two during the fourth, and only one or less at age five onward. By the end of their fifth growing season, lobsters in captivity averaged 82.2 mm (3.3 inches) in carapace length. (Hughes and Matthiessen, 1962). The legal size is 3-1/16 inches (78 mm) carapace length in Rhode Island.

The number of lobsters that have become sexually mature by the time legal size is attained appears to vary with sex and geographic location. For example, along the Maine coast Krouse (1973) reported that only a very small percentage of females become sexually mature below 90 mm carapace length while most males were sexually mature at approximately 55 mm carapace length. In Long Island Sound, Smith (1977) observed that 25-64% of the sublegal size female lobsters were sexually mature.

The temporal abundance of lobster larvae is presented in Figure G.4.2-59; the spatial distribution within the study area is presented in Figures G.4.2-60 and G.4.2-61.

4.2.16.2 Impacts of Construction. Adult lobsters are present in the construction area in very low numbers; those which are present have sufficient mobility to avoid or move away from the construction activity. Lobster larvae which have a relatively short planktonic life are expected in the area of construction from May to August. Although it is possible that relatively high concentrations of larvae may be found, it is expected that their time of passage through the area of suspended sediments and turbidity will be very short and limited to the immediate area of construction. Under these circumstances, no appreciable harm to the lobster population is expected as a result of construction activities.

4.2.16.3 Impacts of Plant Operation

Entrapment. Bimonthly sampling with a commercial otter trawl near the location of the proposed intake from April 1975 through March 1976 failed to net a single lobster.

During 1978, a study was conducted to determine the population structure and harvest rate of the lobster fishery in the immediate vicinity of the proposed NEP 1&2 (Marcello et al., 1979). Mean legal catch rates per pot per setover day ranged from 0.13 to 0.23; rates similar to the lower rates for Narragansett Bay and Rhode Island Sound (Russell et al., 1978). Generally, there was no significant difference in the mean catch rates of lobsters from different areas. The catch rate of sublegal unberried female lobsters in the area of the proposed NEP 1&2 intake and discharge, however, was within the group of station means that were found to be significantly lower than average catch rates in other regions of the study area. Their abundance is apparently no greater than that of other inshore regions of Rhode Island coastal waters.

The ability of lobsters to endure various sustained swimming speeds has been reported by Hyman and Mobray (undated). These investigators found that lobsters with a carapace length of 1.4 to 3.5 inches could endure water velocities of 1.3, 2.1, and 2.9 fps for time periods of at least 60 minutes. Based on the above information, lobsters which might encounter the NEP 1 and 2 intakes should be able to escape from the induced intake currents and avoid entrapment.

Therefore, since lobsters do not appear to occur in substantial numbers near the intake location, and since their benthic life style and swimming capability would tend to preclude entrapment, no appreciable impact on the lobster population is predicted.

Within the Discharge Plume. During 1974 and 1975, Applicant observed adult lobsters in otter trawl samples most frequently during late spring, summer, and fall. Observations made from neuston net studies initiated during the early summer of 1976 have revealed the presence of lobster larvae directly off Ninigret Pond.

As described earlier in the lobster life history section, female lobsters retain the eggs by attaching them to her swimmerets. As a consequence, no thermal impact is expected for eggs since the female can move from an area should it prove untenable.

Records maintained at the Massachusetts State Lobster Hatchery indicate that hatching usually begins in May when water temperatures have reached 15°C (59°F), with most intensive hatching occurring during June and early July when water temperatures reach 20°C (68°F). At 20°C, the hatching process for an individual female is generally completed within a 2-3 day period.

The duration of the planktonic larval period varies indirectly with temperature. According to Perkins (1972) and Hughes et al., (1972), the respective rate of development for lobster embryos and post larval stages are strongly influenced by temperature: with a positive relationship up to temperatures of 24-25°C (77°F). According to Hughes and Matthiessen (1962), the time required for newly hatched larvae to reach stage IV varied from nine days, at an average temperature of 22.3°C (72°F), to as long as three to four weeks at temperatures averaging 17°C (62-63°F). Molting rarely occurs at temperatures below 10°C (50°F) but resumes at 15°C (59°F) the following year. By the fifth stage, the juvenile lobster usually seeks the bottom and shelter, where it remains for the remainder of its existence.

As cited by Smith (1974), an excellent review of lobster temperature effects has been produced by McLeese (1956). Thermal acclimation for this species appears to be accomplished from about 58 to 73.4°F within 22 days. Upper lethal temperature levels were investigated for lobster acclimated at 41°F, 59°F and 77°F. With a test salinity of 25 o/oo and 4.3 mg/l of oxygen, the upper lethal temperatures were 71.8°F, 82.8°F and 85.1°F, respectively.

The lobster larval stages according to Perkins et al., (undated) are more tolerant of high temperatures than is the adult. In thermal tests conducted on the first through fourth larval stages, these investigators claim no mortality with a short term exposure of 87.8°F and only minimal loss at six hour exposures of 80.6°F. The results of their experiments are generally in agreement with the observations of McLeese (1956) and Huntsman (1924) with regard to the acclimated lobster's ability to tolerate increased temperature. A recent investigation covered in the environmental studies report for Boston Edison Company's Pilgrim Station show some lobster larvae survival (TL50) at 84.5°F for 24 hours, 85°F for 2 hours, and 91°F for 1 hour (Battelle Columbus Laboratory, 1972).

Obviously, since lobster larvae are generally associated with the surface component of the plankton, there is a very good possibility that they will be found in the thermal plume. On the basis of the literature, natural water temperatures would have negligible effect on the planktonic stage of this species. A 6°F increase in the natural surface water temperatures would approximate a surface maximum of 75-76°F inside the boundary of the mixing zone, such a temperature is well within the tolerance range indicated by both Battelle Columbus Laboratory and Perkins.

Similarly, adult thermal tolerance studies indicate induced water temperatures fall within the tolerance capabilities of the adult. The likelihood of thermal impact upon the adult is further reduced due to its ability to move out of an area should it prove unsuitable.

The thermal tolerance information available on the lobster is depicted in Figure G.4.2-62.

In-Plant Effects. During 1977, lobster larval stages I, II, III and IV occurred at the location of the proposed intake for approximately 57, 56, 35, and 29 days respectively. Based on calculated average densities (mean of day, night, surface and bottom densities) and assuming 100% plant load during their period of occurrence, 3.820 x 10^5 stage I, 6.675 x 10^4 stage II, 3.154 x 10^4 stage III, and 1.450 x 10^4 stage IV lobster larvae would have been entrained in 1977.

In 1976, lobster larvae were not sampled until the hatching period was well underway (Marine Research, Inc. 1977). Furthermore, no stratified samples were taken nor were day-night effects fully investigated. Nevertheless, comparison of larval densities calculated for 1976 and 1977 revealed that 1976 larval densities were substantially higher than those in 1977. Because of this higher density and therefore the potential for greater entrainment effects, Applicant utilized the procedures described below to estimate the 1976 entrainment of lobster larvae.

For similar periods of occurrence, the average surface density of lobster larvae by stage for 1976 and 1977 were compared. From this comparison, it was determined that the 1976 average surface density of stage I, II, III and IV lobster larvae was approximately 1.33, 3.44, 5.24 and 24 times greater than the densities for 1977. The 1977 lobster larval entrainment estimates by stage were multiplied by the above factors and were assumed to approximate the 1976 entrainment of lobster larvae. This projected 1976 entrainment was 5.080 x 10^5 stage I, 2.296 x 10^5 stage II, 1.653 x 10^5 stage II, and 3.480×10^5 stage IV.

These stage specific entrainment estimates were then converted to the entrainment of equivalent stage I larvae by applying appropriate conversion factors determined from the larval survival data of Scarratt (1964), Lund and Stewart (1970), and survival coefficients derived by Applicant by simple ratio of the 1977 average Block Island Sound larval densities reported by Raytheon (1977). These equivalent stage I entrainment conversion factors are presented in the following table:

Lobster Larval Entrainment Estimate for Stage	Conversion Factor to Equivalent Stage I Entrainment		
	Scarratt (1964)	Lund & Stewart (1970)	Raytheon (1977)
I	1.0	1.0	1.0
II	6.8	1.4	2.5
III	27.4	1.5	4.4
IV	88.8	1.9	13.3

The estimated 1976 entrainment of equivalent stage I larvae obtained by applying the above conversion factors ranged from 1.756×10^6 for conversion factors derived from Lund and Stewart (1970) to 3.749×10^7 for conversion factors derived from Scarratt (1964). The estimated 1977 entrainment of equivalent Stage I larvae ranged from 5.531×10^5 for conversion factors derived from Lund and Stewart (1970 to 2.987×10^6 for conversion factors derived from Scarratt (1964). For conservatism, only the impact of the maximum estimated entrainment of equivalent stage I larvae for 1976 and 1977 obtained by applying conversion factors derived from Scarratt (1964) was assessed.

This maximum entrainment estimate of equivalent stage I larvae was then equated to the number of adult lobsters that would have recruited to the commercial fishery approximately 5 years later.

The survival of stage I lobster larvae until they are recruited to the commercial fishery can be described by the equation (Ricker, 1975):

$$N_t = N_o e^{-Zt}$$

where: N_t = number of lobsters at time t

N_o = number of lobsters at time 0

Z = instantaneous total mortality rate

Saila and Flowers (1966) applied a similar model as described by the above equation to simulate the effects of sex ratios and fishing regulations on a theoretical lobster population.

Wilder (1965) estimated that the instantaneous rate of natural mortality (M) for lobsters was between 10 and 15 percent. Since total instantaneous mortality is equivalent to the sum of natural (M) and fishing (F) instantaneous mortality (Ricker, 1975), and since Applicant assumed that F=0 during the time period prior to recruitment to the fishery, then an estimate of total mortality for pre-recruitment lobsters is approximately 10 to 15 percent.

Applicant calculated Z-values for post-recruitment male and female lobsters ($\geq$81 mm carapace length) from length-frequency data on the heavily exploited Long Island Sound lobster fishery reported by Smith (1977). Age-frequency distributions for these data were developed by applying the Von Bertalanffy growth equation (Ricker, 1975) derived by the Rhode Island Division of Marine Fisheries for lobsters from the mid-shelf region of Rhode Island Sound. The general form of the Von Bertalanffy equation is:

$$L_t = L_\infty \quad [1 - e^{-K(t-t_o)}]$$

where: L_t = length at age t

L_∞ = mean asymptotic length

K = Brody growth coefficient

T = age in years

t_o = age at first egg extrusion

The coefficients for the above equation for Rhode Island Sound (mid-shelf region) male and female lobsters are (M. Fogarty, Rhode Island DEM, personal comm.)

Male	Female
L_∞ = 280.784	L_∞ = 240.020
K = 0.081	K = 0.071
t_o = 0.179	t_o = -0.134

Based on the above information, the male post-recruitment survivorship and total instantaneous mortality coefficients for the Long Island Sound lobster fishery were calculated to be 0.115 and 2.160, respectively. Coefficients for the Rhode Island post-recruitment male lobster stock (which are $\geq$78 mm carapace length) were assumed equivalent to those given above.

Approximately 8%, 8% and 40% of female lobsters, 78, 81 and 89 mm long respectively, from Rhode Island Sound were found to be gravid (M. Fogarty Rhode Island DEM, personal comm.) For Long Island Sound, these gravid female percentages for similar size females were approximately 20%, 21% and 24%.

Due to the difference in the minimum legal size (and therefore the time at which the female populations undergo fishing exploitation), and the difference in the frequency of berried females for the Connecticut and Rhode Island lobster fisheries, survivorship and total instantaneous mortality coefficients for Long Island Sound female lobsters were not directly applied to the Rhode Island females of age 5.4 years (approximate age at minimum legal size) to 6 years (common age of females undergoing fishing exploitation in both populations). Instead, total mortality coefficients for Rhode Island non-gravid female lobsters from age 5.4 years to 6 years were assumed equal to those determined for males in Long Island Sound (only about 8% of Rhode Island female lobsters under age 6 are gravid). For gravid females (which are protected) within this age class, survivorship and Z was assumed equivalent to natural rates, or 0.86 and 0.15, respectively. Survivorship and Z for all Long Island Sound female lobsters greater than or equal to 6 years ($\geq$85 mm carapace length) was 0.186 and 1.682, respectively. Coefficients for the Rhode Island female lobster stock of the same age were assumed to be equal to those given above for Long Island Sound.

Saila et al. (1969) provided the following regression equation for estimating fecundity as a function of size:

$$\text{Log (Fecundity)} = -1.6017 + 2.8647 \text{ log (Carapace length in mm)}$$

Utilizing the above information plus an assumed sex ratio of 1:1 for an unexploited population, and assuming no reproduction after 20 years, a Leslie population projection matrix was constructed (Table G.4.2-1) which described a stable population (the eigen value or finite population growth rate was 1.00). In this model, the survival rate (S_o) from larval stage I to age 1 was determined by a numerical method presented by Vaughan and Saila (1976) to be 5.951×10^{-5}. Values significantly different from the value of S_o will not allow the lobster population size to remain stable.

A Leslie population projection matrix was also constructed for the heavily exploited Long Island Sound population to determine the magnitude of the density dependence in survivorship during the first year of life (S_o) which would be required in order to maintain a stable population. In the exploited population, S_o was 4.067×10^{-4} or a 6.8-fold increase in survivorship from larval stage I to 1 year of age over the unexploited population. This latter estimate of S_o was used to project the number of adults not recruited to the fishery. In reality, it is not believed possible for there to be such great elasticity in S_o, and the following impact estimates are considered to be overly conservative.

From these estimates of age-specific survival, approximately 7880 minimum legal-size lobsters would not be recruited to the fishery due to the estimated 1976 entrainment of equivalent stage I larvae. For 1977, 628 legal size lobsters would not be recruited to the fishery due to entrainment.

Krouse (1973) provided the following length-weight regression for lobsters in Maine:

$$\text{Log } W = -2.9052 + 2.9013 \text{ Log } L$$

where: W = weight in grams, and

L = carapace length in mm

From the above regression, a minimum legal-size lobster (78 mm) in Rhode island would weigh approximately 384 grams or 0.85 pounds. Thus, the total weight of lobsters not recruited to the commercial fishery due to maximum projected 1976 and 1977 entrainment is approximately 6698 and 534 pounds, respectively. This represents 0.20% and 0.02% of the 1976 and 1977 Rhode Island landings, respectively.

As a result of the above calculations, which indicate that the effect of entrainment on this species will be minor, it is concluded that the lobster population will suffer no appreciable harm as a result of entrainment.

Total Impacts. The lobster is a highly thermal-tolerant species which will not be subject to more than occasional entrapment. The one potential source of plant induced effects on this species is entrainment. A conservative analysis of the number of adult lobsters that would not be recruited to the commercial fishery due to estimated 1976 and 1977 entrainment of lobster larvae showed that the impact would be small compared to the commercial fishery; entrainment effects amount to a fractional percentage of the Rhode Island landings.

Consequently, Applicant believes that the operation of the heat dissipation system of NEP 1&2 will not result in appreciable harm to the lobster population.

4.2.17 Eelgrass (Zostera marina)

4.2.17.1 Life History. Eelgrass is an aquatic spermatophyte with a worldwide distribution. On the western side of the North Atlantic, this perennial ranges from as far north as Greenland (Lange, 1887) and Hudson's Bay (Prosild, 1932) southward to the Carolina (Setchell, 1920). Areas of greatest abundance were found between the Gulf of St. Lawrence and North Carolina.

Eelgrass may be found on a wide variety of sea bottoms; from which, through its root systems, it derives most of its nutrients (McRoy and Barsdate, 1970; McRoy and Goering, 1974). It may become established in a variety of substrates, ranging from sandy gravel to soft mud. According to Burkholder and Doheny (1968), the most favorable bottom appears to consist of fine muddy sand beneath a coarser layer of sand or mud.

Eelgrass becomes established from the low tide mark seaward to a depth of 10-12 feet. It is tolerant of a wide range in salinity, having been found living in freshwater (0 ppt) and at 42 ppt (Short et al., 1974); the optimum salinity range is 10-30 ppt (Phillips, 1974).

It is also sensitive to light, as studies by McRoy (1966) have indicated that photosynthetic activity reaches a maximum at about 25 langley/hour. High turbidity, resulting in severe light attenuation, would be detrimental to this species (Short et al., 1974).

Growth has been found to be stimulated by water currents up to 0.7 knots (Conover, 1968).

Burkholder and Doheny (1968) have described the development of Zostera in some detail. They indicate that flowering shoots are developed during the second year after germination. Pollen is filamentous and is maintained in suspension by currents. Each fruit produces a single seed, there being an average of 60 seeds per flowering shoot. Eelgrass may also extend its coverage through expansion of its rhizome system beneath the sediment and subsequent emergency of new shoots.

Eelgrass is periodically affected by disease over large geographic areas, the last serious outbreak - termed the "wasting disease" - occurred around 1930. By 1934, according to Stevens (1936), approximately 90% of the eelgrass in Western Europe as well as of the Eastern United States has been destroyed.

Eelgrass fulfills an extremely important role in areas such as Ninigret Pond, where it occurs in dense concentrations. It offers an ideal shelter, habitat and substrate for a variety of macro- and microinfauna. Studies by Alle (1923) and Stauffer (1937) in the Woods Hole area revealed a 33% reduction in the number of species present after disappearance of eelgrass.

In addition, dead and dying eelgrass yields large amounts of nutritive material (Marshall, 1970) and contributes, directly or indirectly, a high percentage of the food material for fish, shellfish and waterfowl, as well as for the microfauna.

Because the root system of eelgrass tends to stabilize otherwise shifting bottom, it helps to develop a suitable substrate for various valuable species of bivalve mollusks, including the hard clam and bay scallop.

4.2.17.2 Impacts of Construction. Eelgrass is not present in the construction area in Block Island Sound.

4.2.17.3 Impacts of Plant Operation. Because it is confined within Ninigret Pond and because its primary means of reproduction is vegetative (rhizomes), there will be no effect of plant operation on this species.

4.3 Other Impacts

Impacts other than those associated with entrapment, entrainment, and thermal effects can occur due to plant operation. These impacts include effect of chemical and biocide discharges and indirect lethal and sublethal effects as cold shock, gas bubble disease, skinny fish syndrome, pressure effects, and thermal backflushing. A discussion of these potential impacts is provided below.

4.3.1 Cold Shock

The cold shock phenomenon occurs when organisms have become acclimated to high temperatures and are suddenly exposed, due to unit shutdowns, to low temperatures usually near or below their minimum thermal tolerance.

With an offshore multi-port diffuser system, the potential for thermal shock during shutdown or refueling is expected to be very small. Refueling or other scheduled shutdowns are normally planned such that only one unit is operative at a given time so that at least half the plant's thermal discharge will normally be present. Furthermore, the diffuser reduces water temperature by rapid dilution. With the relatively low temperature differential throughout those parts of the nearfield in which fish can maintain their position, it is unlikely that shutdown of one or both units could result in significant thermal shock to aquatic biota because temperature rise is relatively slight in these areas. No physical boundaries exist at the discharge point for mobile organisms to orient into or be confined by, and it is unlikely that marine life can reside in the jets for more than a few seconds due to the discharge velocity and momentum of the diffuser jets. Thus, the potential for significant cold shock impacts to occur at NEP 1&2 is judged minimal.

4.3.2 Gas Bubble Disease

Thermal effluents supersaturated with dissolved gases can have detrimental effects on fish. Fish that are attracted to and subsequently reside in supersaturated effluent water for a long enough period will absorb more gas than can be maintained in solution in their bodies. When this gas comes out of solution within the fish, gas bubbles are formed causing a condition generally referred to as gas bubble disease. Gas bubble disease is a pathological process due to one or more physical manifestations including gas emboli, exopthalmus, and systemic emphysema (Wolke et al., Bouck and Stroud, 1975). In a mild form, gas bubble disease may result in disorientation and erratic behavior. In its most severe form, however, it can result in death. Studies have also shown that fish can recover from the effects of short exposures to high levels of supersaturation if returned to ambient levels.

Incidents of gas bubble disease of fish in the thermal effluent of electric generating stations have been reported by several investigators (De Mont and Miller, 1971; Miller and De Mont, 1974; Marcello and Strawn, 1972; Marcello, 1975; Marcello and Fairbanks, 1976; Fairbanks and Lawton, 1977). Two of these reported incidents occurred at a New England coastal power plant (Pilgrim Station) and involved a species designated as a representative important species for NEP 1&2 (Atlantic menhaden). Each of the above reported incidents of gas bubble disease, however, occurred at power stations utilizing shoreline, surface discharge systems. The likelihood of such incidents occurring at NEP 1&2 is greatly reduced due to utilization of a submerged multiport diffuser discharge.

Submerged diffuser discharges promote rapid dilution of heated effluent with cooler ambient water. Two parameters control saturation levels of gases in the water as it exits from the underwater diffuser and mixes with the ambient water. These parameters are hydrostatic pressure and thermal diffusion characteristics of the diffuser. This interaction of temperature and pressure on the gas solubility of seawater as it passes through a power plant diffuser cooling system was examined by Marcello, Krabach and Bartlett (1975). These authors plotted the gas saturation history of a parcel of seawater through a diffuser system for the conditions of a 37°F temperature rise, and intake water temperature and gas saturation of 40°F and 110% saturation, respectively (typical of surface conditions at coastal sites in this region). The diffuser they evaluated was designed to meet a surface temperature criteria of 5°F above ambient. They pointed out that since the circulating water absorbs heat on passing through the condenser, the percent saturation of dissolved gas increased to about 160%. The highly supersaturated water is pumped to the diffuser located at a depth of 30 feet where the saturation becomes less than 90%. As the heated water is discharged from the diffuser nozzles and rises to the surface, temperatures are attenuated and the hydrostatic pressure decreased such that the effluent gas saturation is slightly above 115% at the surface.

Based on studies of the tolerance of a variety of fish to gas supersaturated conditions, regulatory agencies and other technical advisory groups have established that a 115% saturation surface criterion would provide reasonable protection to fish from gas bubble disease mortality (USEPA, 1977; Rulifson and Pine, 1976). Since the NEP 1&2 circulating water system utilizes a submerged diffuser which discharges between the 30 and 40 foot depth, and is designed to meet a maximum surface temperature criteria of about 6°F above ambient, gas saturation levels will be only slightly above ambient intake levels. Furthermore, an offshore submerged diffuser has been shown to be a technically feasible solution to the problem of gas bubble disease mortality at Pilgrim Nuclear Power Station, Marcello et al. (1975). Thus, the potential for gas bubble disease to occur in the vicinity of the NEP 1&2 thermal discharge is greatly reduced and should cause no significant impact.

4.3.3 Hydrostatic Pressure Effects

The proposed NEP 1&2 intake system will utilize a bedrock tunnel at a depth of about 160 to 200 feet to convey cooling water to the site (see Section 3.0). As a result of this depth, entrapped organisms will be subjected to substantial hydrostatic pressures. These pressures (directly or indirectly) could cause such adverse effects to entrapped biota as gas bubble disease, pressure related mortality, or mechanical abrasion along the tunnel system due to altered buoyancy from gas bladder compression.

A detailed evaluation of the potential for pressure related impacts is provided in ER Appendix I. This evaluation was based on a review of existing literature and power plant operating experience on the survival of fish and other organisms exposed to various pressure regimes. As a result of this study, it was concluded that of the concerns expressed above, only the potential for increased mechanical damage due to abrasion with the intake tunnel walls may occur. While it is not possible to quantify this potential increment effect, it was speculated that factors such as the development of a laminar boundary layer and the possibility for increased swimming activity of fish when pressurized may tend to minimize this effect by keeping fish in the mainstream of the water flow. The potential for gas bubble disease or gas bladder rupture to fish was shown to be minimal at NEP 1&2. Pressures of the magnitude experienced by fish during passage through the proposed NEP 1&2 intake tunnel system was also shown to have a low potential for adverse impact. Thus, the overall potential for adverse impacts resulting from exposure to hydrostatic pressures during transit through the proposed NEP 1&2 intake tunnel system is judged minimal and should cause no appreciable harm.

4.3.4 Skinny Fish Syndrome

Loss of weight and ultimately a corresponding reduction in the coefficient of condition, or "skinny fish syndrome" is alluded to in Marcy (1976). Possible reasons for loss of weight and condition for fish is attributed to: (1) an increased metabolic rate resulting from prolonged exposure to an increased temperature environment; (2) a greater expenditure of energy for fish species to maintain themselves in the discharge plume; and (3) overcrowding resulting in increased competition for food.

Of particular importance in understanding this phenomenon and trying to make projections specific to Applicant's thermal discharge system, is that "skinny fish syndrome" is reported at a power station which utilizes a shoreline, surface discharge system. Such a discharge design encourages finfish to take up residence within a confined area for extended periods of time for example over the winter.

The likelihood of finfish developing similar symptomatic conditions reported at the Connecticut Yankee nuclear generating facility (Marcy, 1976) which utilizes a shoreline discharge, is considered remote since Applicant proposes to use a submerged multiport diffuser discharge system. A diffuser system is designed to enhance the mixing and dilution of the heated discharge. The thermal plume which results is dynamic in nature and is always in a state of transition as it responds to constantly changing ambient reversing tidal currents, wind, and wave action. Consequently, confinement within a restricted area where fish become acclimated and ultimately develop such secondary effects as "skinny fish syndrome" is not anticipated.

4.3.5 Premature Spawning

The sequence of events relating to maturation, spawning migration, release of gametes, and subsequent development of egg and embryo represents a complex interaction of input stimuli. Among the environmental factors are light (photoperiod), temperature, salinity, water currents, tides, and food abundance which are all seasonally related one way or another. On the whole, there appears to be a more pronounced relation between light, particularly where precision of timing and migration are involved. However, one of the reasons for this precision may be the need imposed by a restricted temperature range for early development. In general, temperature may affect the rate of maturation; it is known to act as a timing and/or releasing factor; it undoubtedly imposes a marked confining effect on reproductive limits (Breh, 1970).

Obviously, since temperature is an influential factor in spawning, any direct alteration to background ambient temperatures (such as the addition of waste heat) has the potential of inducing premature spawning activity. Inasmuch as electric power plants introduce waste heat into the environment there must be delineating parameters which enhance the potential for premature spawning. One such parameter is a shoreline discharge structure which enables organisms to orient to the discharge plume with its rather stable isothermal areas over an extended period of time. One particular case in point is EPA's reference to a premature spawning incident in the shoreline discharge canal of Brayton Point (USEPA, 1977).

The possibility of a similar incident occurring at NEP 1&2 is considered remote since a submerged multiport diffuser will be used versus a shoreline discharge structure. Design characteristics specific to a diffuser discharge system enhance rapid mixing and subsequent dilution of the thermal plume. These factors, when combined with the dynamic nature of the discharge caused by tidal fluctuations, wind and waves does not allow aquatic organisms to orient themselves to a preferential isotherm for an extended period of time. Consequently, any possibility for premature spawning is considered minimal.

4.3.6 Effects of Chemical and Biocide Discharges

To prevent biofouling in the circulating and service water systems, a combination of chlorine, antifoulant coatings, and heat treatment will be utilized. Fouling control in the circulating water system will be conducted one unit at a time in order to eliminate the possibility of additive effects. A full discussion of the fouling control systems is presented in Section 3.4, 3.4.2 and 3.6.1 of the ER.

Chlorination of the circulating water system will comply with the EPA regulations which requires a maximum average free available of 0.2 ppm for two hours per day per unit with an instantaneous maximum of 0.5 ppm. Adherence to these regulations will result in minimal environmental impact.

Because equipment temperature requirements prohibit heat treating the service water system, and because the pipes of this system are too small to be painted, the service water must be continuously chlorinated. Chlorine will be injected at a rate which will result in a discharge concentration of 0.2 ppm free available prior to mixing with the circulating water. Upon mixing with the circulating water there will be an immediate dilution of approximately 18:1. In addition to dilution, the circulating water also provides a new chlorine demand. This dilution, then, will effectively dechlorinate all of the free available chlorine in the service water, and it is unlikely that any chloramines will be formed after the mixing. Because of the low volume and great dilution of this flow, it is believed that any incremental mortality caused by continually chlorinating the service water will be insignificant.

Since all organisms will probably be killed when subjected to the 37°F Δt , chlorine induced entrainment mortality may be considered to be zero.

Because the circulating water pumps provide flow in only one direction, the pumphouse, on-site circulating water pipes and the inlet water boxes will never be heat treated. As intermittent chlorination has proven ineffective in the control of the fouling organism of primary concern (the blue mussel *Mytilus edulis*), it will be necessary to coat these components with an antifoulant coating. The concentration of leached toxic material from these coatings will be extremely small and should not adversely affect biota in or beyond the plant discharge.

A description of the chemical treatment system is found in ER Section 3.6. All chemical discharges will conform to applicable regulatory standards. No adverse effects on the marine biota are anticipated.

4.3.7 Effect of Thermal Backflushing

As described in Section 3.3, thermal backflushing is used to control biofouling in order to maintain the cooling system in an operational condition.

For heat treatment to be effective Applicant estimates that a backflush discharge temperature of 120°F (49°C) is required for approximately two hours per treatment. Backflushing heat treatment is expected to be required about once every two weeks during the warmer months between April to November and less frequently during other months. Depending on the ambient water temperature, a backflush temperature of 120°F (49°C) represents a ΔT of from 50 to 83°F (28 to 46°C).

Resultant plume effects are incurred primarily by the more passive plankton which are entrained into the backflush discharge. On the other hand, the nektonic species, such as fish and squid could avoid any deleterious thermal effect as a result of their swimming ability. Similarly, benthic organisms are not expected to be effected since the backflush plume never touches the bottom.

Heat shock resulting from the high ΔT of the effluent water will cause localized mortality among organisms unable to avoid the backflush plume. The number of entrained planktonic organisms is small, however, because of the reduced volumes of cooling water required as a consequence of the corresponding high ΔT.

5.0 ALTERNATIVE INTAKE SYSTEMS

The proposed intake system has been described in Section 3 of this appendix. The purpose of this section is to summarize considerations of alternative intake systems.

As discussed in NEP 1&2 ER Sections 3.4 and 10.2, three alternate intake system concepts were evaluated. These are:

a conventional onshore intake

b. submerged offshore intake located at 30 foot depths

c. submerged far offshore intake located at 50 foot depths.

ER Appendix H describes the decision process used in selection of the proposed intake. Figure G.5.0-1 depicts this decision process and provides references to appropriate sections of the ER.

5.1 Onshore Intake

5.1.1 System Description

The onshore intake system is described in ER Section 10.2.2. For this system, an ocean front intake is located on East Beach where flow is drawn through bar racks into the intake forebay. Sheet pile extends offshore about 400 feet to form an intake canal. Cooling water flows to the pumphouse at the plant site through one 18 foot (I.D.) intake tunnel 3700 feet in length.

5.1.2 Environmental Impacts

Construction impacts of the onshore intake system are greater than those associated with the proposed offshore intake system. Open cut excavation and dredging is required on East Beach and in the nearshore zone whereas similar activities are not required for construction of the proposed intake system.

Entrapment and entrainment impacts associated with the onshore East Bearch intake are judged to be similar to the proposed offshore intake. However, there are no thermal effects of backflushing for the onshore intake because chlorination is used to control biofouling control.

Resource utilization and aesthetic impacts are greater for the onshore East Beach intake. It requires the use of East Beach and may interfere with small boat traffic. The proposed offshore intake requires no use of East Beach, does not affect small boat traffic and has no visible components.

5.1.3 Engineering Considerations

Engineering and economic considerations clearly favor the onshore intake system. Its present value (1985 dollars) is estimated to be $11 million less than the proposed offshore intake. It can be constructed using primarily land based equipment and conventional construction techniques. Geotechnical considerations also favor the onshore intake because the tunnel riser shaft can be fabricated on shore and in shallower overburden.

5.1.4 Summary: Onshore vs. Offshore Intake

A broad evaluation of the foregoing environmental and engineering considerations, led to the selection of the offshore intake concept in preference to the onshore intake. In general, engineering factors favor the onshore intake; however, the environmental benefits of the offshore intake are considered sufficient to justify the additional cost and engineering disadvantages.

5.2 Far Offshore Intake

5.2.1 System Description

The alternate offshore intake system is described in ER Section 10.2.3. It consists of two identical off-set submerged intakes, two 14-foot inside diameter intake pipes connected to one 18-foot inside diameter intake tunnel through associated riser shafts, and a pumphouse located on the site. The intakes are located at a water depth of about 50 ft in Block Island Sound approximately 10,000 feet south of the plant site. Tunnels would extend out an initial 6000 feet from the site followed by an additional 4000 feet of pipe. This intake system is estimated to cost $60 million (present value - 1985 dollars) more than the proposed intake system.

5.2.2 Environmental Impacts

Construction effects of the far offshore intake are greater than for the proposed offshore intake. This is because cut and fill pipe installation is probably required to extend the cooling system beyond the 30 foot depth contour.

Entrapment and entrainment impacts vary by species for the proposed and far offshore intake location. Although the far offshore intake accounts for a small reduction in annual average entrainment of ichthyoplankton, it results in an increased entrainment of eggs and larvae of six representative important species as compared to the proposed intake. Of these six RIS exposed to greater entrainment by the far offshore intake, five are commercially important species (i.e., Atlantic menhaden, silver hake, scup, Atlantic mackerel and butterfish) which contribute to the economically important Rhode Island offshore commercial finfish community (NEP 1&2).

Although the predicted absolute number of entrained and entrapped individuals varies by species for the proposed and far offshore intake locations, there is no practical justification for selecting the far offshore intake. As demonstrated by Section 4.2 of this Appendix, the overall impacts attributed to the proposed intake are negligible. Consequently, relocating the intakes farther offshore in an attempt to further minimize an already negligible impact is neither cost effective nor could it have any measurable environmental benefit.

The aesthetic impact of the proposed and far offshore intake locations are similar. In neither case will any structure be visible after construction is complete.

In both cases, the quantity of backflush flow and temperature rise are similar; consequently, thermal effects of backflushing are also similar for the proposed and far offshore intakes.

5.2.3 Engineering Considerations

Engineering considerations favor the proposed intake location. It is anticipated that cut and cover pipe installation is required to extend the cooling system beyond the 30 foot depth contour. This results in construction problems not encountered in fabrication of bedrock tunnels which extend to the proposed intake location. Furthermore, placement of the intakes at the far offshore location requires construction activity in deeper water which is also a disadvantage.

The additional $60 million cost (present value-1985 dollars) of the far offshore intake is also a disadvantage. This increased cost is incurred primarily due to the addition of two 4000 foot lengths of 14 foot I.D. pipe.

5.2.4 Summary: Proposed vs. Far Offshore Intake

It has been demonstrated that the environmental impacts of the proposed intake system are negligible (Section 4.2 of this appendix ER Section 5.1). Furthermore, it is unlikely that any net measurable environmental benefit can be derived by relocating the intake farther offshore. In fact, for at least five commercially important species, the far offshore intake location incurs greater entrainment impacts. Even if there were a theoretical environmental benefit to relocating the intake farther offshore, it could not be measured because the impacts of the proposed intake are negligible.

Incurring an additional cost of $60 million to relocate the intake far offshore is wholly disproportionate to any potential environmental benefit to be gained. In fact, it is likely that the impact on certain important species would be increased by relocating the intake far offshore. Furthermore, construction impacts would be substantially increased.

The proposed intake system is believed to be feasible from a construction and engineering perspective. Its cost, although excessive in comparison to a conventional onshore intake system, is believed to be commensurate with its environmental benefits.

6.0 REPRESENTATIVE IMPORTANT SPECIES IMPACT SUMMARIES AND MASTER ECOSYSTEM RATIONALE

Concise summaries of predicted impacts on the NEP 1&2 Representative Important Species are presented below in Section 6.1 and are summarized in Table G.6.0-1. In addition, Section 6.2 provides the master ecosystem rationale that integrates biological, physical and plant operational data to demonstrate that construction and operation of NEP 1&2 will not cause appreciable harm to the aquatic ecosystem of Block Island Sound, and thus will assure the protection and propogation of the balanced indigenous population of shellfish, fish, and wildlife in and on Block Island Sound in the vicinity of NEP 1&2.

6.1 Representative Important Species - Impact Summaries

With the exception of construction effects, impacts of plant operation (i.e., entrapment, thermal, and entrainment effects) are given below for each Representative Important Species. Because of the general nature of Applicant's construction impact assessments, construction effects for all species are addressed together in Section 6.1.1.

6.1.1 Impacts of Construction: Negligible.

Basis for Prediction: Twelve of the Representative Important Species are free swimming species. The temporary increases of suspended sediments and turbidity in the immediate area of the offshore construction will not affect juveniles or adults as they are sufficiently mobile to avoid such occurrences. There may be some adverse affect on egg and larval forms, but because of the transitory nature of the construction effects and the relatively small numbers of eggs and larvae in Block Island Sound, no appreciable impact is expected.

No adult hard clams were found in Block Island Sound and larvae were sparce.

Sand shrimp (*Crangon septemspinosa*) and adult lobster (*Homarus americanus*) are sufficiently mobile and sediment tolerant such that no appreciable impact will occur.

6.1.2 Atlantic menhaden (Brevoortia tyrannus)

Entrapment Effects: Negligible.

Basis for Prediction: Based on the comparative evaluation study of menhaden and their ecological counterparts at facilities with velocity cap intakes, Atlantic menhaden were judged to have a medium to high potential for entrapment. However, factors were identified which would tend to minimize entrapment of this species at NEP 1&2. These factors included the wariness of adults which may cause them to avoid the intake structure, the young remain in the estuary much of the time and would not be available for entrapment, and the lack of entrapment of this species and others of the same genera at the operating velocity cap intake at St. Lucie Generating Station in Florida. To place any potential menhaden entrapment losses at NEP 1&2 into perspective, modeling results on the population impact to menhaden resulting from entrapment at two nearby coastal power stations were evaluated. Modeling results from these nearby facilities indicated that within the range of annual intake entrapment losses of 1000 menhaden to 210 million menhaden (the larger number being derived from a mortality coefficient over 1700 times larger than normally expected), no significant impact occurred to the Atlantic menhaden population. Since any projected entrapment loss of menhaden at NEP 1&2 would probably fall on the low side of the range of losses cited above, it was concluded that entrapment of menhaden at NEP 1&2 should cause no appreciable harm to the Atlantic menhaden population.

Thermal Effects: Negligible.

Basis for Prediction: This impact is predicted on the basis of the Applicant's thermal assessment model which integrates background hydrographic data, plant thermal discharge parameters and published literature pertaining to the species' life history/thermal tolerance characteristics.

Such a thermal tolerance assessment indicates rather conclusively that the NEP 1&2 thermal discharge should not have an appreciable impact upon this species. The NEP 1&2 thermal discharge may interact with this species nearshore activities anytime during late spring or early fall. During this period, the various life history stages of this species could experience surface water temperatures between 53 to 75°F. Based upon the results obtained by the various investigators cited, such a temperature range falls well within the temperature tolerance capabilities of this species.

Entrainment Effects: Negligible.

Basis for Prediction: Larval entrainment losses were compared to those predicted to occur for Pilgrim Station Units 1 and 2 and Millstone Station Units 1, 2 and 3. Pilgrim Station, which would entrain 4.5 times more larvae than NEP 1&2 was predicted to conservatively cause a 0.00275 percent reduction in menhaden population over 50 years. A predicted 0.08 to 1.1 percent reduction in the menhaden population after 50 years was calculated for Millstone Station using an intentional overestimate of inplant mortality. The estimated number of larvae entrained at Millstone Station is over 1.2 times greater than the number of larvae predicted to be lost by NEP 1&2. Thus, the Atlantic menhaden population would not suffer appreciable harm as a result of larval entrainment.

6.1.3 Bay Anchovy (*Anchoa mitchilli*)

Entrapment Effects: Negligible.

Basis for Prediction: Based on the comparative entrapment study, bay anchovy were judged to have a medium to high entrapment potential. However, life history characteristics of this species indicates that it is primarily an estuarine species using the upper estuary as a nursery ground. Thus, the location of the intake is not in an area of preferred habitat. Furthermore, design development studies conducted for Southern California Edison on the velocity cap indicates that entrapment of the northern anchovy were substantially reduced. Thus, based on documented life history characteristics and velocity cap intake design, no appreciable harm to the anchovy population is anticipated.

Thermal Effects: Negligible.

Basis for Prediction: Applicant predicts no appreciable impact upon this species resulting from the NEP 1&2 thermal discharge. Such an assessment is based upon the Applicant's integration of existing thermal tolerance literature, the species life history characteristics and predicted plant operating parameters.

Similar to the Atlantic menhaden, the bay anchovy is an ubiquitous species which is customarily associated with warmer water temperatures. Results generated from the Applicant's thermal tolerance analysis of bay anchovy eggs, larvae and adults indicates that these various life history stages should satisfactorily tolerate induced surface water temperatures predicted to range between 53 and 75°F.

Entrainment Effects: Negligible.

Basis for Prediction: Stone and Webster Engineering Corporation was commissioned to conduct an entrainment assessment for anchovy. Using 1974 field data, they estimated the annual loss of 9.919×10^6 eggs and 6.064×10^8 larvae. These values, using a series of conservative assumptions, result in a prediction of an annual loss of 7×10^6 adults. Applicant used slightly different calculation methods and estimated annual losses of 6.08×10^6 and 6.03×10^6 adults for 1974 and 1975 field data, respectively.

It is concluded that Block Island Sound (BIS) is not particularly important to this species as a spawning area considering the relative abundance of anchovy ichthyoplankton in BIS versus other coastal estuaries such as Narragansett Bay. Given that the area has comparatively low ichthyoplankton numbers, it follows that the adults lost also constitute a small portion of the population. Applicant, therefore, concludes that there will be no appreciable harm associated with the entrainment of this species.

6.1.4 Silver Hake (*Merluccius bilinearis*)

Entrapment Effects: Negligible.

Basis for Prediction: Based on the comparative entrapment life history evaluation, silver hake, particularly small hake, were judged to have a low to medium entrapment potential. Whatever entrapment that may occur, however, is expected to have an insignificant impact on the silver hake population due to its relatively low abundance in the proposed intake location, and its reported high swim speed capability. Furthermore, no entrapment of its ecological counterpart, the Pacific hake, has been recorded at operating velocity cap intakes in southern California. Therefore, no significant impact to the silver hake population is expected.

Thermal Effects: Possible temporary effect to eggs and larvae.

Basis for Prediction: Basis for such a prediction is predicated on the Applicant's analysis of existing thermal tolerance literature, the species life history characteristics and known plant discharge design parameters.

Making a conservative assumption that both the eggs and larvae cannot tolerate induced temperatures above those observed by the Applicant and cited in the literature, then these particular life history stages could be affected by the discharge plume at the end of its spawning season. It should be emphasized, however, that the egg and larval densities collected in Block Island Sound are comparatively low when compared to such areas as the Gulf of Maine. When this factor is combined with the small surface area influenced by the 6°F induced maximum temperature rise (i.e. ≤1 acre) overall impact is considered minimal.

Any impact to the adult is expected to be negligible due to species' strong swimming ability and dynamic nature of the discharge plume.

Entrainment Effects: Negligible.

Basis for Prediction: Using field data from 1974 and 1975, Applicant calculated the loss of 3.054×10^7 and 1.108×10^8 eggs, respectively. Larval losses would have been 8.614×10^5 and 4.281×10^6, respectively, for the same two years. These values represent the conservative loss of 332 and 1,413 adults for 1974 and 1975, respectively. If only spawning females were considered, then the 1974 and 1975 entrainment projections equate to the loss of 166 and 707 adults, respectively. Thus, the number of silver hake that would have developed from 1974 and 1975 entrained eggs and larvae is equal to 0.006% and 0.02% of the 1975 Rhode Island commercial silver hake landings (5,347,000 pounds). Also, the equivalent loss of gravid females for 1974 and 1975 would be 0.003% and 0.01%, respectively, of the same landings data. It is, therefore, evident that the impact of entrainment on silver hake will be insignificant.

6.1.5 Striped bass (*Morone saxatilis*)

Entrapment Effects: Negligible.

Basis for Prediction: Results from the comparative entrapment evaluation study identified several factors which indicated that striped bass are not candidates for significant entrapment. These factors included the minor entrapment of the ecologically similar species, white seabass, at operating velocity cap intakes in California, the absence of striped bass less than 12 inches in the site area, the high swim speed capability of this species, their seasonal occurrence, and their close distribution inshore for a relatively short time.

Thermal Effects: Negligible.

Basis for Prediction: Thermal impact assessment evaluating the striped bass is based on the results generated from the Applicant's thermal impact assessment model which integrates: (1) the species' life history characteristics; (2) background hydrographic data and plant operating parameters, and; (3) published literature of the species thermal tolerance characteristics.

Such an analysis demonstrates the striped bass should be able to interact with the Applicant's thermal discharge with no apparent detrimental effects. During the six to seven month interim when the striped bass is known to inhabit Rhode Island waters, M. saxatilis could encounter an induced surface water temperature ranging from a low of 53°F to a high of 75°F. Based on existing literature such temperatures fall well within the thermal tolerance capabilities of this species.

Inasmuch as spawning and juvenile development up to two years of age only takes place in more southerly waters, the plant discharge will in no way, interfere with striped bass egg, larval or early juvenile development.

Entrainment Effects: None.

Basis for Prediction: No striped bass ichthyoplankton have been found in the study area, therefore, there will be no entrainment related losses.

6.1.6 Bluefish (Pomatomus saltatrix)

Entrapment Effects: Negligible.

Basis for Prediction: Results from the comparative entrapment evaluation study identified several factors which indicated that bluefish are not candidates for significant entrapment. These factors included the lack of impingement of this species by the operating velocity cap intake at St. Lucie, Florida (even though yearling bluefish are present throughout the winter), the high swim speed capability of bluefish, and that they are seasonal in occurrence at the proposed site thus being available for entrapment for only about four months of the year.

Thermal Effects: Negligible.

Basis for Prediction: Results obtained from the Applicant's thermal assessment model form the basis for such a prediction.

Such an analysis demonstrates rather conclusively that this species would be very tolerant of any induced temperature change resulting from NEP 1&2 operation.

Any thermal discharge/organism interface will involve the juvenile and adult life history stages only. During the six to seven month interim in which bluefish are known to inhabit Rhode Island waters, *P. saltatrix* could encounter a plant induced surface temperature range from a low of 58°F to a high of 75°F. Integration of such temperatures with the species known thermal tolerance characteristics indicate such induced temperatures are well within the tolerance limits of the bluefish.

Entrainment Effects: None

Basis for Prediction: No bluefish ichthyoplankton have been found in the study area, therefore, there will be no entrainment related losses.

6.1.7 Scup (*Stenotomus chrysops*)

Entrapment Effects: Possibility of some entrapment, however, overall effect considered small.

Basis for Prediction: Based on factors identified during the comparative entrapment evaluation study, scup were not judged candidates for significant entrapment especially during daylight hours since they are strong swimmers, they tend to be closely associated with the bottom during daylight hours, they are exceedingly wary fish, they have not been entrapped in significant numbers at conventional shoreline intakes, and they are not particularly abundant in the location of the proposed intake. Because of the lack of data, entrapment of scup during the dark hours is difficult to predict.

Thermal Effects: Minimal.

Basis for Prediction: Scup life history characteristics in conjunction with: (1) known hydrographic and plant operating parameters; and, (2) available thermal tolerance literature form the basis for this species' thermal impact assessment.

Relatively low densities of scup eggs and larvae were collected in ichthyoplankton samples suggesting that this area of Block Island Sound is not a particularly favorable spawning area. Such low egg and larval densities when combined with the species' preference of warmer spawning temperatures, indicates a small potential for thermal impact resulting from plant operation. Similar to the earlier life history stages of this species, the anticipated thermal impact upon the adult is also considered small due to the scup's ability to move from an area should it prove unsuitable, and its zoogeographical temperature range which is known to exceed those induced temperatures resulting from plant operation.

Entrainment Effects: Negligible.

Basis for Prediction: If NEP 1&2 had been operating at full load during the period when scup eggs and larvae were present, 2.946×10^7 eggs and 2.169×10^6 larvae would have been entrained in 1974. During 1975, 1.299×10^8 eggs and 7.429×10^6 larvae would have been entrained. Using conservative estimates of fecundity and egg-to-larval ratio, the larval entrainment in 1974 and 1975 would have been equivalent to 3.36×10^7 and 1.15×10^8 eggs, respectively. Based on the total spawning life fecundity, the predicted egg and larval entrainment, and the assumption that only two sexually mature scup will develop from the lifetime spawn, the entrainment by NEP 1&2 during 1974 and 1975 would have resulted in a loss of 3,360 and 13,100 scup, respectively.

Applicant thus estimates that the amount of scup potentially lost due to entrainment in 1974 and 1975 is equivalent to 0.08% and 0.3%, respectively of the average 1971, 1973 and 1975 Rhode Island commercial scup landings, based on an assumed weight of 1 pound per fish lost.

6.1.8 Cunner (Tautogolabrus adspersus)

Entrapment Effects: Negligible.

Basis for Prediction: Based on the comparative entrapment evaluation, cunner were judged to have a low to medium entrapment potential. However, several factors were identified that would indicate that entrapment of cunner should not be significant. These factors included the low entrapment of its ecological counterpart, opaleye, by velocity cap intakes in California, its inactivity at night, its unavailability in the winter, the tendency for larger cunners to inhabit water deeper than that at the proposed intake location, and that cunners are well adapted to wave surge conditions.

Thermal Effects: Minimal.

Basis for Prediction: This impact is predicted on the basis of thermal tolerance data for this species integrated with known biological, hydrographic and plant operating parameters to produce a thermal assessment model.

Such an analysis indicates that from a temperature tolerance standpoint the cunner appears to be a ha-dy species. Based on the literature, the cunner can tolerate temperatures as high as the mid to upper seventies during the colder months and the mid-eighties during the warmest summer months. Such a tolerance level makes the cunner well suited to withstand the maximum induced temperature rise of 6°F within the boundary of the mixing zone.

Entrainment Effects: Negligible.

Basis for Prediction: Stone and Webster Engineering Corporation was commissioned by Applicant to analyze potential entrainment losses on the local cunner population. A density-independent eigenvalue model which incorporates a Leslie population projection matrix was used. Using several very conservative assumptions, the net effect after 40 years of continuous operation at 100% load (approximately 80% load is expected) would be a 3.03 % reduction in population size.

6.1.9 Sand Lance (Ammodytes americanus)

Entrapment Effects: Negligible.

Basis for Prediction: Based on existing information on this species' abundance and distribution in the study area, plus such factors identified during the comparative entrapment evaluation study as its preference for water over unobstructed sand bottoms, its failure to be attracted to reef-like structures, its apparent exceptional night-time vision, and its sporadic and sometimes lengthy sojourns into bottom substrate thereby reducing its entrapment availability, it was judged unlikely that sand lance will be entrapped in large numbers.

Thermal Effects: Possibility of some thermal effect.

Basis for Prediction: The integration of published thermal tolerance literature and the species' known life history characteristics form the basis for the thermal impact assessment.

Existing thermal tolerance information indicates that a 6^{o}F induced temperature increase could possibly affect the egg and larval stages of this species. Adults, of course, are able to choose their preferred temperature and will not reside in the plume. It should be pointed out, however, that any area of exclusion would be relatively small when compared to the total habitat area where sand lance could exist.

Entrainment Effects: Negligible

Basis for Prediction: Eggs of the sand lance are demersal and adhesive thus entrainment will not affect this life stage.

During 1974-1975 and 1975-1976, larvae were present in the site area for 194 and 218 days, respectively. If the plant were operating at 100% load, an estimated 1.763×10^8 and 4.577×10^7 larvae would have been entrained during 1974-1975 and 1975-1976, respectively. Using conservative assumptions, Applicant estimates that between 43,000 and 8,300,000 adults would have been lost annually during those years. This equates to between 22,000 and 4,150,000 females whose spawn would be lost.

The 4,150,C00 would weigh approximately 19,920 kg while the 8,300,000 lost adults would weigh approximately 41,915 kg. Thus, the annual loss to the population can be viewed as negligible when considering that the European fishing fleet have reported the catch rate of between 2500 kg per hour and 15,000 kg per hour of their sand lance fishery.

6.1.10 Atlantic Mackerel (*Scomber scombrus*)

Entrapment Effects: Negligible.

Basis for Prediction: Based on the comparative entrapment evaluation study, Atlantic mackerel are not considered serious candidates for entrapment for the following reasons.

Its west coast ecological counterpart, the chub mackerel, is rarely entrapped by operating velocity cap intakes. Atlantic mackerel are fast swimmers, quickly become visually oriented, grow rapidly, and as yearling fish are in the area of the proposed intake only in June and July. Thus, no appreciable harm is expected to occur to the Atlantic mackerel population.

Thermal Effects: Possibility of some thermal effect.

Basis for Prediction: The thermal impact prediction for this species is based on the Applicant's evaluation of the thermal impact assessment model.

Available thermal tolerance literature indicates the Atlantic mackerel is more of a cold water oriented species; consequently, the possibility exists that the various life history stages of *Scomber scombrus* will interact with the discharge plume. As a consequence of the mackerel's affinity for lower water temperatures the possibility of some thermal effect is anticipated. The likelihood of appreciable impact is considered remote, however, based on: (1) the adult's ability to select its preferential temperature as a result of its swimming ability; (2) the increased abundance of eggs and larvae further offshore relative to the proposed discharge area; and, (3) major spawning and larval life stage development will have been concluded before the upper thermal tolerance limit of the upper sixties to lower seventies is attained.

Entrainment Effects: Negligible.

Basis for Prediction: Applicant commissioned Stone and Webster Engineering Corporation to develop a sophisticated mathematical model to predict the effects of entrainment on this species.

Using very conservative assumptions the model predicts the loss to the mackerel population of 0.9 to 3.4%. This range represents 6.7 to 20.7% of the natural population oscillations predicted by inclusion of the respective input parameters. The small predicted impact, magnified by the model conservatism, should not disrupt the normal pattern of the population.

6.1.11 Butterfish (*Peprilus triacanthus*)

Entrapment Effects: Minimal.

Basis for Prediction: Results from the comparative intake entrapment study indicated that this species has a medium to high entrapment potential. However, available data on its abundance and distribution in the site area indicates that the location of the proposed intake is not a preferred habitat for butterfish. In addition, the swimming capability of this species is sufficient to permit the fish to avoid the intakes. Also, this species will only be available in the area (and thus subject to potential entrapment) from May through October. Furthermore, this species has a history of sporadic population peaks and declines. Thus, in some years few will be available for entrapment. Consequently, the potential for significant entrapment impacts is judged minimal.

Thermal Effects: Minimal.

Basis for Prediction: The basis for such a prediction is derived from existing thermal tolerance literature, the organism's life history characteristics and known operating parameters.

As demonstrated by the literature, it is reasonable to assume butterfish are tolerant or even prefer relatively warm water temperatures. The information presented suggests butterfish eggs and larvae will not be adversely affected by an induced temperature increase of $6^{o}F$ above ambient. The adults are not likely to be affected by the plume since they can freely avoid a stressful situation should it arise.

Entrainment Effects: Negligible.

Basis for Prediction: Based on the plant operating at full load, 2.832×10^7 eggs and 6.621×10^6 larvae would have been entrained in 1974, and 8.889×10^7 eggs and 1.876×10^7 larvae, in 1975. Several aspects of the life history of this species are poorly documented. However, using conservative assumptions, Applicant estimated the loss during 1974 and 1975 due to entrainment would have been 29,000 and 86,700 adults, respectively. This equates to approximately 7250 and 21,680 pounds of butterfish for the same years, respectively. Since the 1971, 1973 and 1975 average commercial landings in Rhode Island was 1,433,000 pounds, the loss due to entrainment of eggs and larvae 1974 and 1975 is, therefore, equivalent to 0.5% and 1.5% of the average commercial butterfish landing.

6.1.12 Winter Flounder (Pseudopleuronectes americanus)

Entrapment Effects: Negligible.

Basis for Prediction: The comparative entrapment evaluation, as well as available data on abundance and distribution in the area, identified several factors which indicated that entrapment of winter flounder should not be substantial. The winter flounder, because of its affinity for the bottom and the design of the intake with the protruding lip, is not expected to be vulnerable to entrapment. Additionally, experience with its west coast ecological counterpart, the diamond turbot, has shown that even archaic velocity cap designs are effective in preventing entrapment of benthic flatfish. Furthermore, winter flounder are in relatively low abundance in the region of the proposed intake, and also have a sufficient swim speed capability to permit them to avoid the intake structure.

Thermal Effects: Minimal

Basis for Prediction: The evaluation of the winter flounder thermal tolerance is based on the Applicant's thermal assessment model.

Such an analysis indicates a 6°F induced temperature rise falls well within the thermal tolerance capabilities of this species. Such a position is based on several factors:

a. The eggs of this species are demersal and adhesive, with the majority of spawning taking place in coastal salt ponds such as Ninigret Pond. Therefore, the probability of this life history stage being involved with the thermal discharge or being affected by a design surface maximum within the boundary of the mixing zone is relatively small.

b. The literature demonstrates rather conclusively that the juveniles can tolerate water temperatures well in excess of those anticipated once the plant is operational. Temperature tolerance limits for periods when juveniles are known to occur at the site (i.e., winter and spring) exceed the projected surface maximum temperature by anywhere from 3 to 18°F.

c. As presented in Figure G.4.2-48, adult flounder are found throughout most of the year at the proposed site. Of particular relevance is that a majority of the temperatures of the temperature tolerance studies conducted coincide quite closely with the warmest water temperatures that the adult would experience during the month of August. In all instances, the upper thermal tolerance limits exceed the anticipated surface maximum of 76°F that would be experienced within the boundary of the mixing zone. Impacts as a result of thermal stress are, therefore, not anticipated.

Entrainment Effect: Negligible.

Basis for Prediction: Winter flounder eggs are demersal adhesive and are, therefore, not subject to entrainment.

The larvae of winter flounder, which are subject to entrainment, are concentrated inside Ninigret Pond in densities which greatly exceed those found in Block Island Sound. A mathematical model, developed by Stone and Webster Engineering Corporation, estimated that only 1.5% of the Pond's larvae will be entrained in the unlikely event that a series of very conservative assumptions proved correct.

Applicant estimated that during 1975 the plant would have entrained 4.577×10^8 winter flounder larvae had it been operating at full load. This would have resulted in the loss of approximately 20,070 pounds of spawning females or the loss of 14,164 pounds of three year old (breeding age) adults. Thus, the adults whose spawn is lost and the projected loss of three year olds represents 0.5% and 0.35%, respectively of the average 1971 through 1975 Rhode Island winter flounder landings.

6.1.13 Blue Mussel (*Mytilus edulis*)

Entrapment Effects: None

Basis for Prediction: With the exception of those mussels which are killed or which release their bysall threads during backflushing operations, no mussels will be entrapped since they are a non-motile benthic invertebrate.

Thermal Effects: Some thermal effect possible.

Basis for Prediction: The thermal assessment model generated for the blue mussel formed the basis of thermal impact assessment for this mollusk.

Such an evaluation indicates that the somewhat sensitive egg and larval stages could be affected to a limited degree. The overall potential for thermal effect is expected to be small, however, based on several factors: first, to a great degree blue mussel spawning activity and larval metamorphosis takes place before maximum induced surface water temperatures would approach temperatures which were cited in the literature as being limiting (i.e., upper seventies); second, the Applicant's mixing zone is small relative to the total area of Block Island Sound; and third, the species is noted for being a prolific spawner.

Since adults are primarily associated with the bottom, any interaction with the thermal discharge plume is expected to be minimal for two reasons: (1) the expected peak isotherms should not exceed the species' thermal tolerance limit, and (2) within the confines of the proposed discharge area where the thermal plume could contact the bottom there is a limited amount of suitable substrate (i.e., rocks) for mussel attachment.

Entrainment Effects: Negligible.

Basis for Prediction: Applicant estimated that 6.393×10^8 and 2.799×10^8 adult mussels would have been lost during the sampling periods 1974-1975 and 1975-1976, respectively.

Since the estimated losses for blue mussel at Pilgrim Station Units 1 and 2 are 3.8 to 8.2 times greater than those predicted for NEP 1 and 2, and since mussel larval entrainment losses of this magnitude have been previously shown to have negligible impact on adult mussel populations, it is concluded that mussel larval entrainment at NEP 1 and 2 should also be negligible.

6.1.14 Hard Clam (*Mercenaria mercenaria*)

Entrapment Effects: No impact.

Basis for Prediction: As a non-motile benthic bivalve, the hard clam will not be subject to entrapment.

Thermal Effects: Negligible.

Basis for Prediction: The basis for such a prediction is derived from a knowledge of the hard clam's life history and thermal tolerance characteristics.

Because of the known ability of egg and larval stages to tolerate water temperatures in excess of 80°F, and the comparatively low densities of larvae observed in Block Island Sound, little, if any, thermal impact is expected. In addition, no thermal impact is anticipated for the adult since *M. mercenaria* beds are found almost exclusively in Ninigret Pond and it has been demonstrated that there will be no significant temperature rise in the Pond attributable to operation of NEP 1&2.

Entrainment Effects: Negligible.

Basis for Prediction: During the 1975 sampling year, a conservative maximum density of $1452/m^3$ hard clam larvae were observed in Block Island Sound. Larval concentrations of 7,500 to 10,000 per cubic meter have been reported by others. Applicant observed densities of Mercenaria in excess of 16,000 per cubic meter in Ninigret Pond. Because the comparatively low density of hard clam larvae in Block Island Sound, it is predicted that negligible effects will occur due to the plant's operation.

6.1.15 Long-Finned Squid (Loligo pealei)

Entrapment Effects: Negligible.

Basis for Prediction: Results from the comparative intake entrapment evaluation indicates that this species will rarely be subject to entrapment. This assessment is substantiated by experience at operating velocity cap intakes in Florida and California where both the long finned squid and its west coast counterpart, L. opalescens, are rarely impinged. Additionally, this species has an exceptional swim speed capability which would easily permit it to avoid the intakes.

Thermal Effects: Minimal.

Basis for Prediction: The basis for minimal thermal impact to the squid was derived from integrating the species' life history and thermal tolerance characteristics with known plant thermal discharge operating parameters.

The possibility exists that squid eggs, larvae and adults could be influenced by the Applicant's thermal discharge plume. Natural background water temperatures presented in the literature for egg laying, and development of eggs and larvae coincide rather closely with those induced water temperature expected from plant operation. Consequently, no appreciable impact upon these early developmental stages is predicted.

Similarly, thermal impact to the adult is also considered small due to the cephalopod's mobility and known zoogeographical range where natural background water temperatures equal or exceed those expected from plant operation.

Entrainment Effects: Negligible.

Basis for Prediction: Squid eggs are laid in gelatinous strings on the ocean bottom and are not subject to entrainment. No intermediate planktonic larval form is produced and juvenile squid hatch directly from the egg.

Based on calculated average densities and assuming full plant load, Applicant estimated that 1.984×10^6 squid juveniles would have been entrained in 1977. The projected entrainment of squid juveniles at hatching would thus result in the loss of 18,991 or 8,921 one year old squid, depending on the value of S_o used. These values equate to the loss of approximately 1.7 metric tons (3771 pounds) or 0.8 metric tons (1771 pounds). These values equate to the loss of less than 0.008% of the minimum long finned-squid stock size which is recognized as stretching from Cape Hatteras to the northern edge of Georges Bank. Additionally, the projected entrainment loss is equal to less than 0.5% of recent Rhode Island landings.

6.1.16 Sand Shrimp (*Crangon septemspinosa*)

Entrapment Effects: Negligible.

Basis for Prediction: Results from the comparative intake entrapment study indicated that this species has a low potential for entrapment. This assessment is based on the facts that it prefers unobstructed sandy bottoms over the boulder strewn area comprising the proposed intake location. Furthermore, sand shrimp tend to burrow beneath the sand and because of its benthic habits would generally not be available for entrapment.

Thermal Effects: Possibility of some thermal effect.

Basis for Prediction: The basis for such a prediction was dervied from the Applicant's analysis of the sand shrimp thermal assessment model.

Such an assessment indicates that during certain periods of the year (i.e., August) the induced bottom and surface temperatures (i.e., 6°F above ambient) which the adult and larval sand shrimp could encounter approximate the upper temperature limits of this species. On the other hand, notably during the winter, early spring and fall, adult preference temperatures exceed any induced temperatures by as little as 10°F to as great as 25°F.

Even though the possibility of some plume interaction exists, any anticipated impact is expected to be small for several reasons:

1. Since the female can move from an area should it prove untenable and she retains the eggs in in her swimmeretts, sand shrimp eggs would not be entrained in the thermal plume.

2. The surface induced temperature plume approximates the upper thermal tolerance limit of the juvenile stage.

3. The expected induced temperature increase which the adult could experience on the bottom falls within the upper thermal tolerance limit of this species. In addition, the adult is free to move from an area should it prove unsuitable.

Entrainment Effects: Negligible

Basis for Prediction: An estimated 2.982×10^9 sand shrimp larvae would have been entrained from May 1978 to May 1979 assuming 100% plant load throughout the year. From entrainment estimates of equivalent Stage I larvae, an estimated 7.92×10^6 adult and shrimp would have been due to entrainment during 1978-1979. Based on estimated consumption rates of fish in Block Island Sound, the amount of adult sand shrimp lost to entrainment was equated to 6.6 x 10^3 lbs. of fish or 0.0089% of Rhode Island's 1978 commercial landings.

6.1.17 American Lobster (*Homarus americanus*)

Entrapment Effects: Negligible.

Basis for Prediction: The low entrapment potential of this species was based on data on its abundance in the area, its biological characteristics, and its swim speed capability. Results from field programs have shown that lobsters do not occur in unusually high numbers near the intake location. In addition, lobsters are benthic organisms, being normally secretive in behavior, seeking shelter in burrows or beneath rocks. Furthermore, available information on the swim speed capability of lobster indicates that this species could avoid the intakes.

Thermal Effects: Minimal.

Basis for Prediction: Analysis of the Applicant's thermal assessment model forms the basis upon which this prediction is formulated.

Results generated from the Applicant's model discussed previously in Section 4.2.16.3 indicates thermal impact to be small. Similar to the sand shrimp, the female retains the eggs in a brood pouch, and can move from the area should it prove untenable. Since lobster larvae are generally associated with the surface component of the plankton, there is a good possibility they will be found in the surface discharge plume. However, thermal tolerance data presented in the literature indicates a 6°F induced temperature rise falls within the reported tolerance range of lobster larvae.

Any thermal impact to the adult is also expected to be negligible due to the animal's mobility and demonstrated capacity to withstand reported test temperature as high as 85°F.

Entrainment Effects: Negligible.

Basis for Prediction: Based on calculated average densities and assuming full plant load, 3.820×10^5 Stage I, 6.675×10^4 Stage II, 3.154×10^4 Stage III, and 1.450×10^4 Stage IV lobster larvae would have been entrained in 1977. For 1976, the projected entrainment was estimated, after data refinement, to be 5.080×10^5 stage I, 2.296×10^5 stage II, 1.653×10^5 stage III, and 3.480×10^5 stage IV. From these projections, it was conservatively estimated that 3.749×10^7 and 2.987×10^6 equivalent stage I lobster would have been entrained in 1976 and 1977, respectively. When these equivalent stage I larvae were equated to the number of adult lobster that would have been recruited to the commercial fishery approximately 5 years later, it was found that 7880 and 638 minimum legal size lobsters would have been lost during 1976 and 1977, respectively.

This lost recruitment represents 6698 and 534 pounds or 0.20% and 0.02% of the 1976 and 1977 Rhode Island landings, respectively.

6.1.18 Eelgrass (*Zostera marina*)

Entrapment: Not applicable.

Basis for Prediction: Because this species is confined within Ninigret Pond and because its primary means of reproduction is vegetative, no part of its life cycle is subject to entrapment.

Thermal Effects: Negligible.

Basis for Prediction: The basis for such a prediction is derived from a knowledge of the species' life history characteristics and an understanding of the Applicant's discharge plume behavior.

Of particular relevance to this species' relationship to the Applicant's thermal specific to an open coastal environment and how they may fluctuate spatially and temporally. With the biological characteristics of existing populations intimately associated with and acclimated to the existing physical environment, a detailed understanding and characterization of the physical environment is vital in assessing environmental impacts because whatever changes that may occur in these factors as a result of construction and operation of NEP 1&2 may likewise cause associated changes in the biological community. Information of the existing physical environment is provided in Section 2.1 of this Appendix.

- existing biological environment - this information describes the various components of the biological community (e.g., plankton, benthos, and nekton) and how they naturally vary temporally and spatially. The information forms the biological bases for selecting representative important species which undergo detailed impact appraisals. Data on the existing aquatic environment is given in Section 2.2 of this Appendix.

- descriptions of the proposed intake and discharge systems and their physical and chemical effects - this information describes the design, materials, dimensions, and operations of the proposed circulating cooling water system. Information provided includes cooling water flows, intake velocities, condenser temperature rise, discharge performance characteristics, physical bounds of impact areas (e.g., thermal plume size), biofouling control and other operational factors. These data identify the interfaces between power plant and the physical/biological environment and thereby delineates the pathways of potential environmental impacts. Information on the proposed cooling water system is given in Section 3.0 of this Appendix.

The U.S. Environmental Protection Agency designated a list of 17 species as the Representative Important Species for NEP 1&2. This list of designated RIS was then subjected to a rigorous impact assessment as described in Sections 4.1 and 4.2 of this

Operational velocity cap intakes in southern California and Florida were examined with respect to design criteria, operational conditions and the faunas exposed to them. The NEP 1&2 Representative Important Species were paired with ecologically similar species occurring in Florida and/or southern California. The life histories of the paired species were examined in detail, and the entrapment records of the California and Florida equivalent species were studied.

From this information, as well as site specific data on the temporal and spatial abundance and distribution of the RIS, estimates of the relative entrapment potential NEP 1&2 holds for the NEP 1&2 RIS were prepared. This technique provides the best means possible for predicting the potential entrapment of the RIS since it is based on actual operating experience of similar intakes. Results of these RIS entrapment appraisals provided evidence that some of the RIS are subject to potential entrapment and impingement; however, in no case does this impact cause appreciable harm to the populations of RIS.

Alternative intake designs and locations were also evaluated (see Section 5.0) to determine whether these alternatives would provide a net measurable environmental benefit, commensurate with their costs. From this analysis, it is shown that the alternative intake designs or locations do not provide substantially improved levels of environmental protection commensurate with their cost.Thus, Applicant has demonstrated that the location, design, construction, and capacity of the proposed NEP 1&2 cooling water intake structure reflects the best technology available for minimizing adverse environmental impact.

To evaluate impacts of the NEP 1&2 thermal discharge, Applicant consolidated information on temporal abundance and distribution, thermal tolerance, range, response of RIS populations to natural and above ambient temperatures, and on the physical extent of were constructed to extrapolate entrainment estimates to the projected loss to the adult populations or to the commercial harvest. By this approach, Applicant's entrainment estimates are used to predict the short term and long term impacts on the populations of RIS. Results of these entrainment analyses indicate that no population of RIS will be so severely impacted that they will suffer appreciable harm.

Impacts other than those due to construction, entrapment, entrained and direct thermal effects can also occur due to plant operation. These impacts include effects of chemical and biocide discharges and such indirect lethal and sublethal effects as cold shock, gas bubble disease, skinny fish syndrome, and premature spawning. The potential for these additional impacts to occur was evaluated by Applicant (see Section 4.3 of this Appendix), and found to be of low magnitude. This conclusion is based on the fact that these categories of impacts are more likely to occur at shoreline surface discharges, particularly those that utilize long discharge canals that do not prevent passage of nekton into the canal. Once in the canal, nekton are continuously exposed to undiluted plant effluent and are thus subject to maximum potential effluent impact, be it cold shock, gas bubble disease, or any of the other above cited potential effects. NEP 1&2 will discharge thermal effluent to the receiving water via an offshore, submerged, high velocity diffuser (see Section 3.0). This discharge design promotes very rapid mixing with ambient water, and thereby reduces the potential for development of large areas of confined, elevated temperature water that can result in the types of impacts described above. As a result, no appreciable harm to the Block Island Sound aquatic populations is expected to occur as a result of these other potential effects.

In summary, Applicant has integrated physical, biological and plant engineering design and operational information in evaluating affects of construction and operation of NEP 1&2 on selected populations of RIS. A construction technique, i.e., tunneling, was selected to minimize construction impacts both in Ninigret Pond and Block Island Sound.

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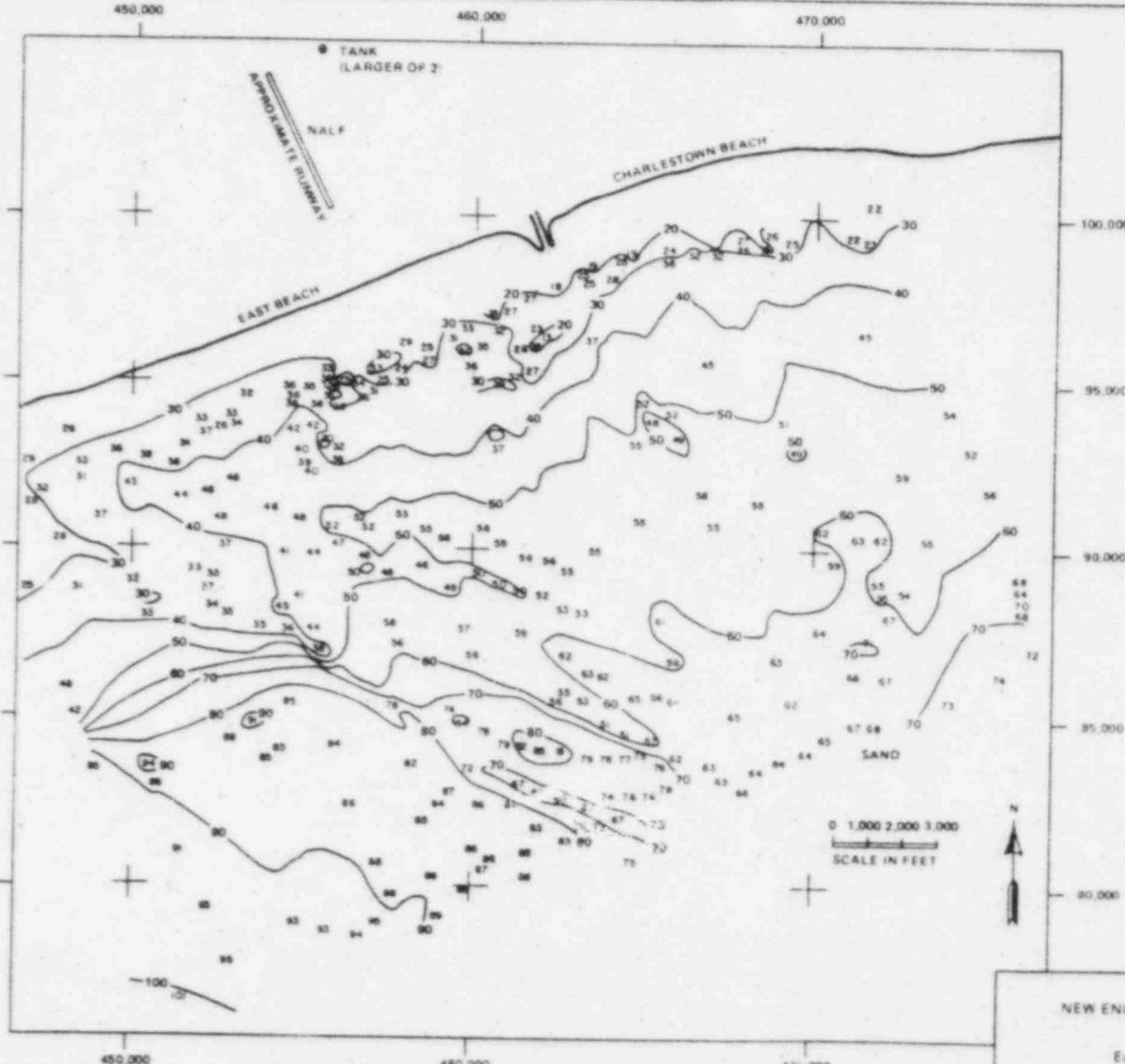


NOTES:

WATER DEPTHS AND CONTOURS SHOWN IN FEET IN REFERENCE TO M.L.W.

CONTOUR INTERVAL – 10 FEET

COORDINATES SHOWN ARE R.I. STATE COORDINATES

NEW ENGLAND POWER COMPANY NEP 1 & 2 Environmental Report	BATHYMETRY OF PROPOSED INTAKES AND DIFFUSER VICINITY OF CHARLESTOWN, RI
	FIGURE G.2.1-2 — NEP 1 & 2

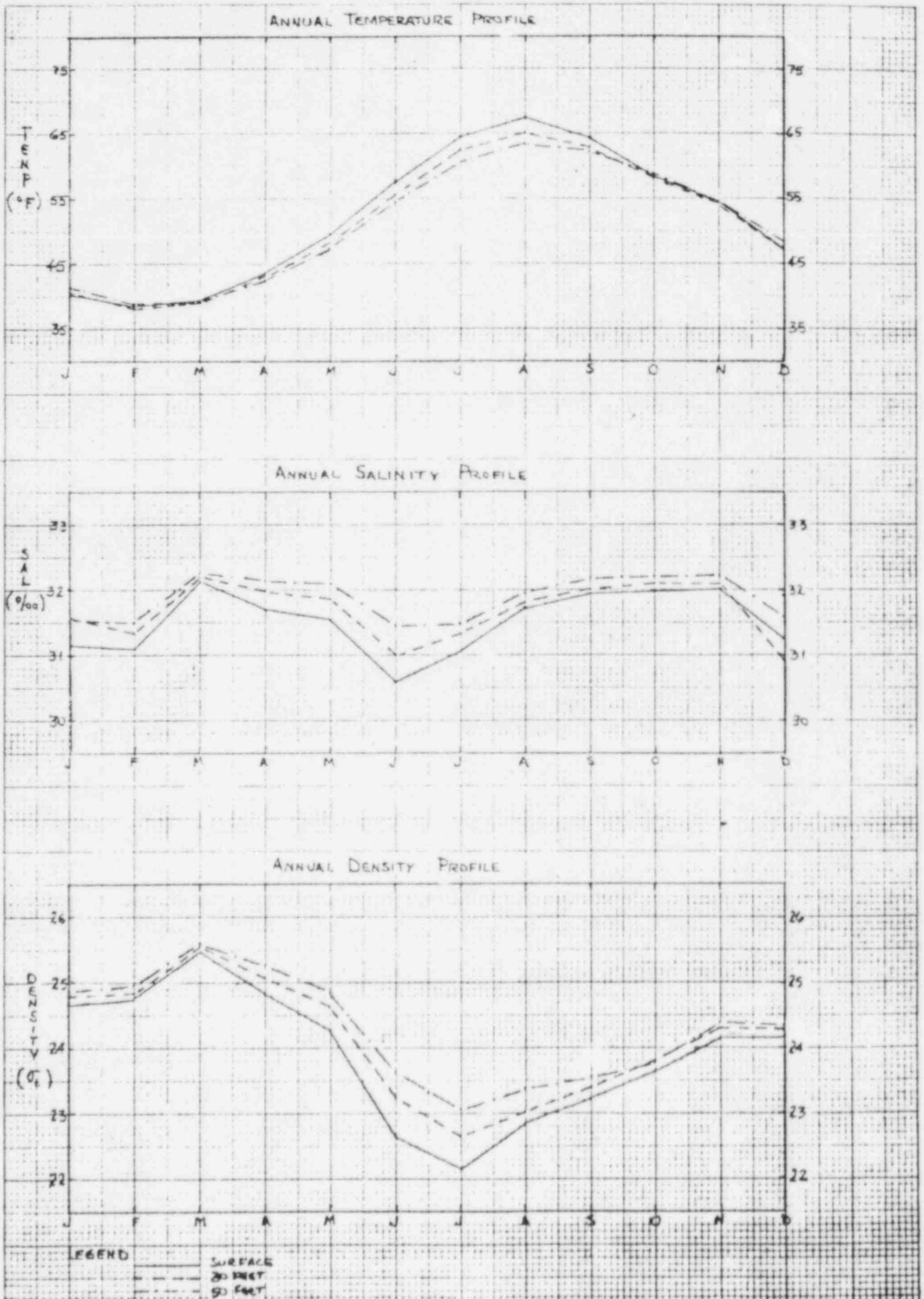
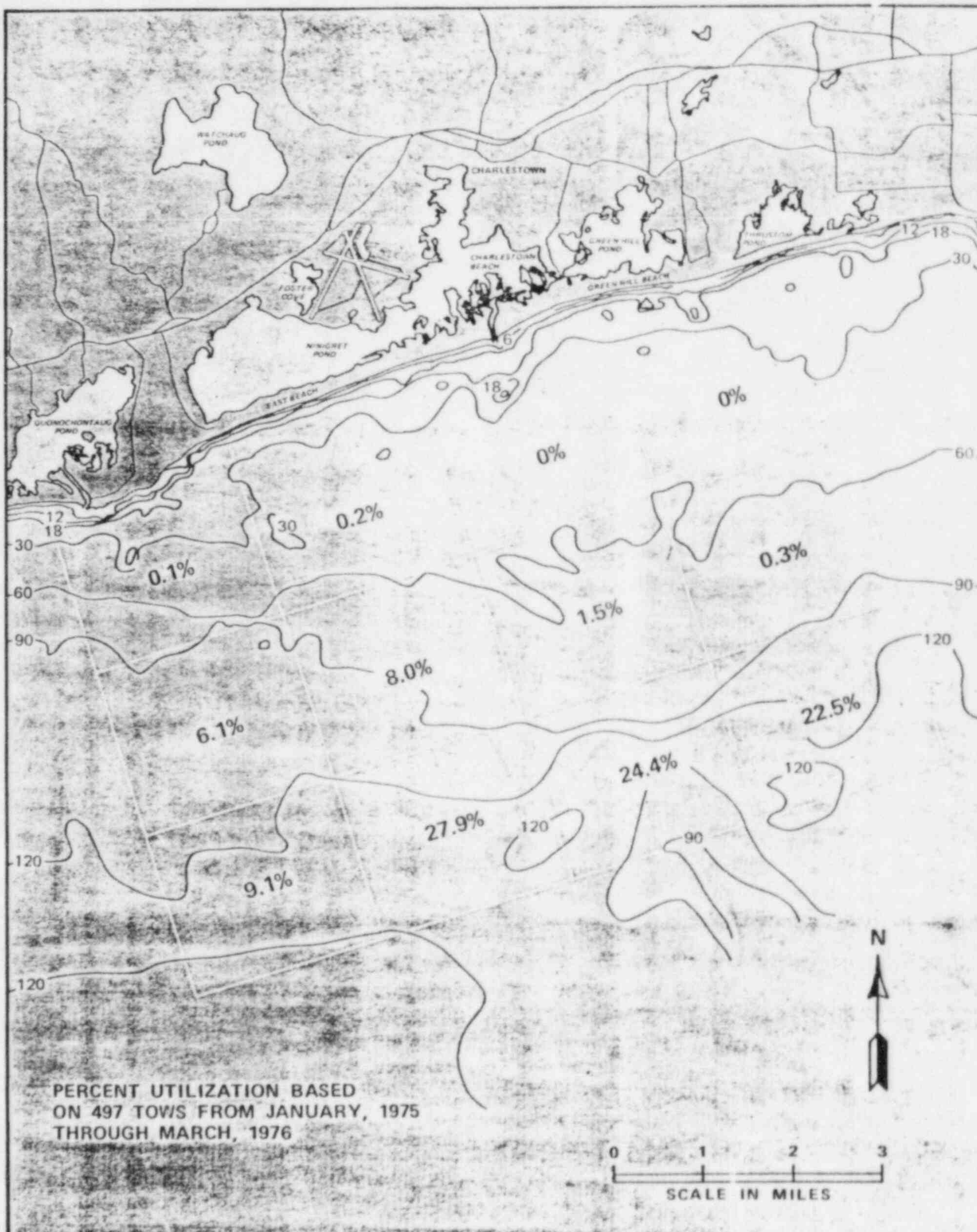
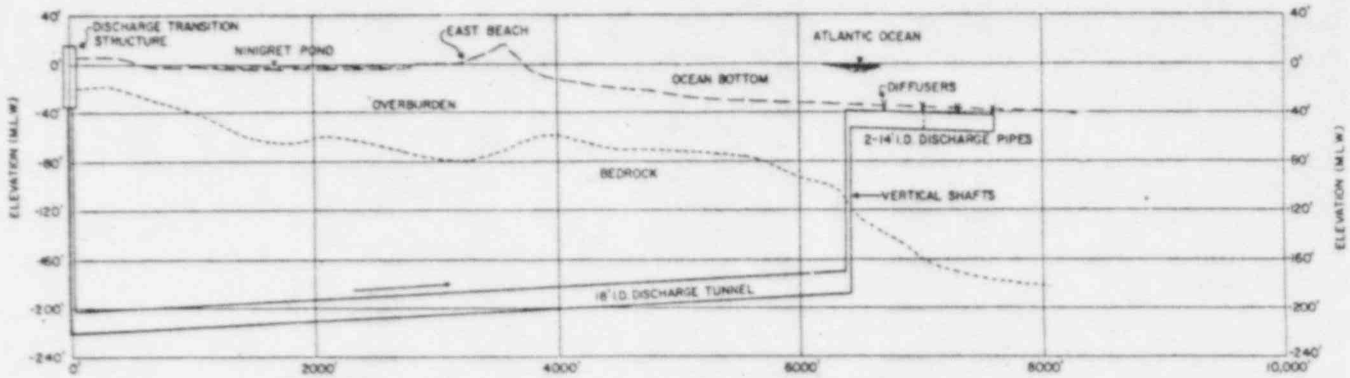


Fig. G.2.1-4 Annual Block Island Sound Salinity Temperature Density Profile

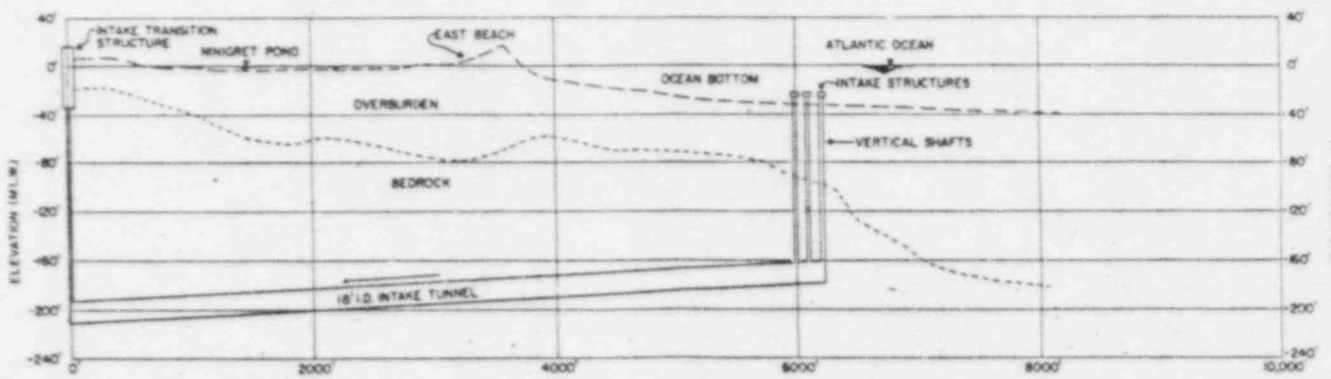
46 1322



NEW ENGLAND POWER COMPANY NEP 1&2 Environmental Report	RELATIVE UTILIZATION OF ADJACENT OFFSHORE WATERS BY TWO COMMERCIAL TRAWLERS
	FIGURE G.2.2-2 / NEP 1&2



DISCHARGE TUNNEL PROFILE

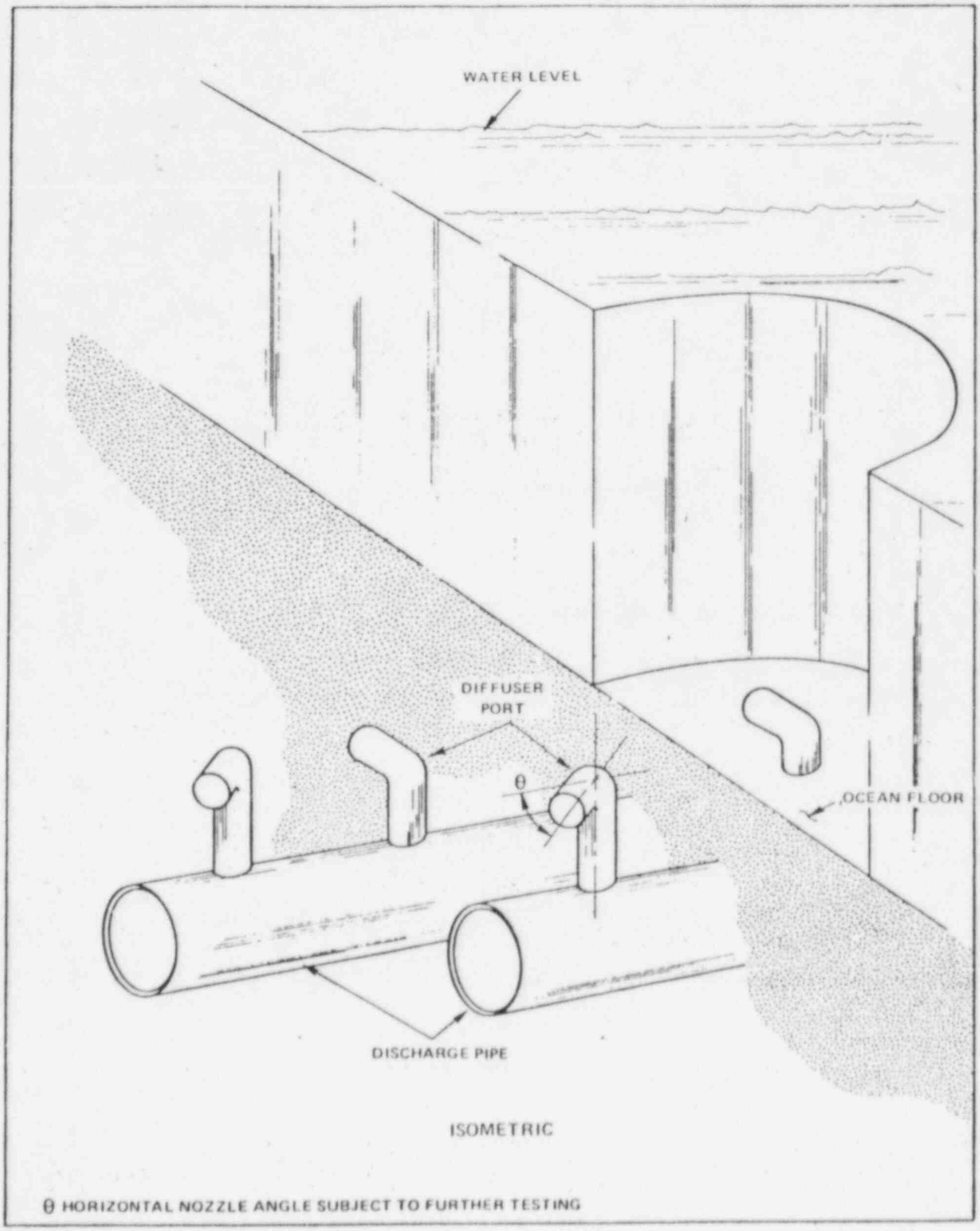


INTAKE TUNNEL PROFILE

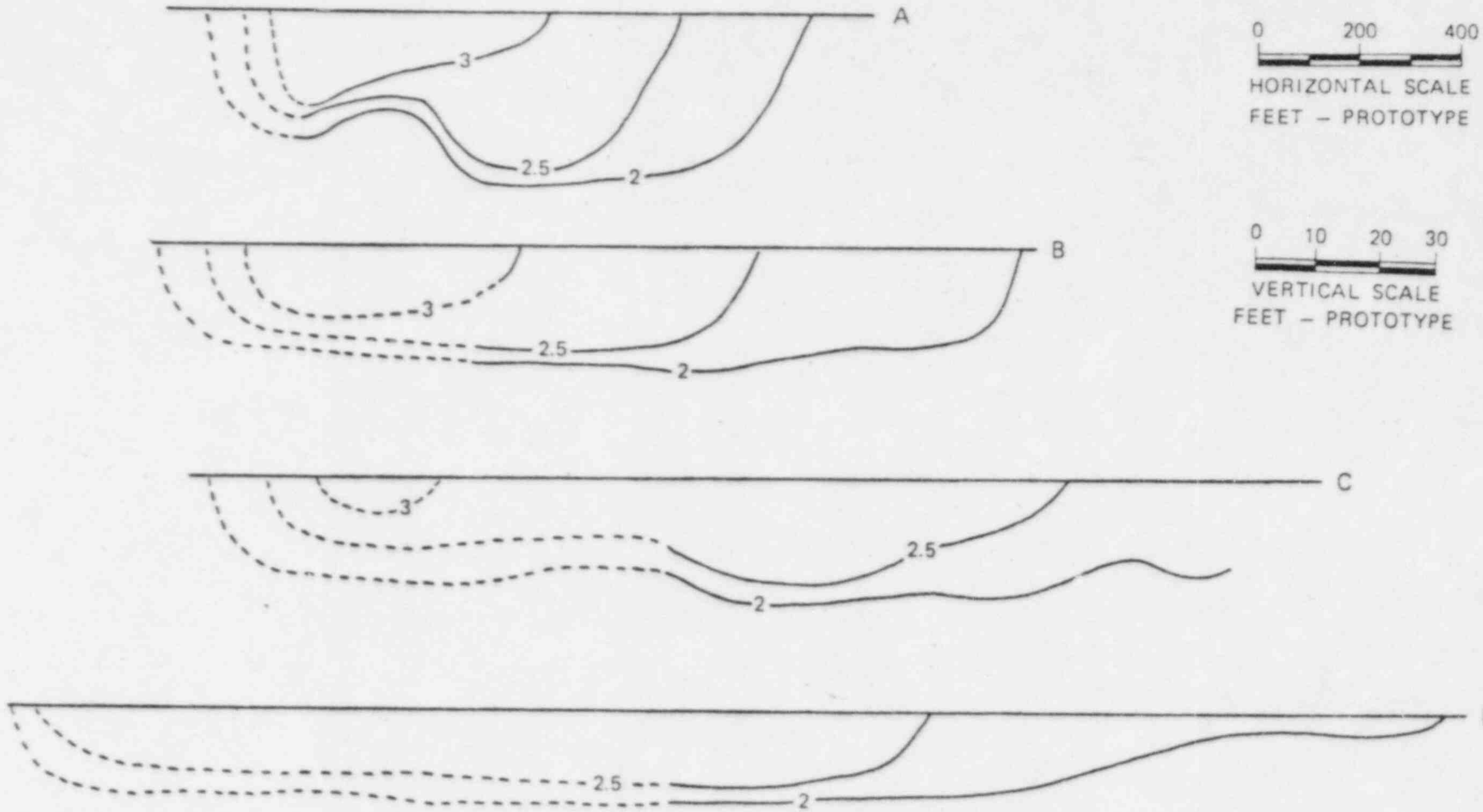
NEW ENGLAND POWER COMPANY
NEP 1&2
Environmental Report

PROFILE OF CIRCULATING WATER SYSTEM

FIGURE G.3.0-2 | NEP 1&2



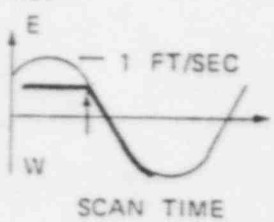
NEW ENGLAND POWER COMPANY NEP 1&2 Environmental Report	CIRCULATING WATER MULTIPORT DISCHARGE DIFFUSER	
	Figure G.3.2-1	NEP 1&2



TEST NO. R23

CROSS-SECTIONAL TEMPERATURE RISE ISOTHERMS

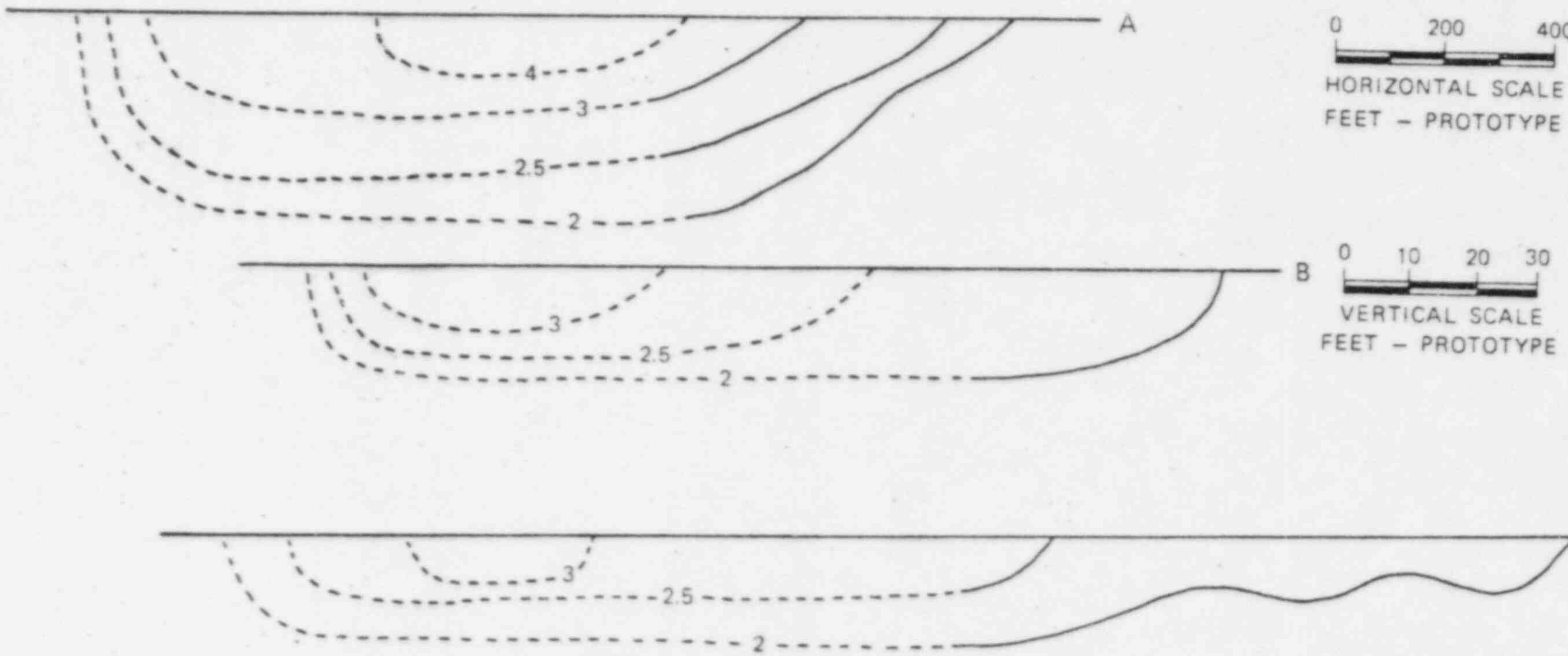
TRANSIENT LONGSHORE CURRENT



DIFFUSER LENGTH	1200 FT
DISCHARGE VELOCITY	18 FT/SEC
NUMBER OF NOZZLES	34
WATER DEPTH AT DIFFUSER	30-33 FT

NEP - CHARLESTOWN
HYDROTHERMAL STUDIES
ARL

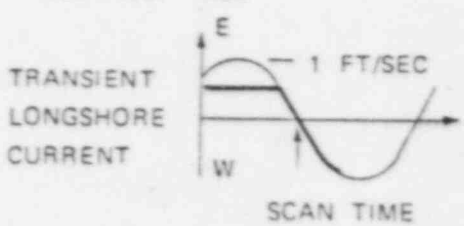
Figure G.3.2-3



B30

TEST NO. R23

CROSS-SECTIONAL TEMPERATURE RISE ISOTHERMS



DIFFUSER LENGTH	1200 FT
DISCHARGE VELOCITY	18 FT/SEC
NUMBER OF NOZZLES	34
WATER DEPTH AT DIFFUSER	30-33 FT

NEP - CHARLESTOWN
HYDROTHERMAL STUDIES
ARL

Figure G.3.2-5

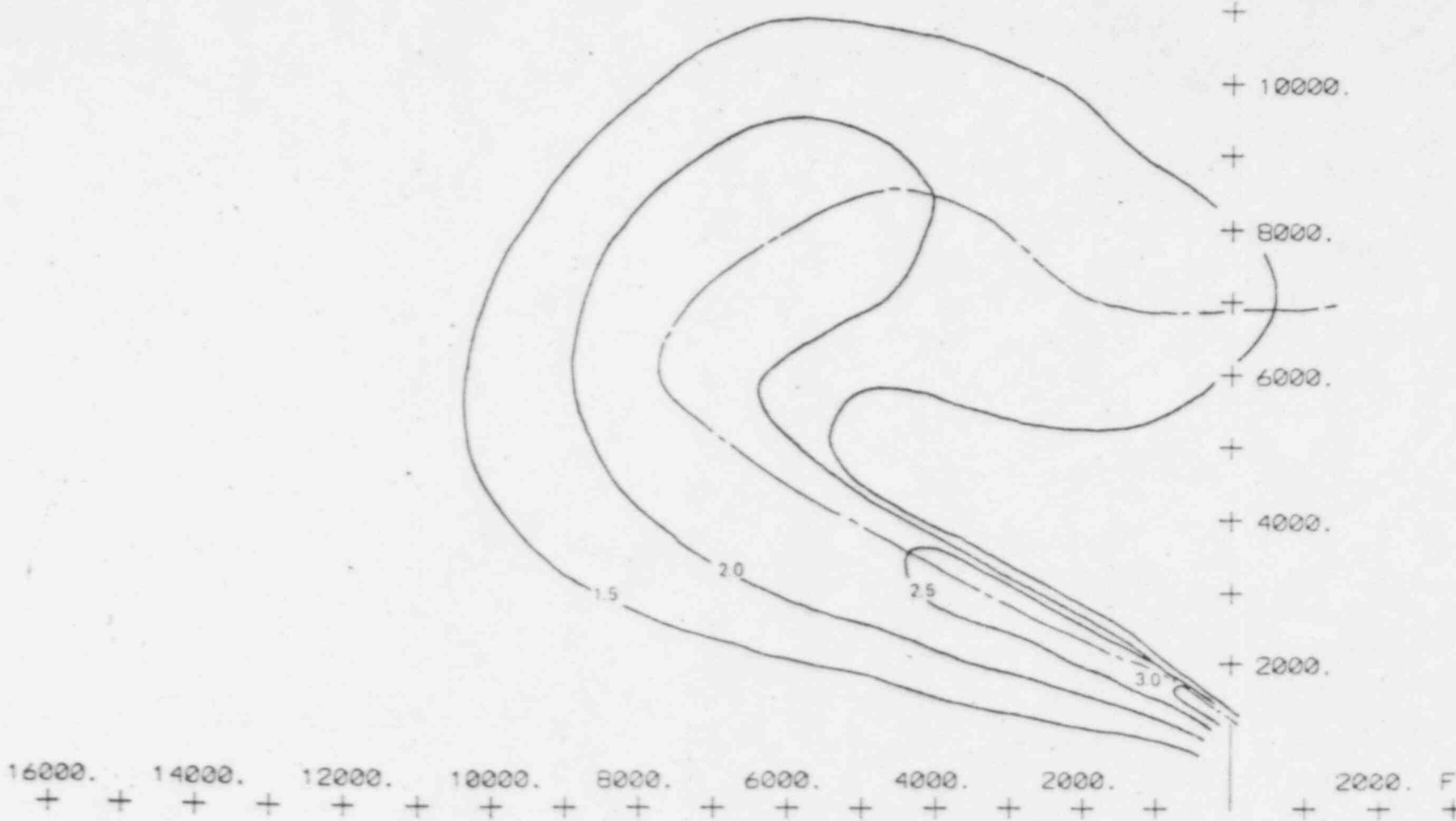
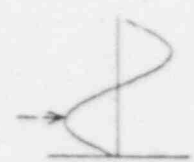


FIGURE G.3.2-7 SURFACE TEMPERATURE RISE ISOTHERMS

NEP 1&2

TIME IN TIDE CYCLE = T/4
CURRENT VELOCITY = 1.0 FPS
STRATIFICATION TEMP. DIFFERENCE = .00 °F
SURFACE HEAT FLUX COEFFICIENT = 200. BTU/FT**2/DAY/°F



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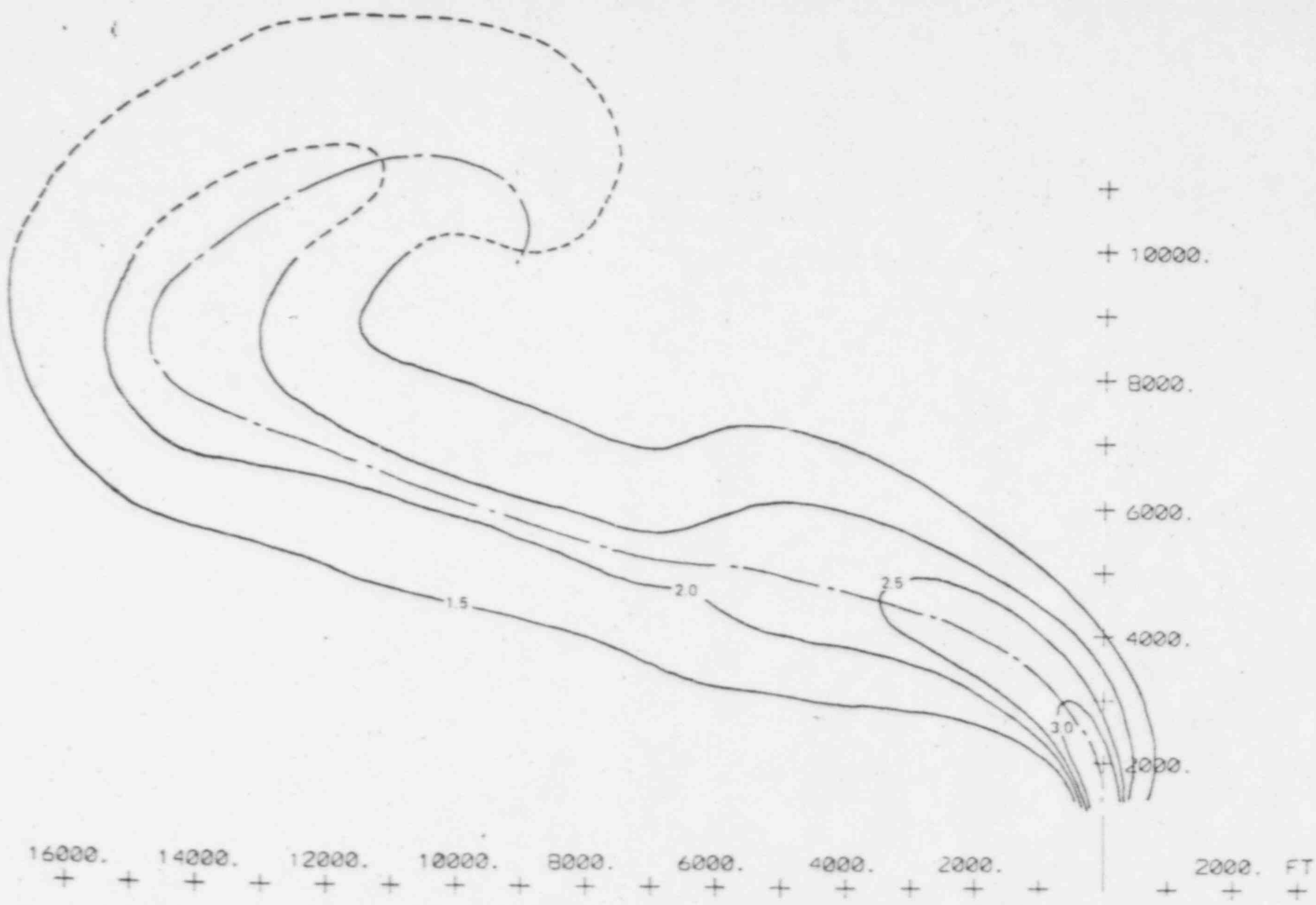


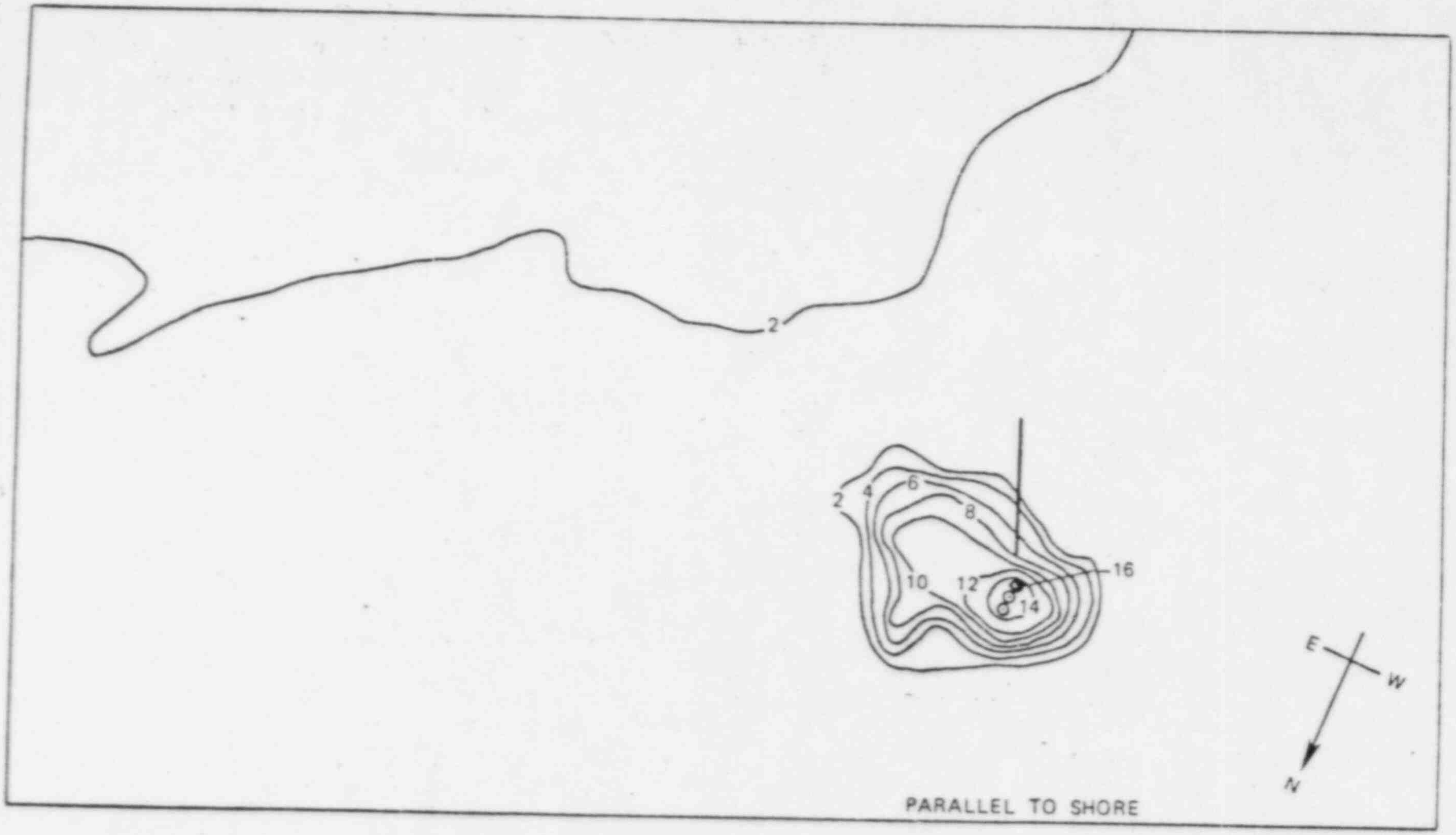
FIGURE
G.3.2-9

SURFACE TEMPERATURE RISE ISOTHERMS

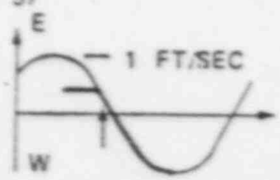
NEP 1&2

TIME IN TIDE CYCLE = T/2
CURRENT VELOCITY = 0.0 FPS
STRATIFICATION TEMP. DIFFERENCE = .00 °F
SURFACE HEAT FLUX COEFFICIENT = 200 BTU/FT**2/DAY/°F

ARL



TEST NO. 57



TRANSIENT LONGSHORE CURRENT

SCAN TIME: 1 HR. 15 MIN. AFTER BACKFLUSH START

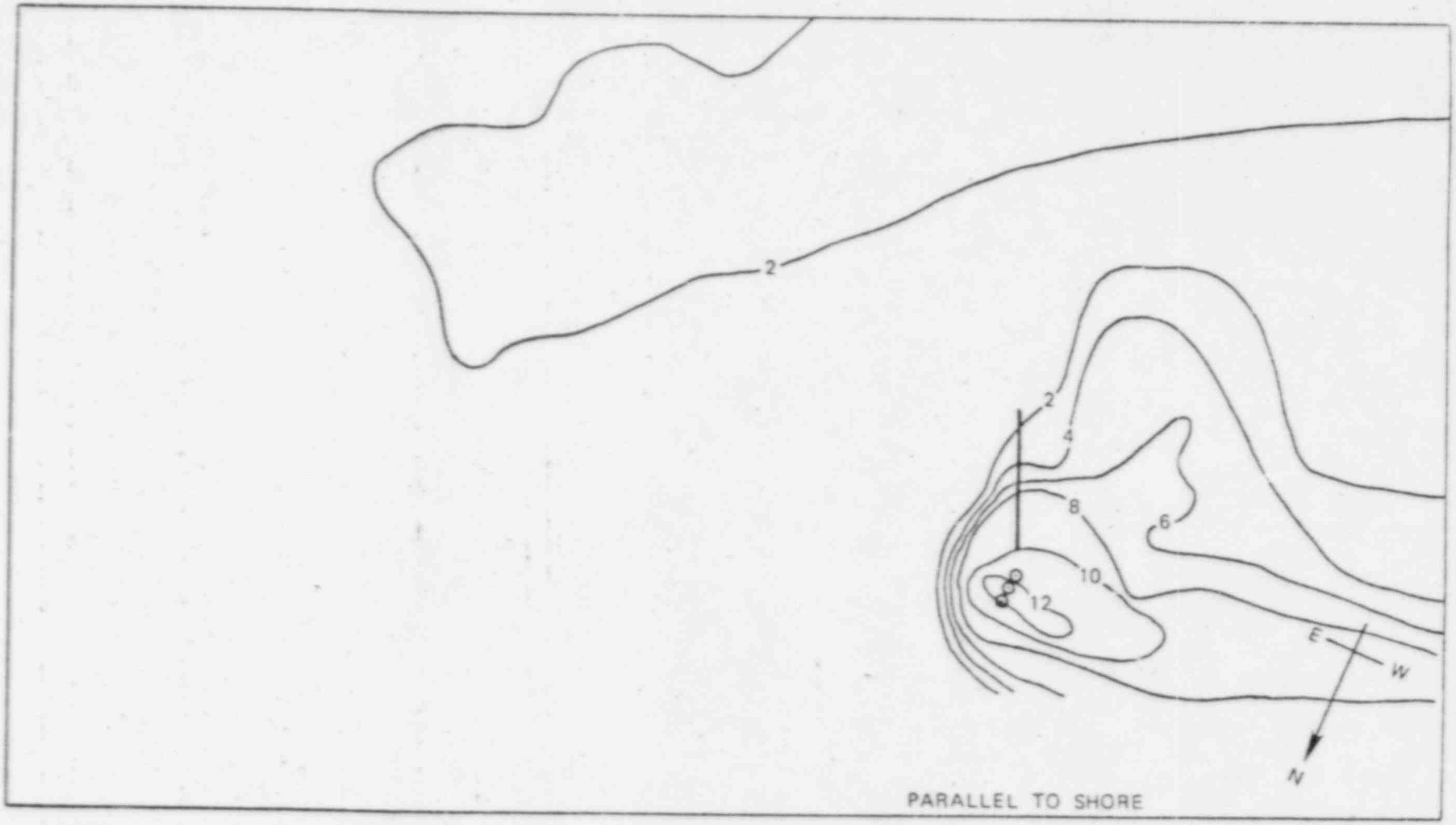
SURFACE TEMPERATURE RISE ISOTHERMS
BACKFLUSHING

COOLING SYSTEM LAYOUT C	
INTAKE BACKFLUSHING	ALL
AMBIENT TEMPERATURE	70°F
BACKFLUSH TEMPERATURE RISE	51.5°F

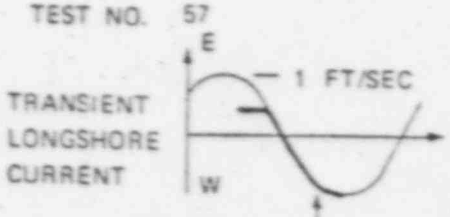
0 1000
SCALE-FEET

NEP - CHARLESTOWN
HYDROTHERMAL STUDIES
ARL

Figure G.3.3-1



TEST NO. 57



SCAN TIME: 3 HR. 45 MIN.
AFTER BACKFLUSH START

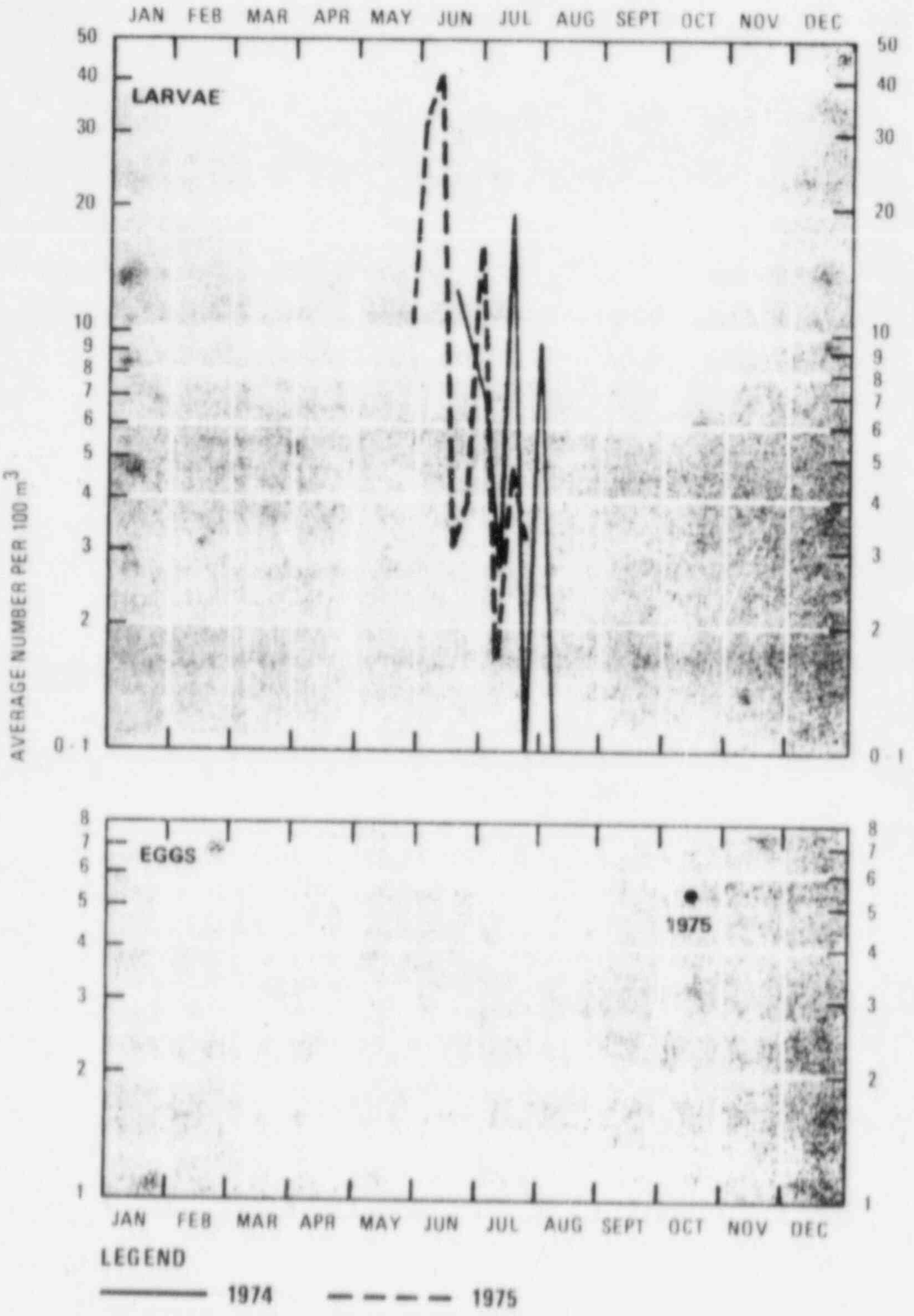
SURFACE TEMPERATURE RISE ISOTHERMS
BACKFLUSHING

COOLING SYSTEM LAYOUT C	
INTAKE BACKFLUSHING	ALL
AMBIENT TEMPERATURE	70°F
BACKFLUSH TEMPERATURE RISE	41.2°F

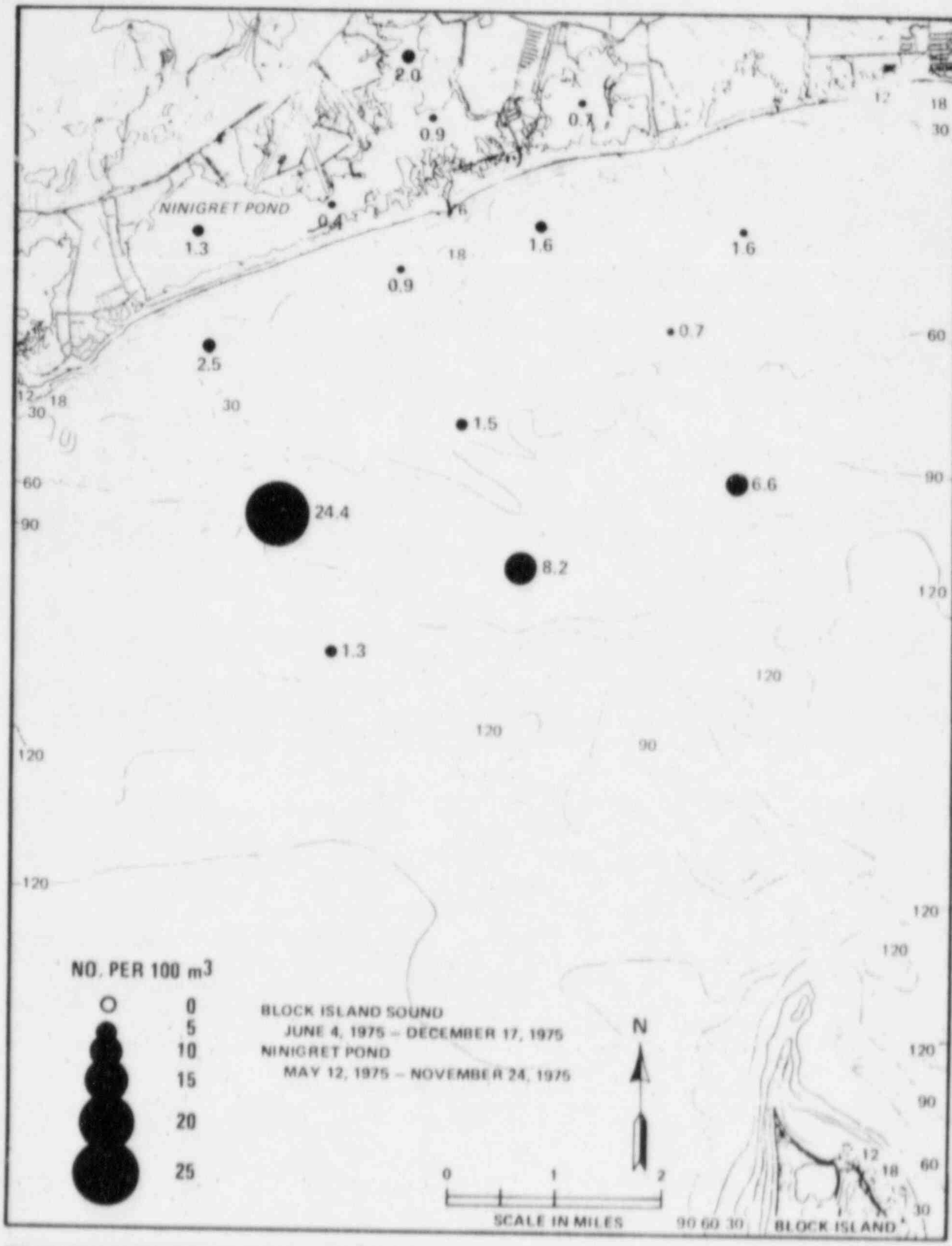
0 1000
SCALE-FEET

NEP - CHARLESTOWN
HYDROTHERMAL STUDIES
ARL

Figure G.3.3-3



NEW ENGLAND POWER COMPANY NEP 1 & 2 Environmental Report	ATLANTIC MENHADEN TEMPORAL ABUNDANCE AT BLOCK ISLAND SOUND STATION A	
	FIGURE G.4.2-1	NEP 1 & 2

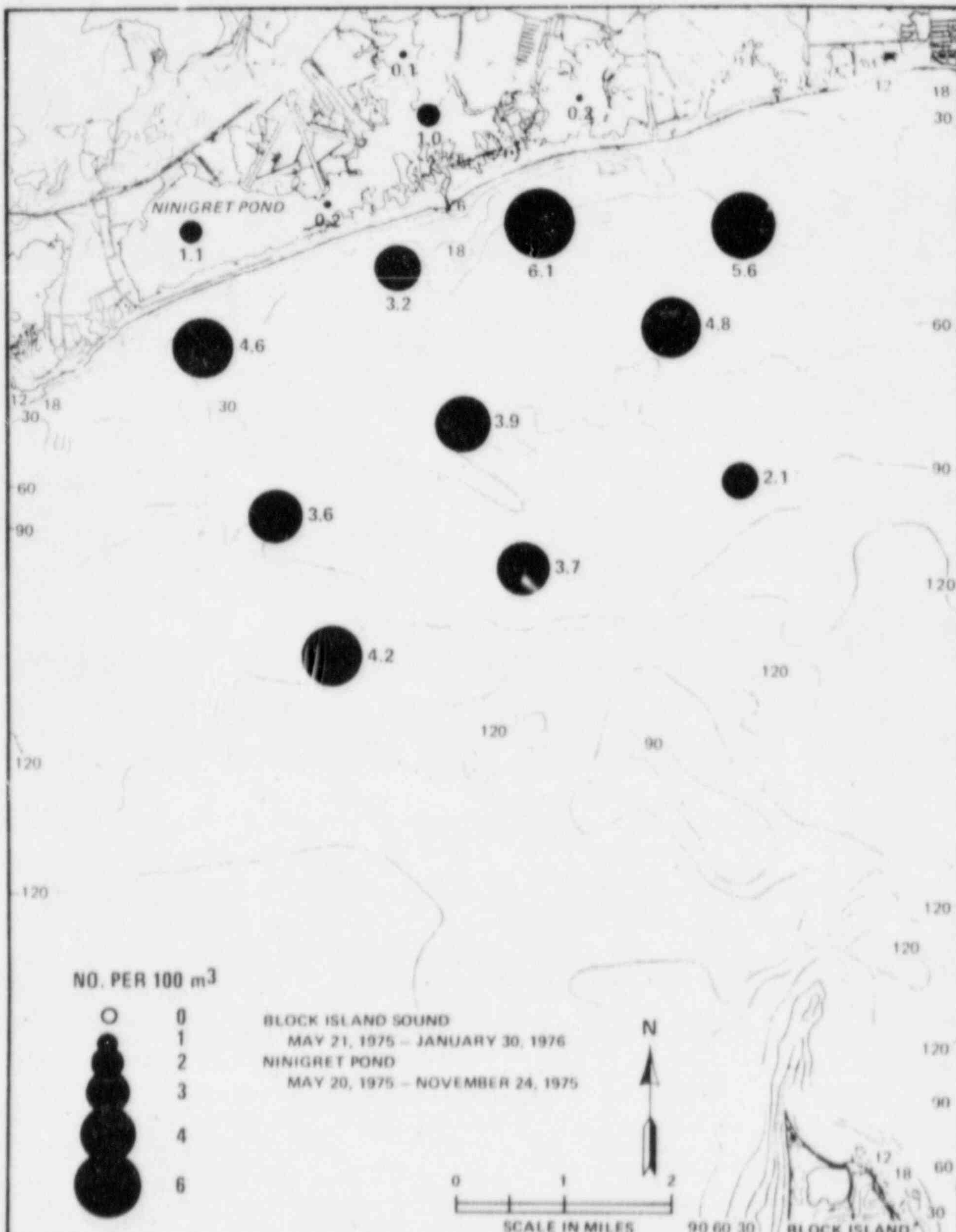


NEW ENGLAND POWER COMPANY
NEP 1& 2
Environmental Report

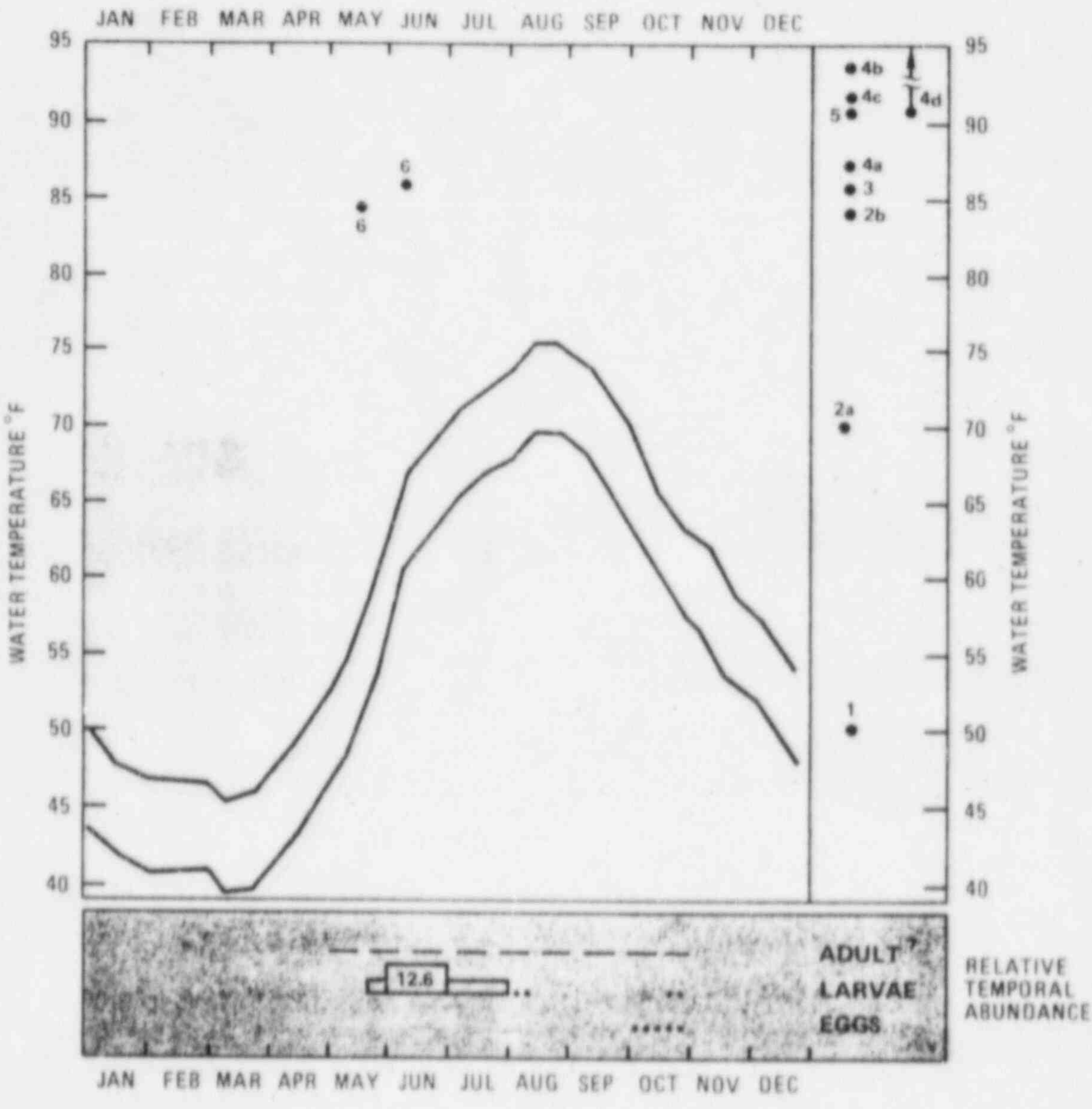
DISTRIBUTION AND AVERAGE DENSITY OF ATLANTIC MENHADEN EGGS

FIGURE G.4.2-3

NEP 1& 2

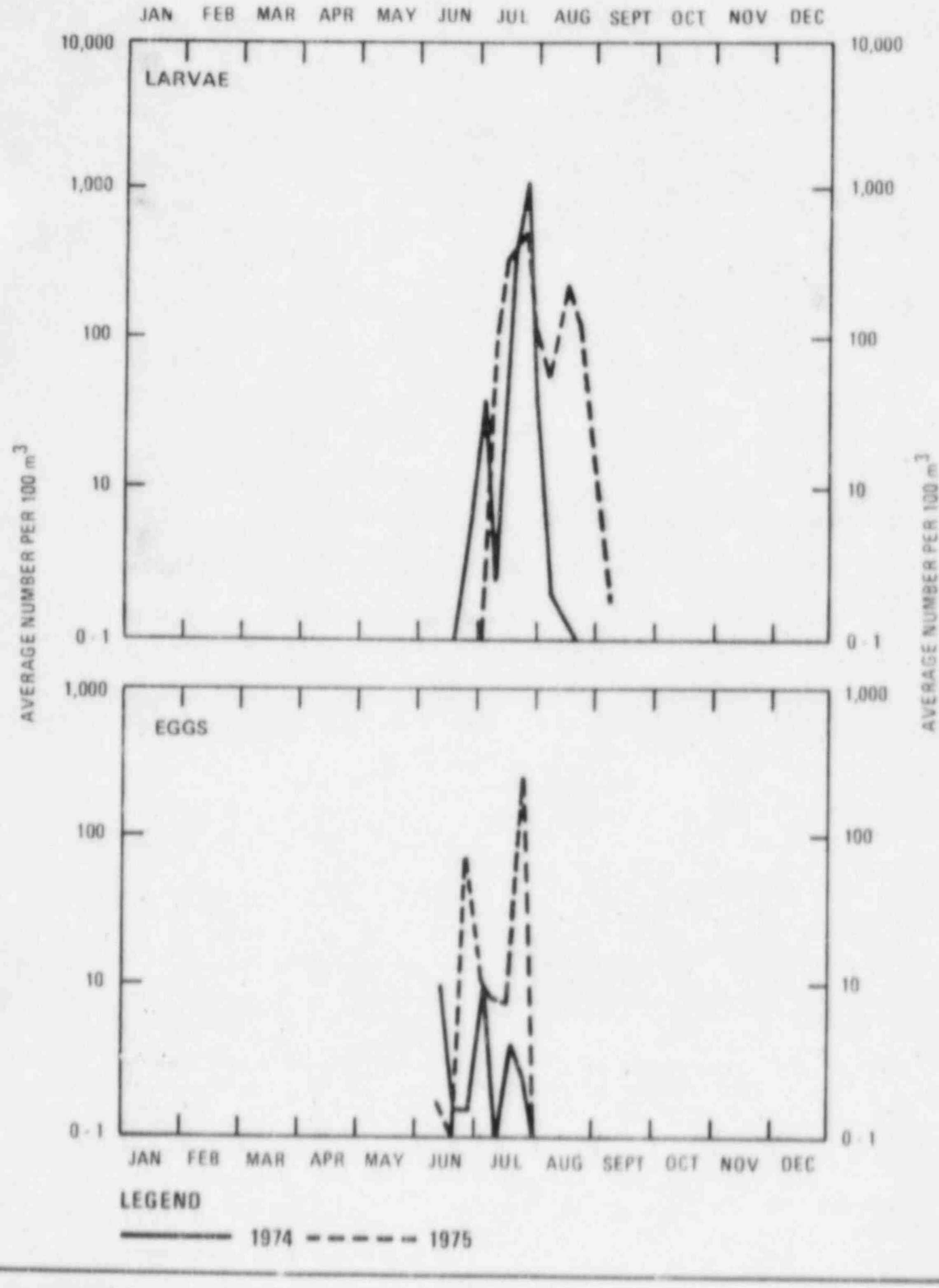


NEW ENGLAND POWER COMPANY NEP 1 & 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF ATLANTIC MENHADEN LARVAE
	FIGURE G.4.2-5 — NEP 1 & 2



1. MINIMAL TEMPERATURE WHERE MENHADEN APPEAR (BIGELOW AND SCHROEDER, 1953)
2a. PREFERRED TEMPERATURE (MELDRIM AND GIFT, 1971)
b. AVOIDANCE TEMPERATURE
3. TLM (BATTELLE COLUMBUS LABORATORIES, 1971-72)
4a. STRESS OF MENHADEN OBSERVED AT CANAL STATION (SMITH, 1974)
b. MORTALITY OF MENHADEN OBSERVED AT CANAL STATION
c. SURVIVAL OF MENHADEN REPORTED AT OYSTER CREEK STATION
d. MORTALITY OF MENHADEN OBSERVED AT OYSTER CREEK STATION: 99°F
5. DEATH OF YOUNG MENHADEN REPORTED ABOVE (LEWIS AND HETTLER, 1968)
6. UPPER LETHAL TEMPERATURE FOR LARVAE (HOSS ET. AL., 1973)
7. TEMPORAL OCCURRENCE OF MENHADEN (COASTAL AND OFFSHORE ENVIRONMENTAL INVENTORY, 1973)

NEW ENGLAND POWER COMPANY NEP 1 & 2 Environmental Report	ATLANTIC MENHADEN RELATIVE TEMPORAL ABUNDANCE AND THERMAL CHARACTERISTICS	
	FIGURE G.4.2-6	NEP 1 & 2

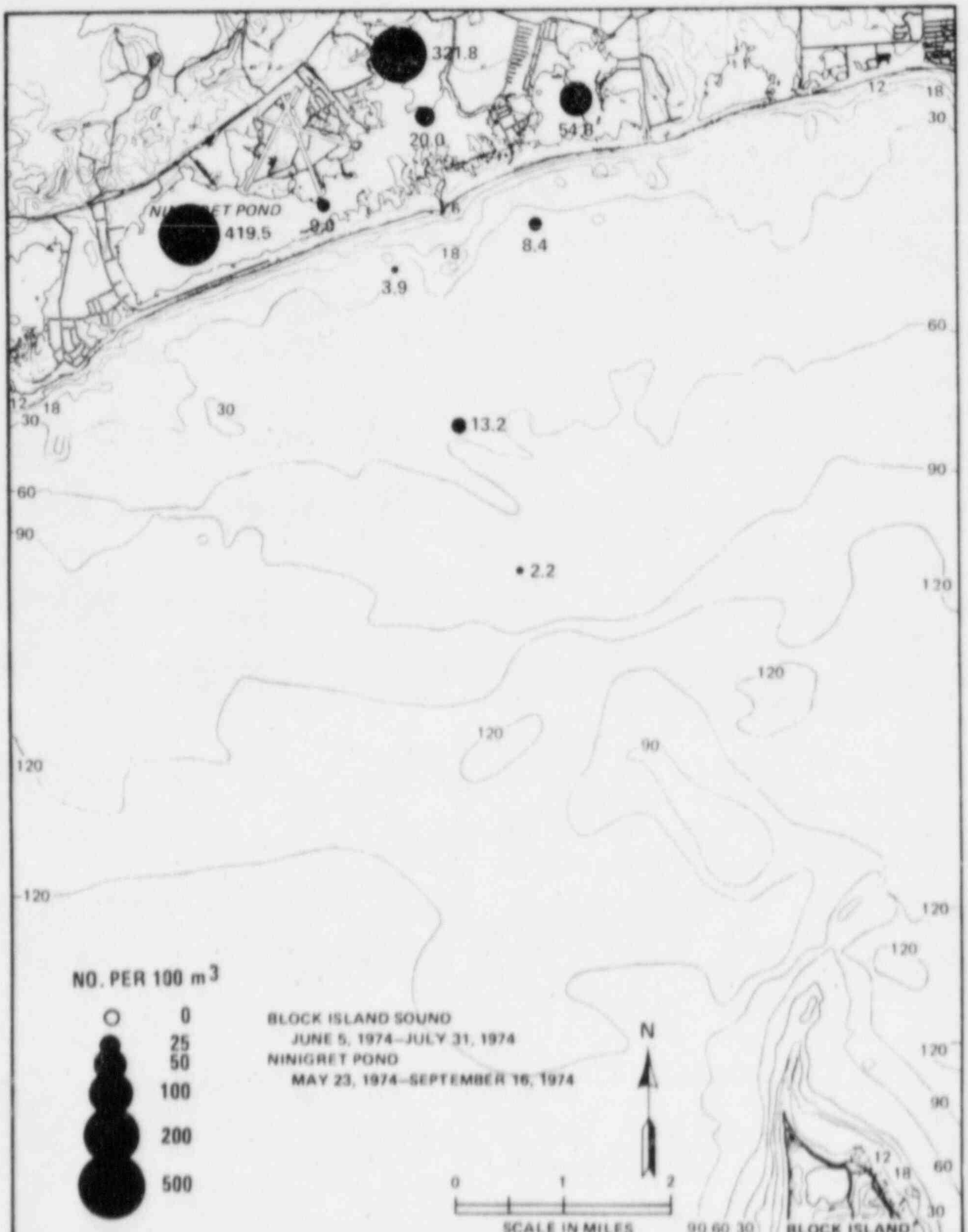


NEW ENGLAND POWER COMPANY
NEP 1&2
Environmental Report

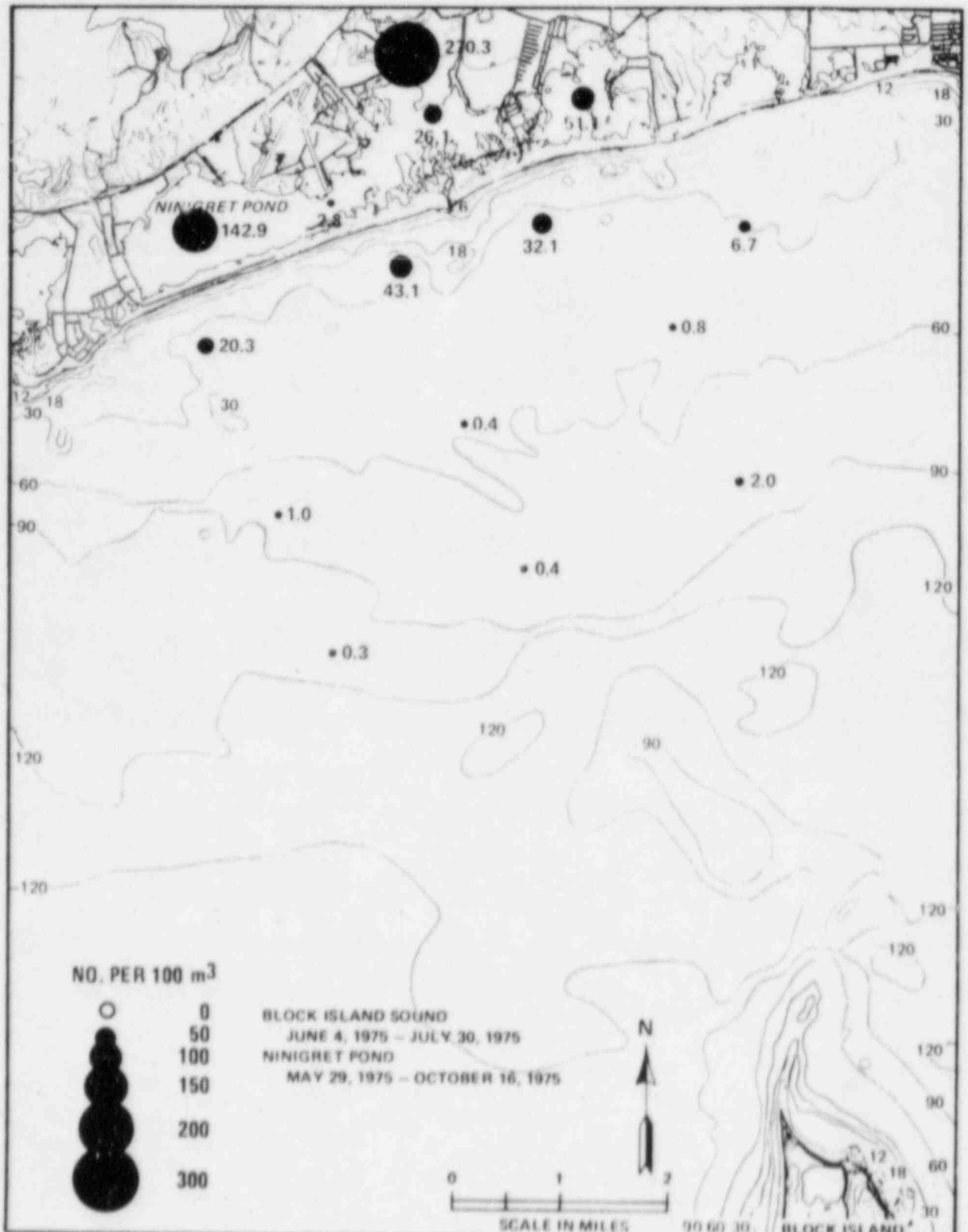
BAY ANCHOVY
TEMPORAL ABUNDANCE AT
BLOCK ISLAND SOUND STATION A

FIGURE G.4.2-7

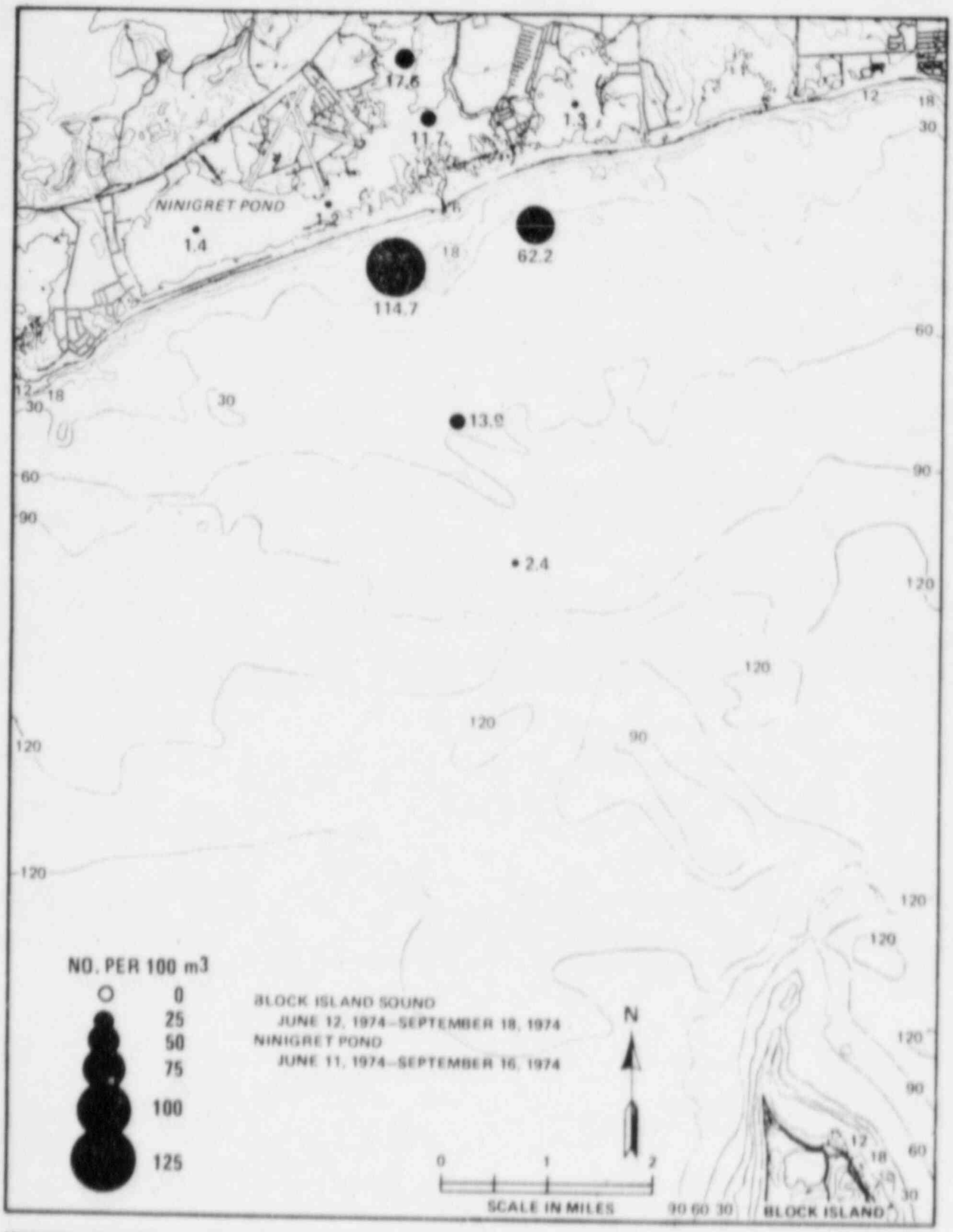
NEP 1&2



NEW ENGLAND POWER COMPANY N E P 1 & 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF BAY ANCHOVY EGGS	
	FIGURE G.4.2-8	N E P 1 & 2



NEW ENGLAND POWER COMPANY N E P 1 & 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF BAY ANCHOVY EGGS	
	FIGURE G.4.2-9	N E P 1 & 2

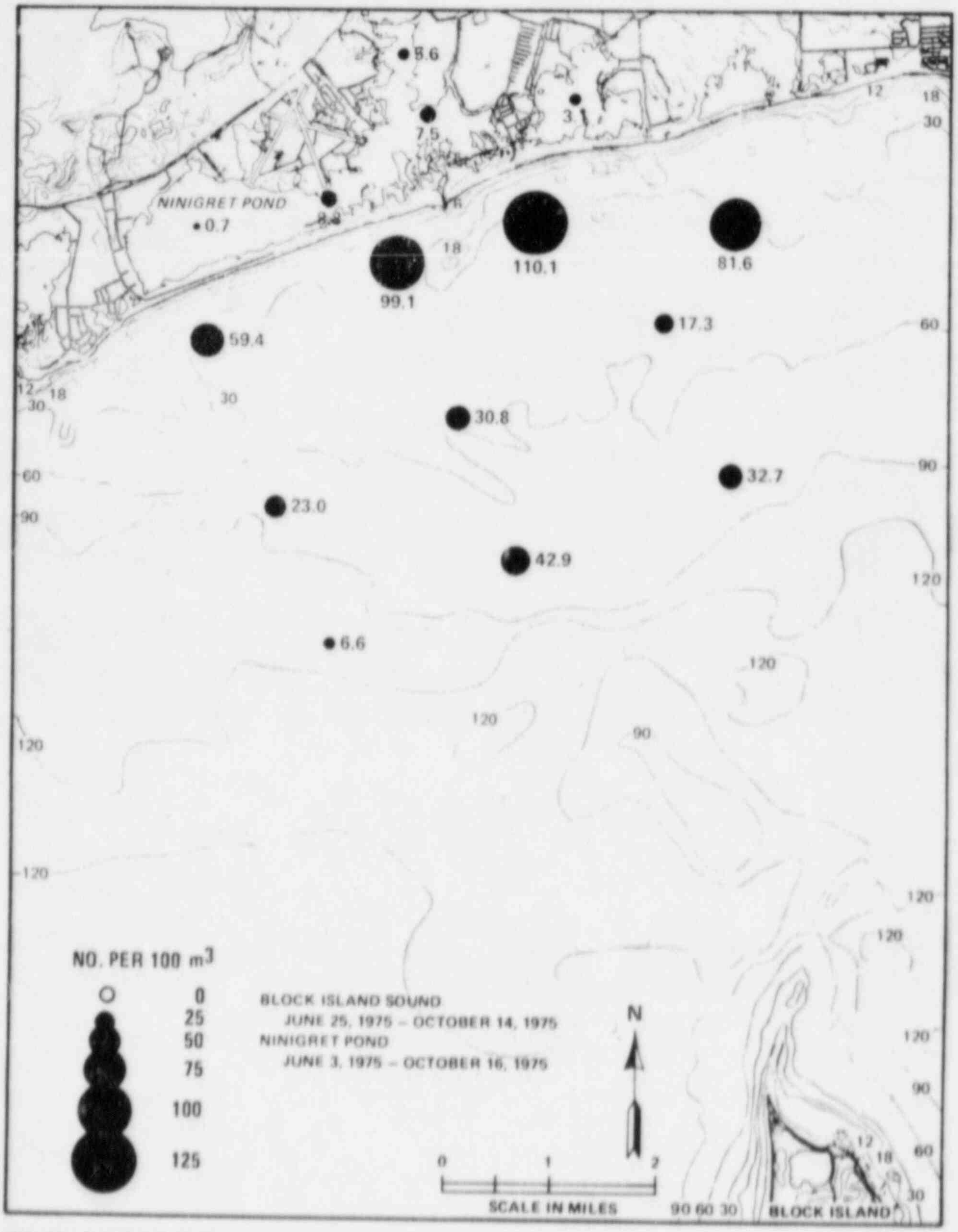


NEW ENGLAND POWER COMPANY
NEP 1& 2
Environmental Report

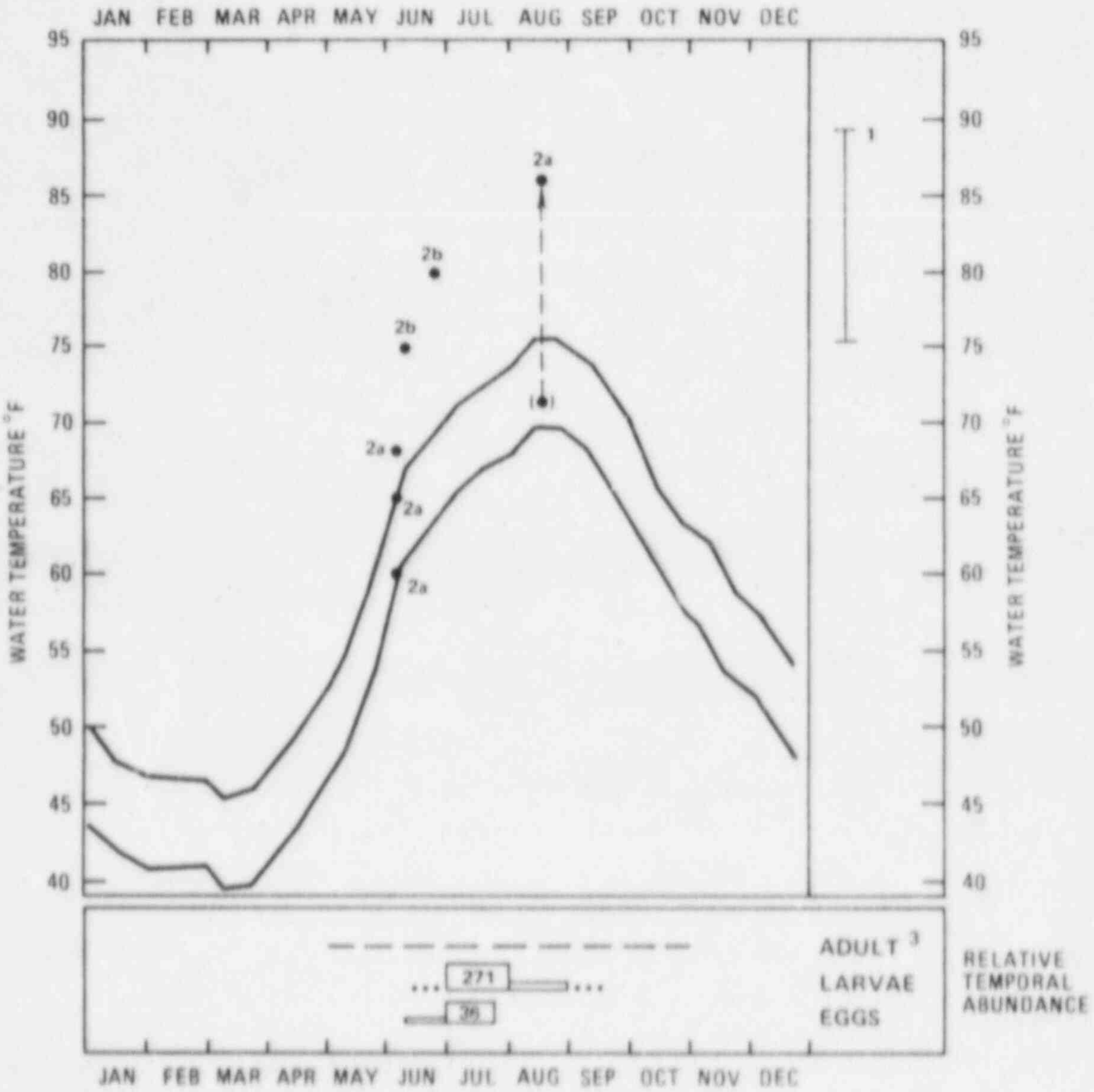
DISTRIBUTION AND AVERAGE DENSITY OF BAY ANCHOVY LARVAE

FIGURE G.4.2-10

NEP 1& 2

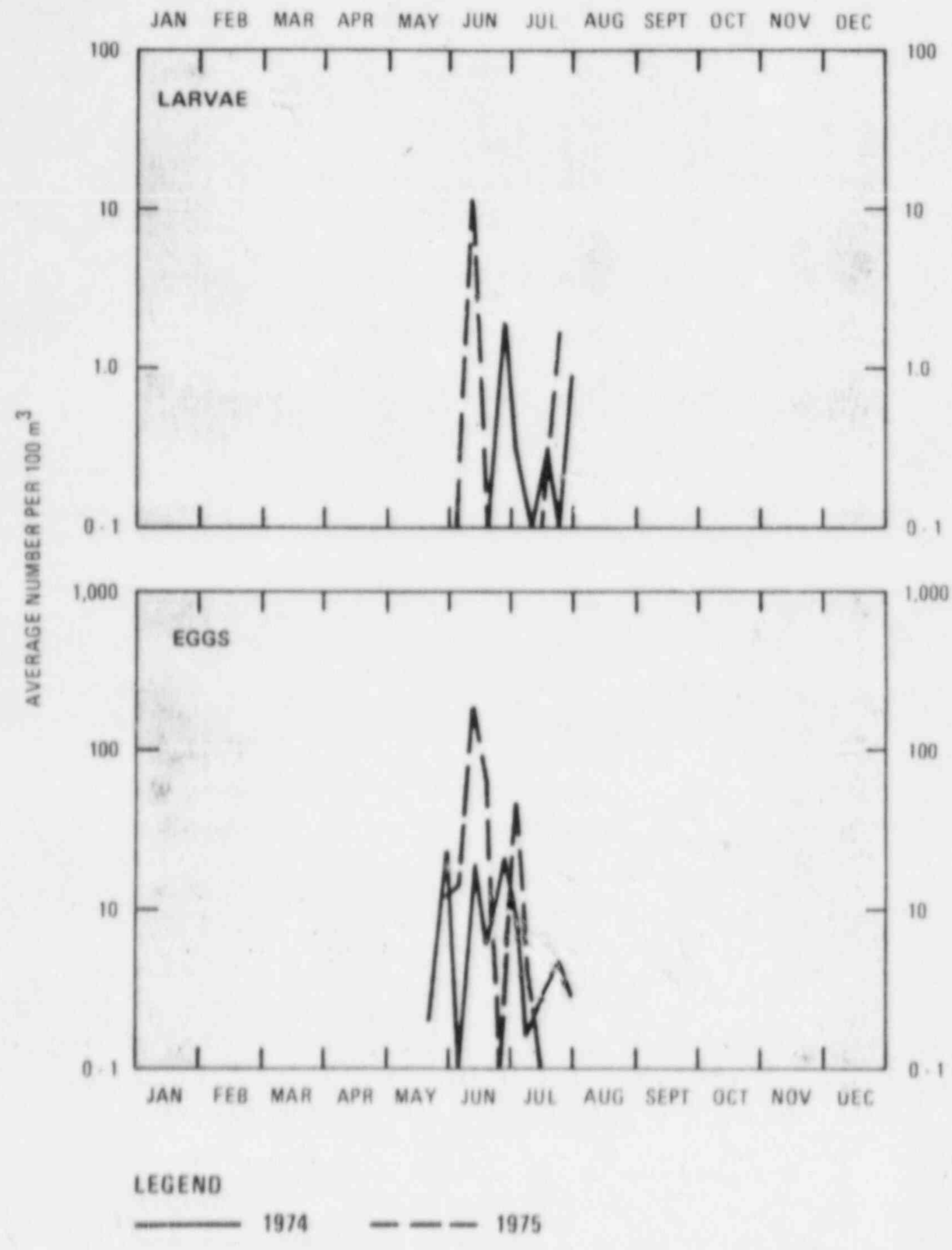


NEW ENGLAND POWER COMPANY NEP 1& 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF BAY ANCHOVY LARVAE	
	FIGURE G.4.2-11	NEP 1& 2



1. FEEDING TEMPERATURE SURVIVORSHIP INDICATED FOR LARVAE (HOUDE, 1974)
2a. PREFERRED TEMPERATURE (MELDRIM AND GIFT, 1971)
b. AVOIDANCE TEMPERATURE (MELDRIM AND GIFT, 1971)
3. TEMPORAL OCCURRENCE OF ADULTS (GORDON, 1974)

NEW ENGLAND POWER COMPANY N E P 1 & 2 Environmental Report	BAY ANCHOVY RELATIVE TEMPORAL ABUNDANCE AND THERMAL CHARACTERISTICS
	FIGURE G.4.2-12 — N E P 1 & 2

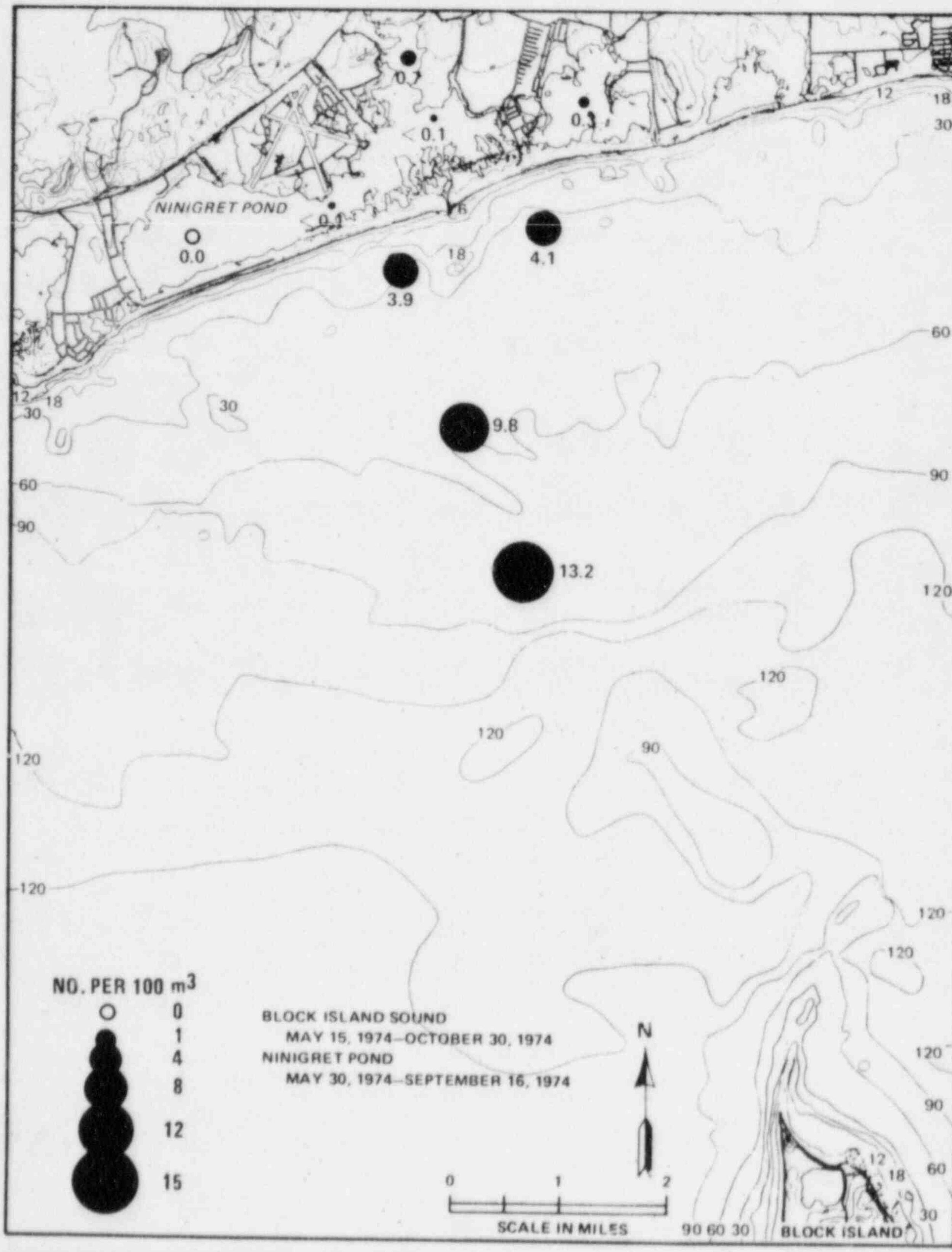


NEW ENGLAND POWER COMPANY
NEP 1 & 2
Environmental Report

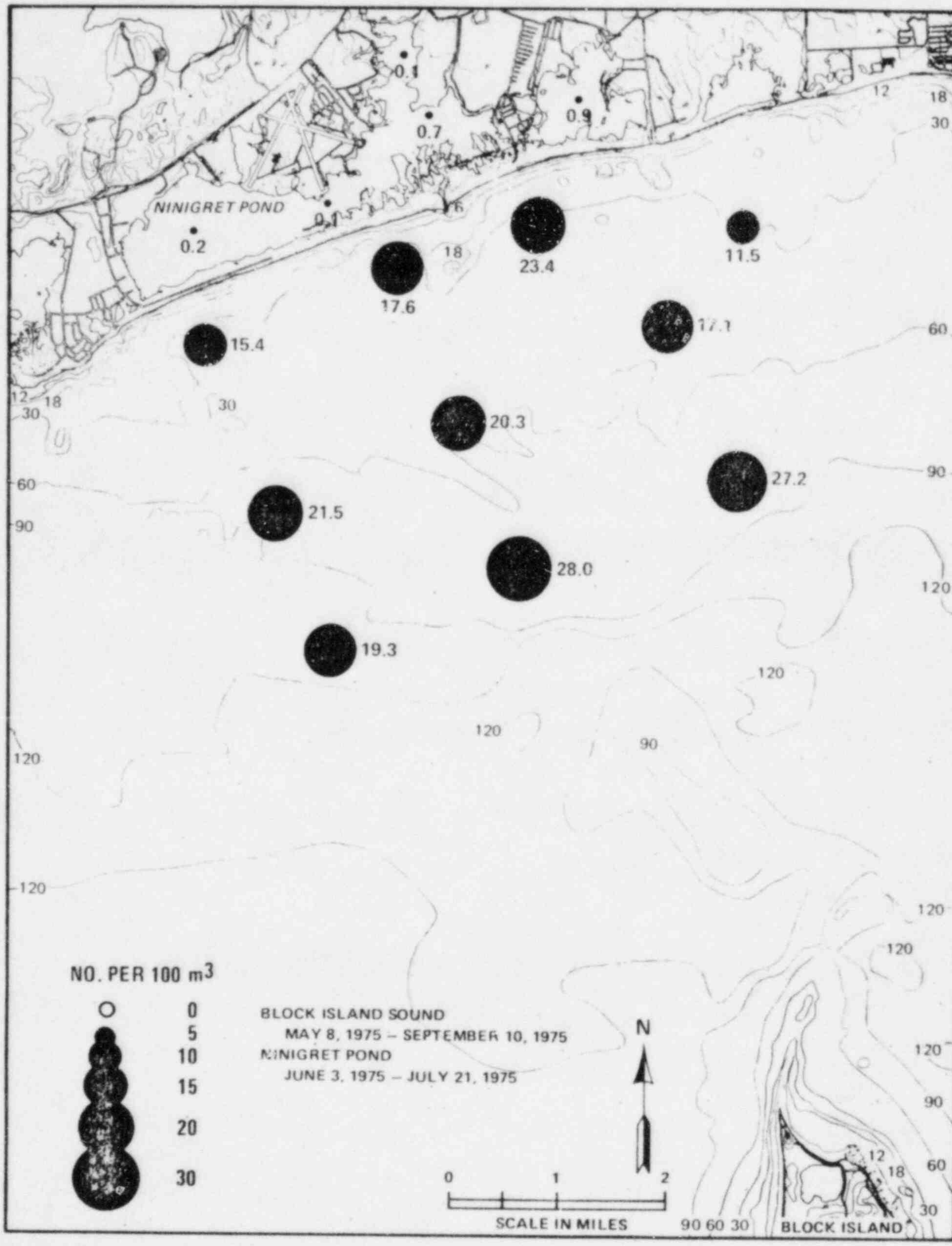
SILVER HAKE
TEMPORAL ABUNDANCE AT
BLOCK ISLAND SOUND STATION A

FIGURE G.4.2-13

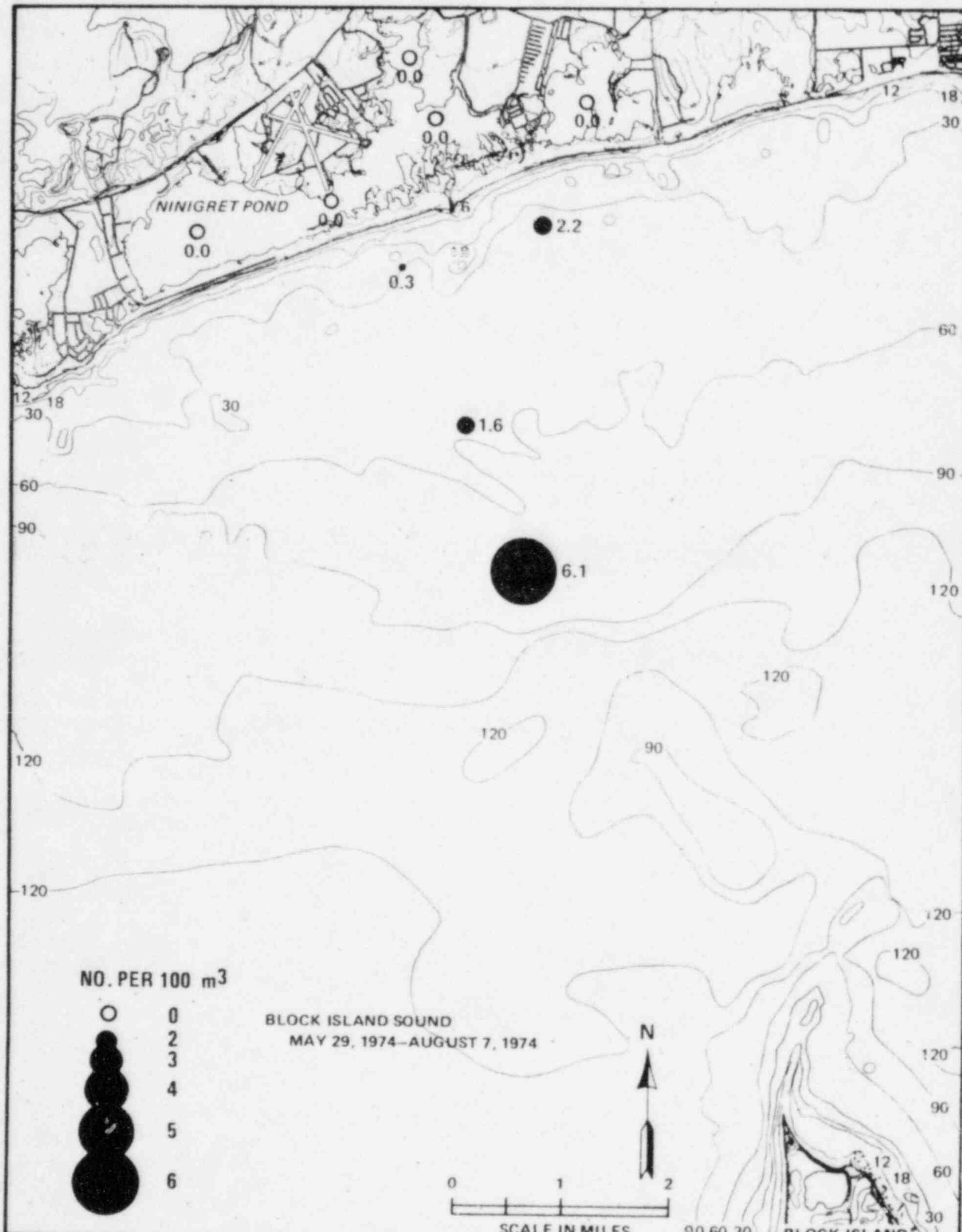
NEP 1 & 2



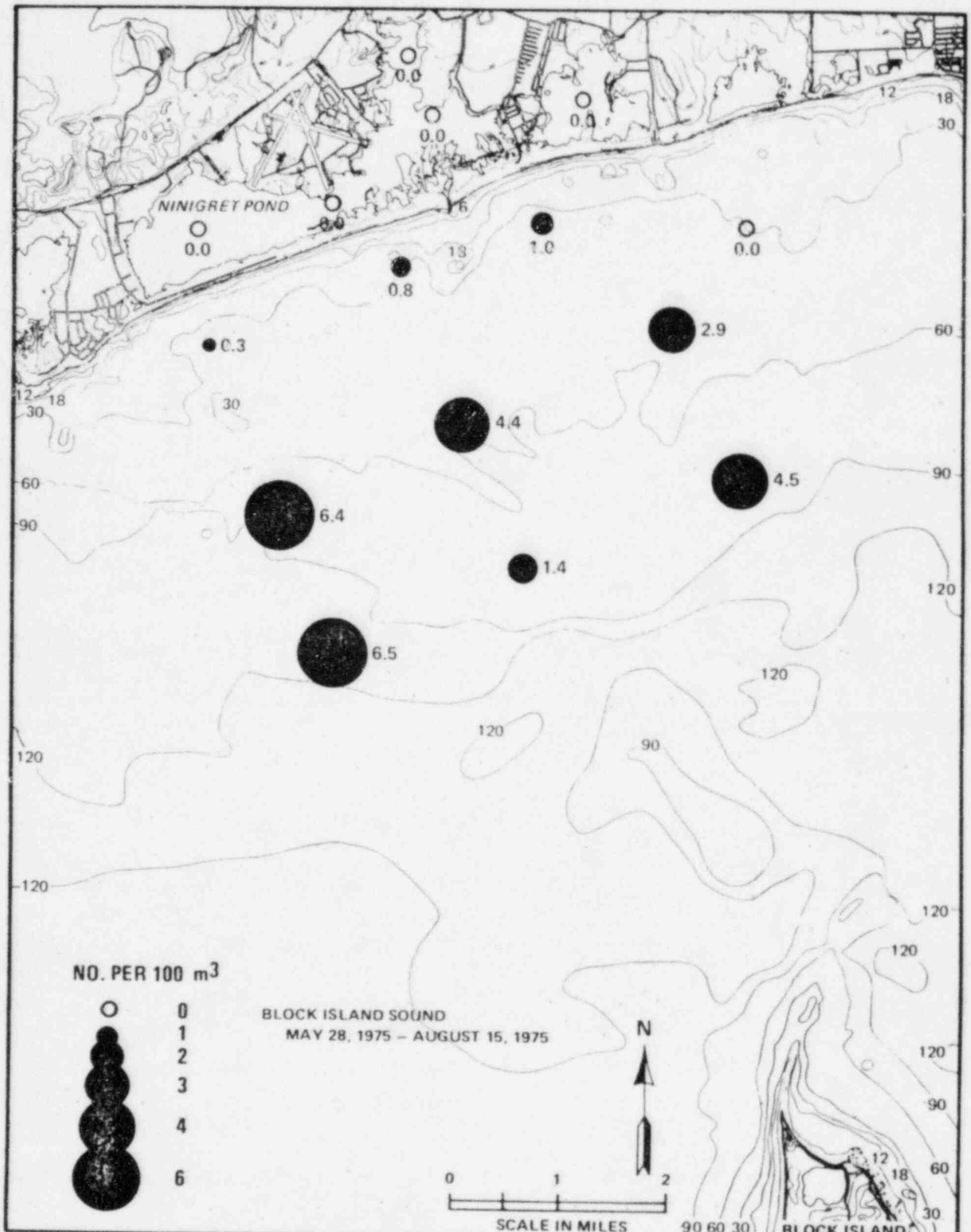
NEW ENGLAND POWER COMPANY N E P 1 & 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF SILVER HAKE EGGS	
	FIGURE G.4.2-14	N E P 1 & 2



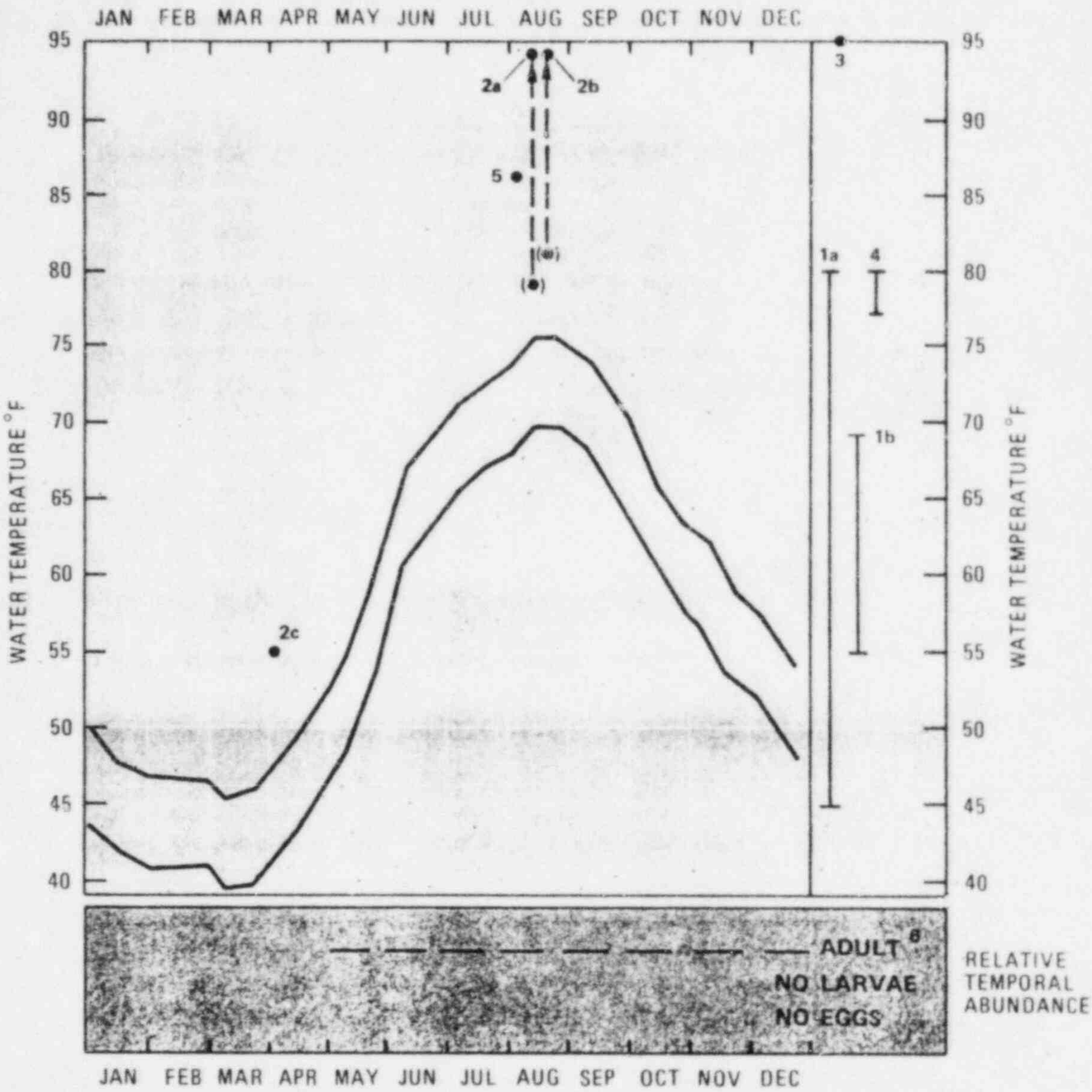
NEW ENGLAND POWER COMPANY NEP 1 & 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF SILVER HAKE EGGS	
	FIGURE G.4.2-15	NEP 1 & 2



NEW ENGLAND POWER COMPANY NEP 1& 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF SILVER HAKE LARVAE
	FIGURE G.4.2-16 | NEP 1& 2

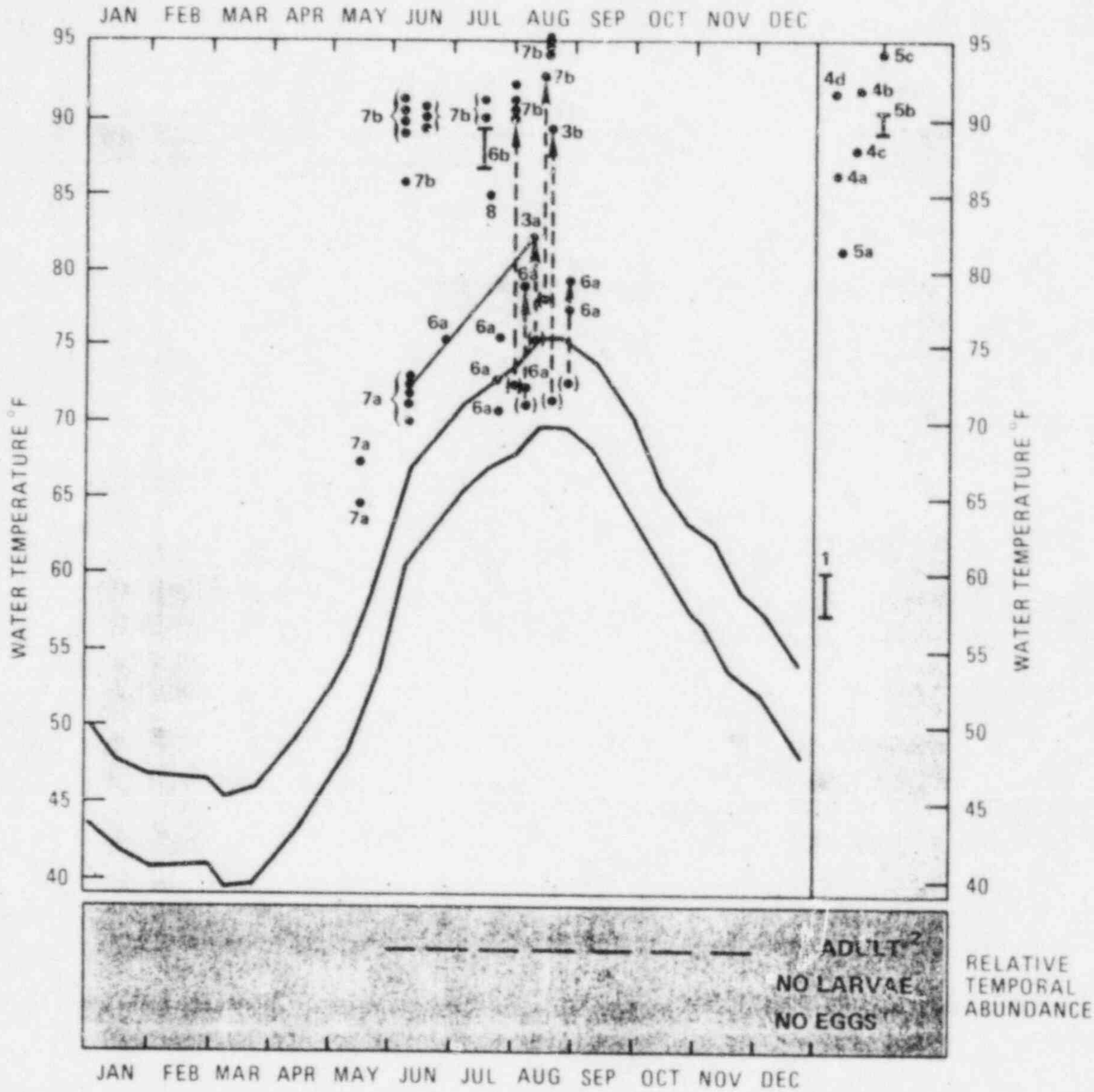


NEW ENGLAND POWER COMPANY NEP 1 & 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF SILVER HAKE LARVAE	
	FIGURE G.4.2-17	NEP 1 & 2



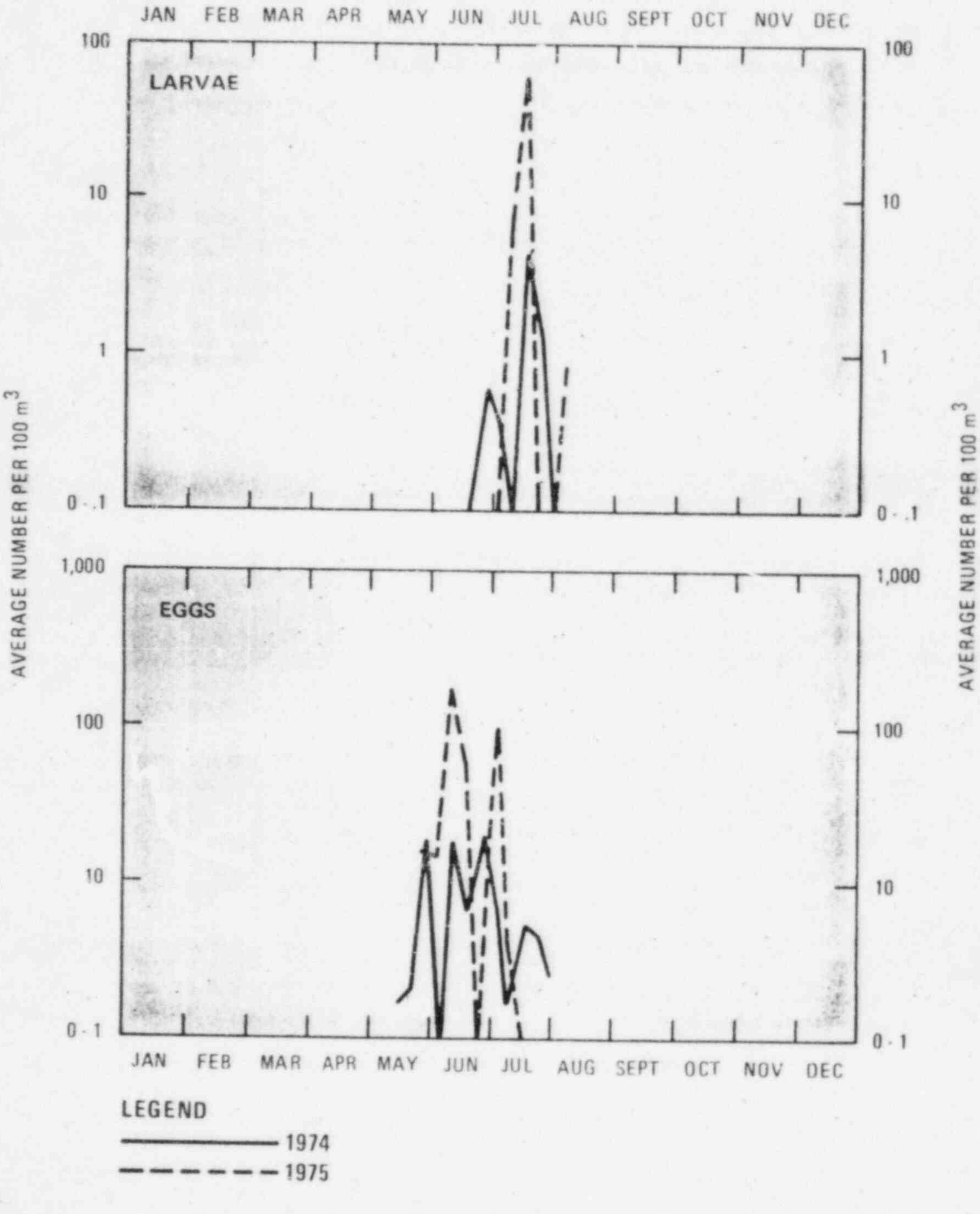
1a. TEMPERATURE TOLERANCE RANGE FOR ADULT WHEN ABRUPTLY TRANSFERRED FROM SALT WATER TO FRESH WATER (TAGATZ, 1961)
 b. TEMPERATURE TOLERANCE RANGE FOR JUVENILES WHEN TRANSFERRED FROM SALT WATER TO FRESH WATER
2a. SHOCK TEMPERATURE SURVIVED BY JUVENILES (MELDRIM AND GIFT, 1971)
 b. MAXIMUM AVOIDANCE TEMPERATURE
 c. WINTER MAXIMUM AVOIDANCE TEMPERATURE
3. SURVIVAL AND FEEDING INDICATED (DORFMAN AND WESTMAN, 1970)
4. MAXIMUM TEMPERATURES FOR *M. SAXATILIS* IN NEW ENGLAND (MERRIMAN, 1941)
5. UPPER AVOIDANCE BREAKDOWN TEMPERATURE (GIFT AND WESTMAN, 1971)
6. TEMPORAL OCCURRENCE OF ADULTS IN NEW ENGLAND (BIGELOW AND SCHROEDER, 1953)

NEW ENGLAND POWER COMPANY NEP 1& 2 Environmental Report	STRIPED BASS RELATIVE TEMPORAL ABUNDANCE AND THERMAL CHARACTERISTICS
	FIGURE G.4.2-18 — NEP 1& 2



1. LOWEST TEMPERATURE WHERE BLUEFISH ARE FOUND (BIGELOW AND SCHROEDER, 1953)
2. TEMPORAL OCCURRENCE OF BLUEFISH IN RHODE ISLAND (GORDON, 1974)
3a. PREFERENCE TEMPERATURES FOR JUVENILES (78-125 MM) (MEDLDRIM AND GIFT, 1971)
 b. AVOIDANCE TEMPERATURE RESPONSE
4a. MEAN AVOIDANCE TEMPERATURE FOR 7.9 CM (AVERAGE). (GIFT AND WESTMAN, 1971)
 b. MEAN AVOIDANCE BREAKDOWN TEMPERATURE
 c. MEAN AVOIDANCE TEMPERATURE FOR 13.9 CM (AVERAGE)
 d. MEAN AVOIDANCE BREAKDOWN TEMPERATURE
5a. TEMPERATURE WHERE SIGNIFICANT INCREASE OF SWIMMING SPEED OBSERVED (OLLA, ET.AL., 1975)
 b. MAXIMUM SWIMMING SPEED TEMPERATURE (JUVENILE)
 c. LOSS OF EQUILIBRIUM OBSERVED
6a. PREFERENCE TEMPERATURES FOR JUVENILES (WYLLIE, 1976)
 b. AVOIDANCE RESPONSE TEMPERATURE FOR JUVENILES
7a. PREFERENCE TEMPERATURES FOR JUVENILES (TERPIN, ET.AL., 1977)
 b. AVOIDANCE TEMPERATURE FOR JUVENILES
8. AVOIDANCE RESPONSE TEMPERATURE FOR ADULTS (OLLA AND STUDHOME, 1971)

NEW ENGLAND POWER COMPANY NEP 1 & 2 Environmental Report	BLUEFISH RELATIVE TEMPORAL ABUNDANCE AND THERMAL CHARACTERISTICS
	FIGURE G.4.2-19 — NEP 1 & 2

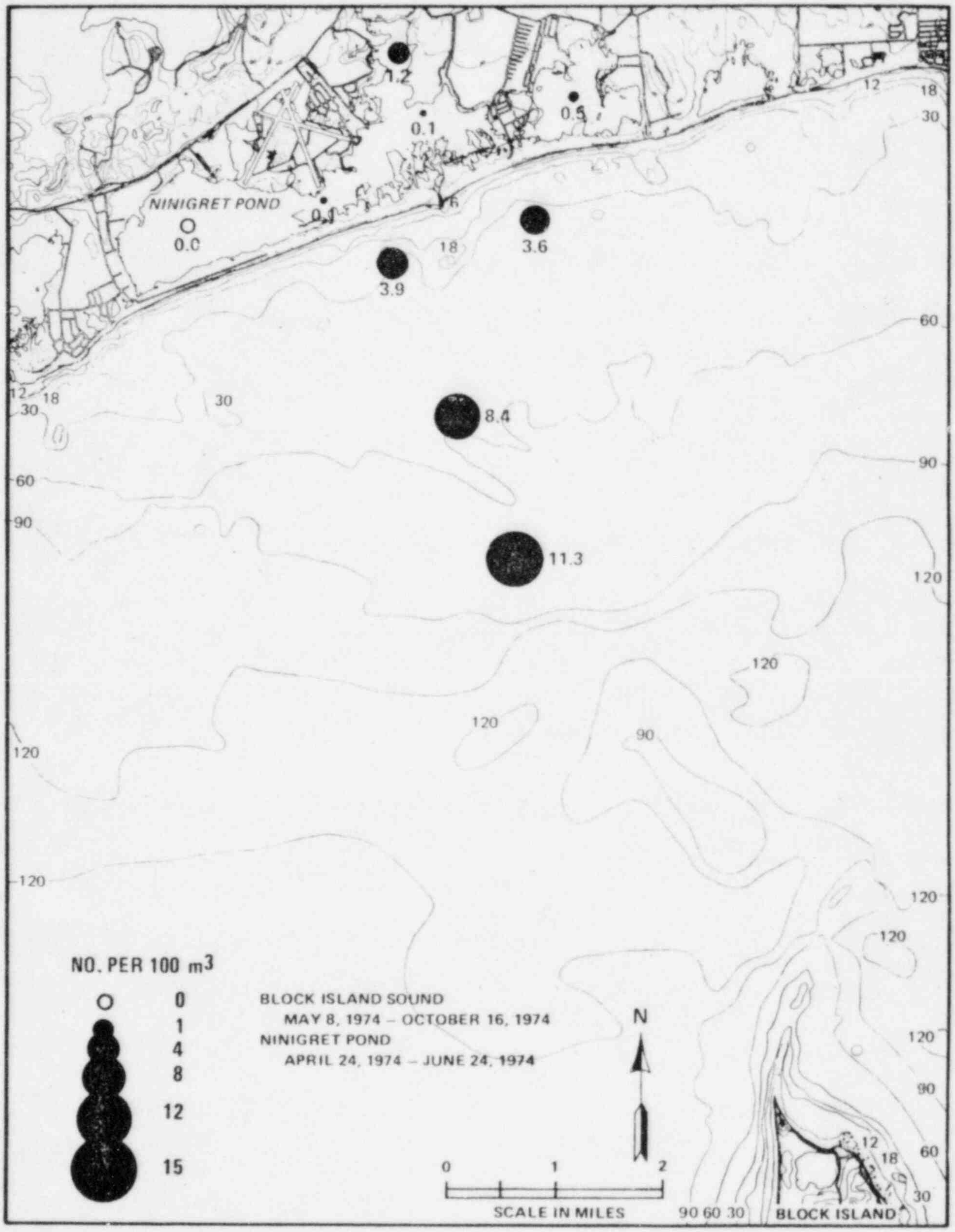


NEW ENGLAND POWER COMPANY
NEP 1 & 2
Environmental Report

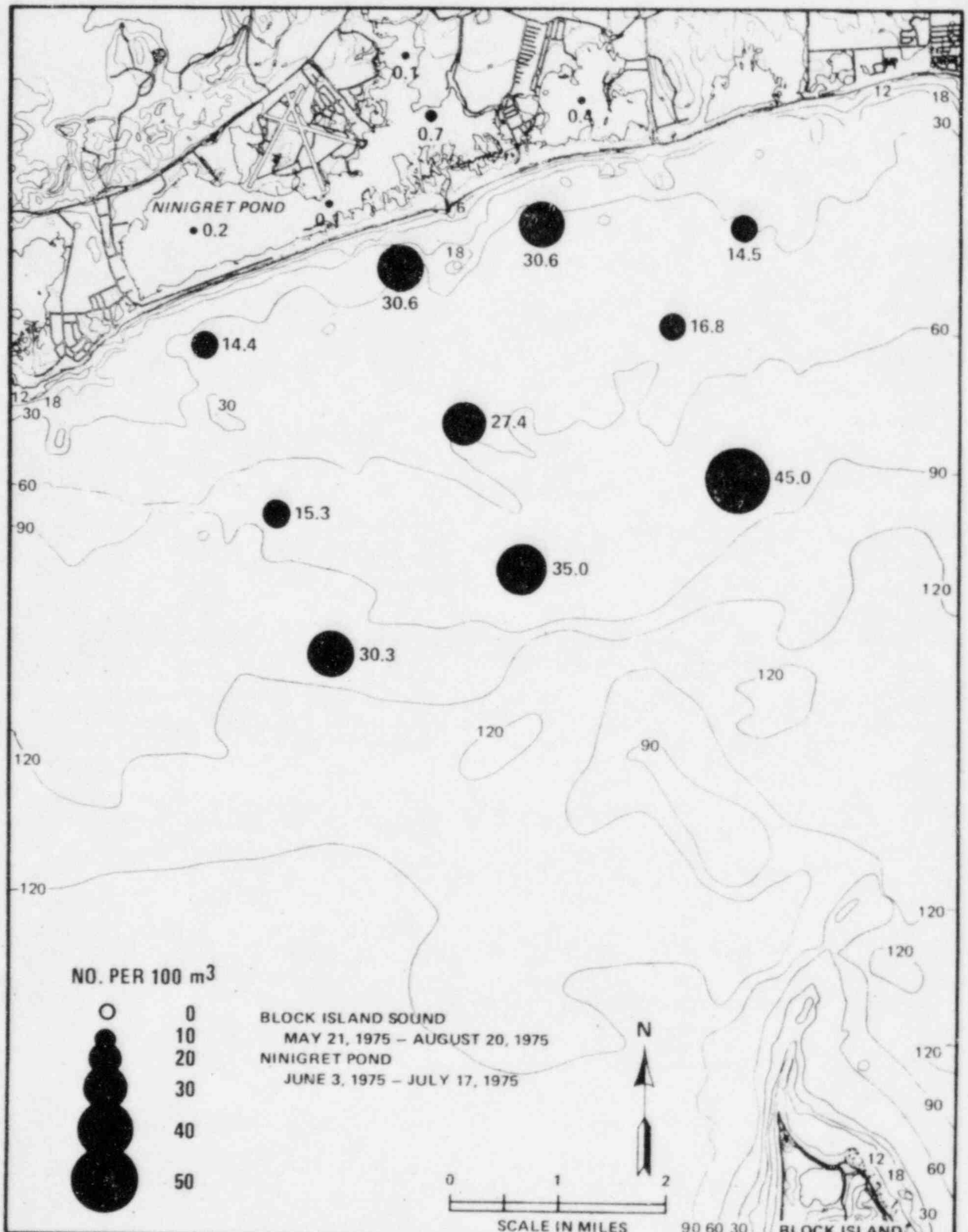
SCUP
TEMPORAL ABUNDANCE AT
BLOCK ISLAND SOUND STATION A

FIGURE G.4.2-20

NEP 1 & 2



NEW ENGLAND POWER COMPANY NEP 1& 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF SCUP EGGS	
	FIGURE G.4.2-21	NEP 1& 2

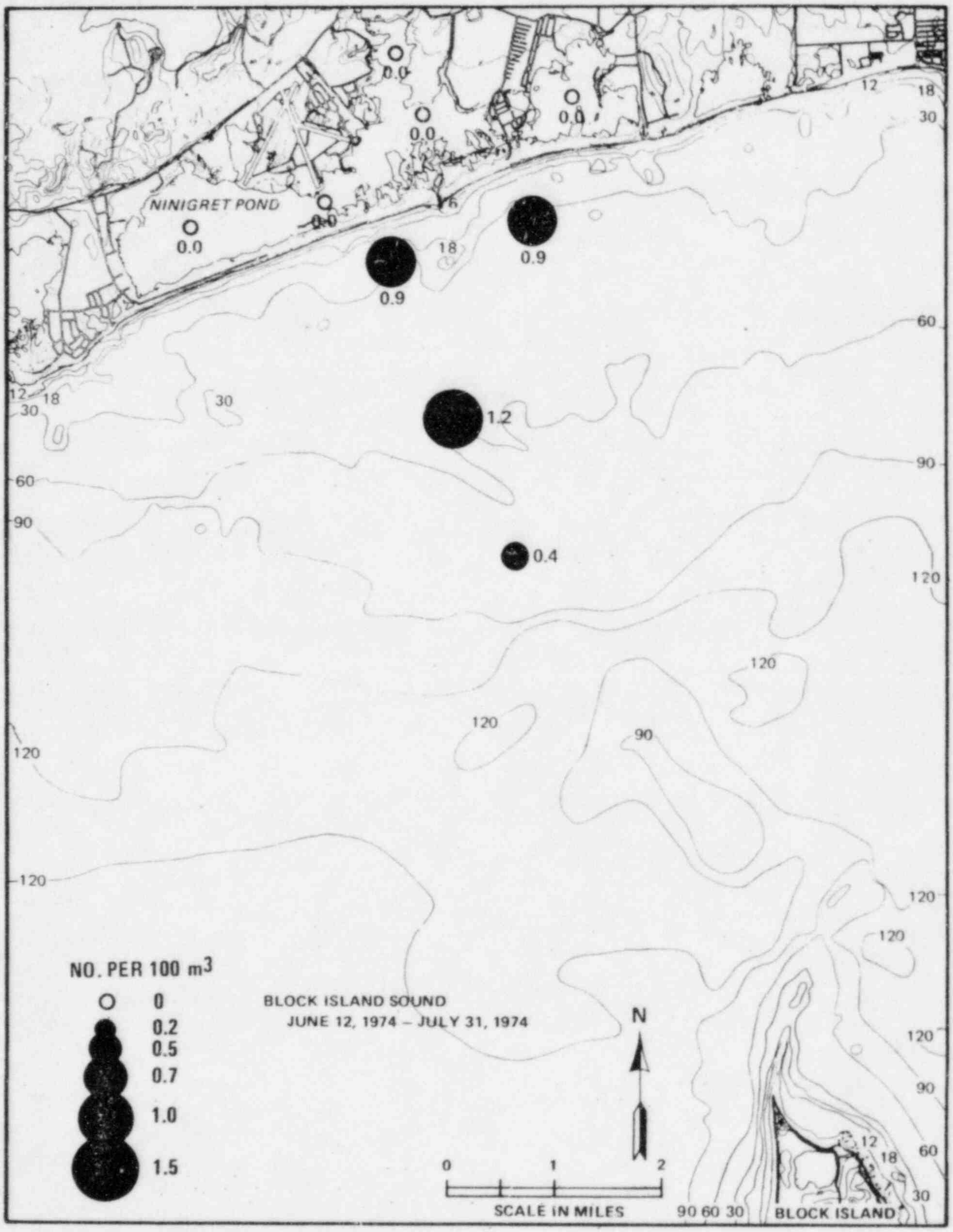


NEW ENGLAND POWER COMPANY
NEP 1&2
Environmental Report

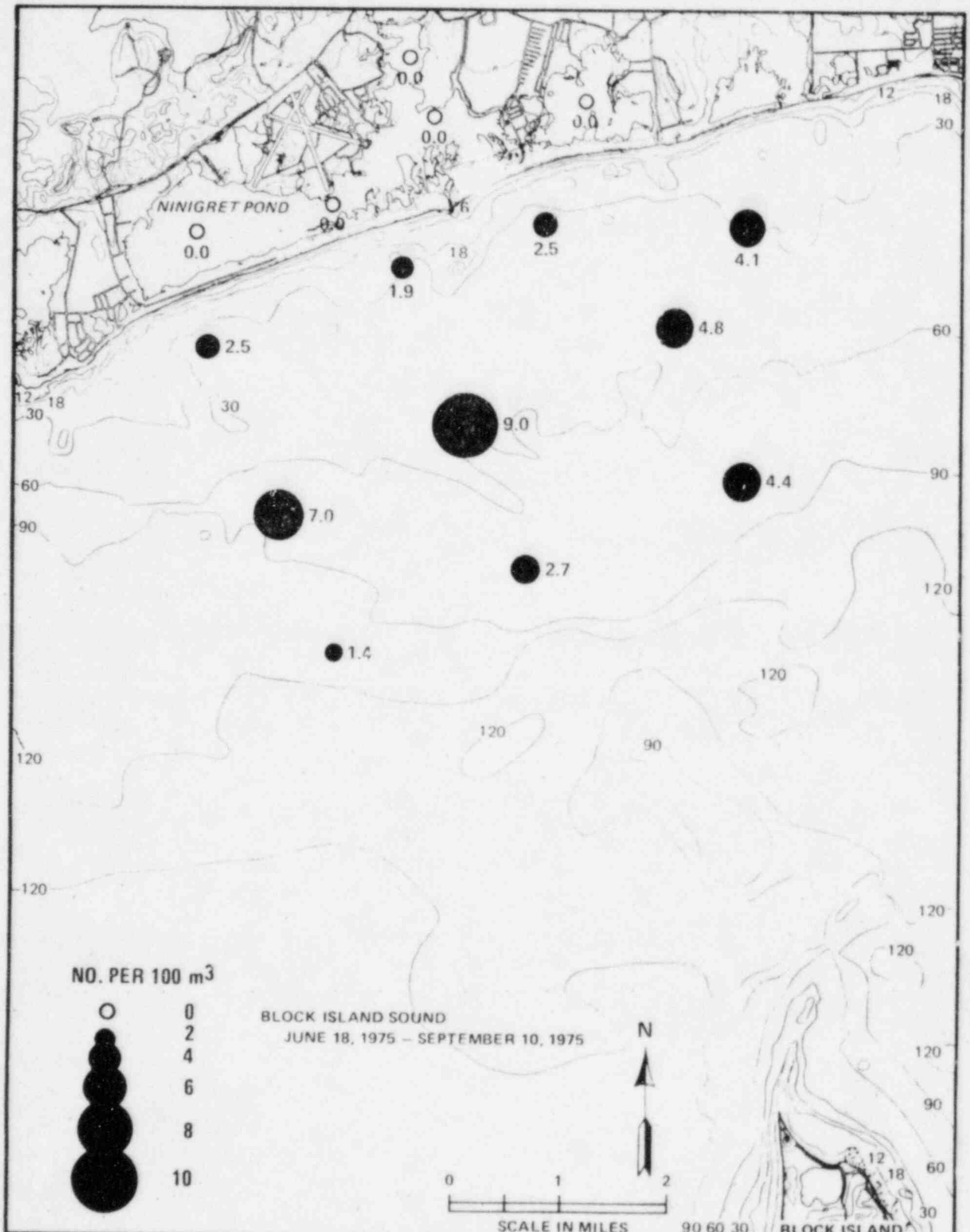
DISTRIBUTION AND AVERAGE DENSITY OF SCUP EGGS

FIGURE G.4.2-22

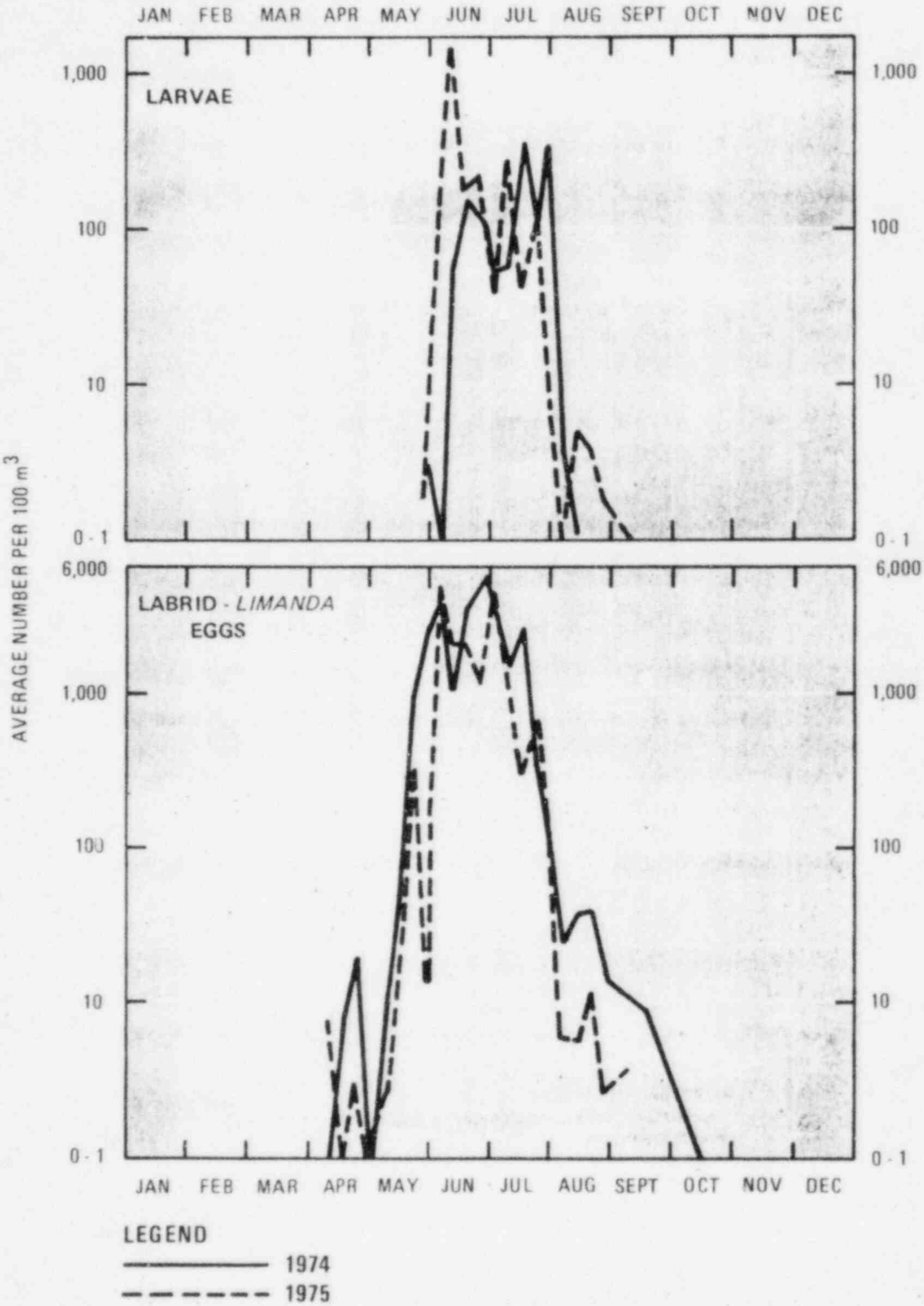
NEP 1&2



NEW ENGLAND POWER COMPANY NEP 1& 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF SCUP LARVAE	
	FIGURE G.4.2-23	NEP 1& 2



NEW ENGLAND POWER COMPANY N E P 1 & 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF SCUP LARVAE	
	FIGURE G.4.2-24	N E P 1 & 2

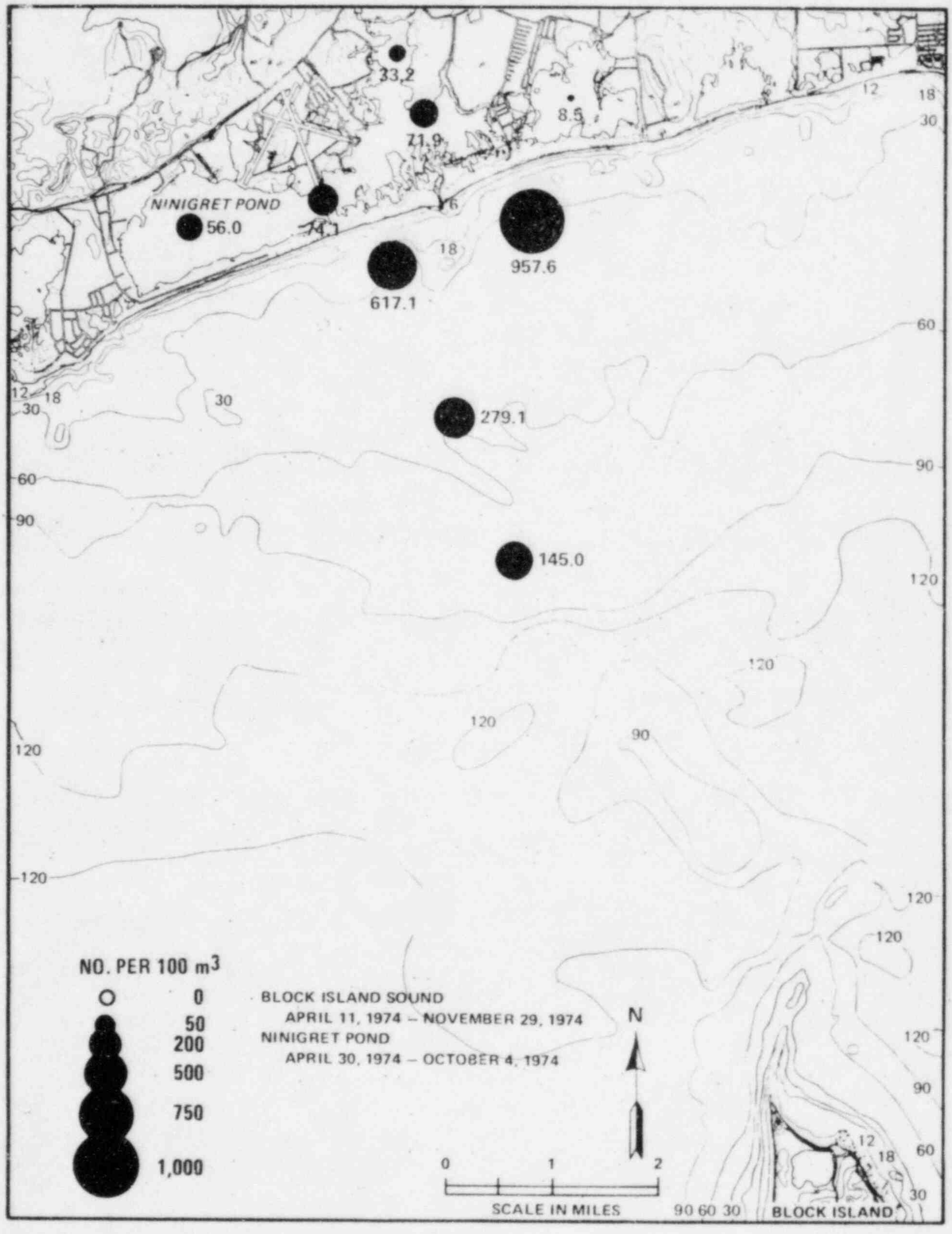


NEW ENGLAND POWER COMPANY
NEP 1&2
Environmental Report

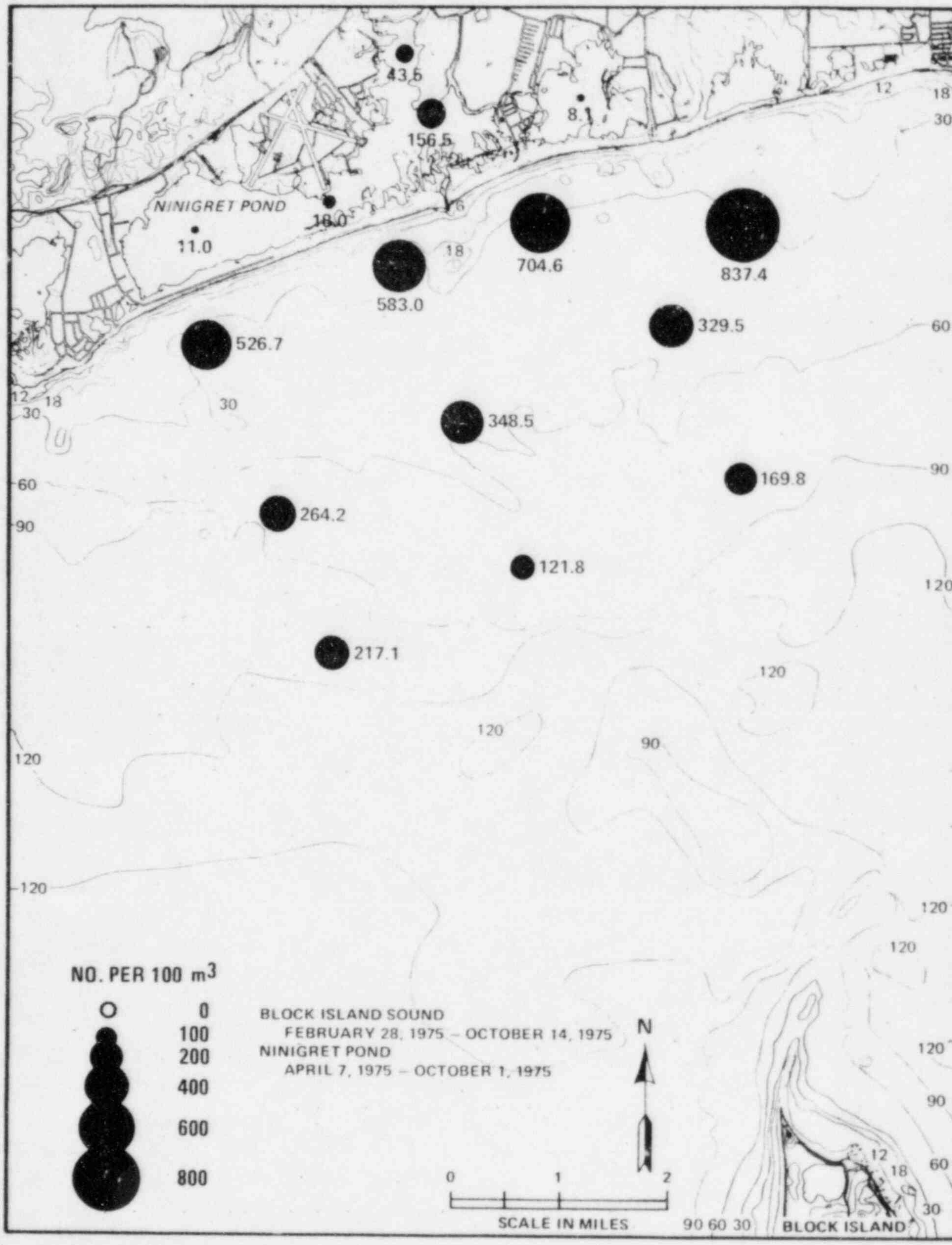
CUNNER
TEMPORAL ABUNDANCE AT
BLOCK ISLAND SOUND STATION A

FIGURE G.4.2-25

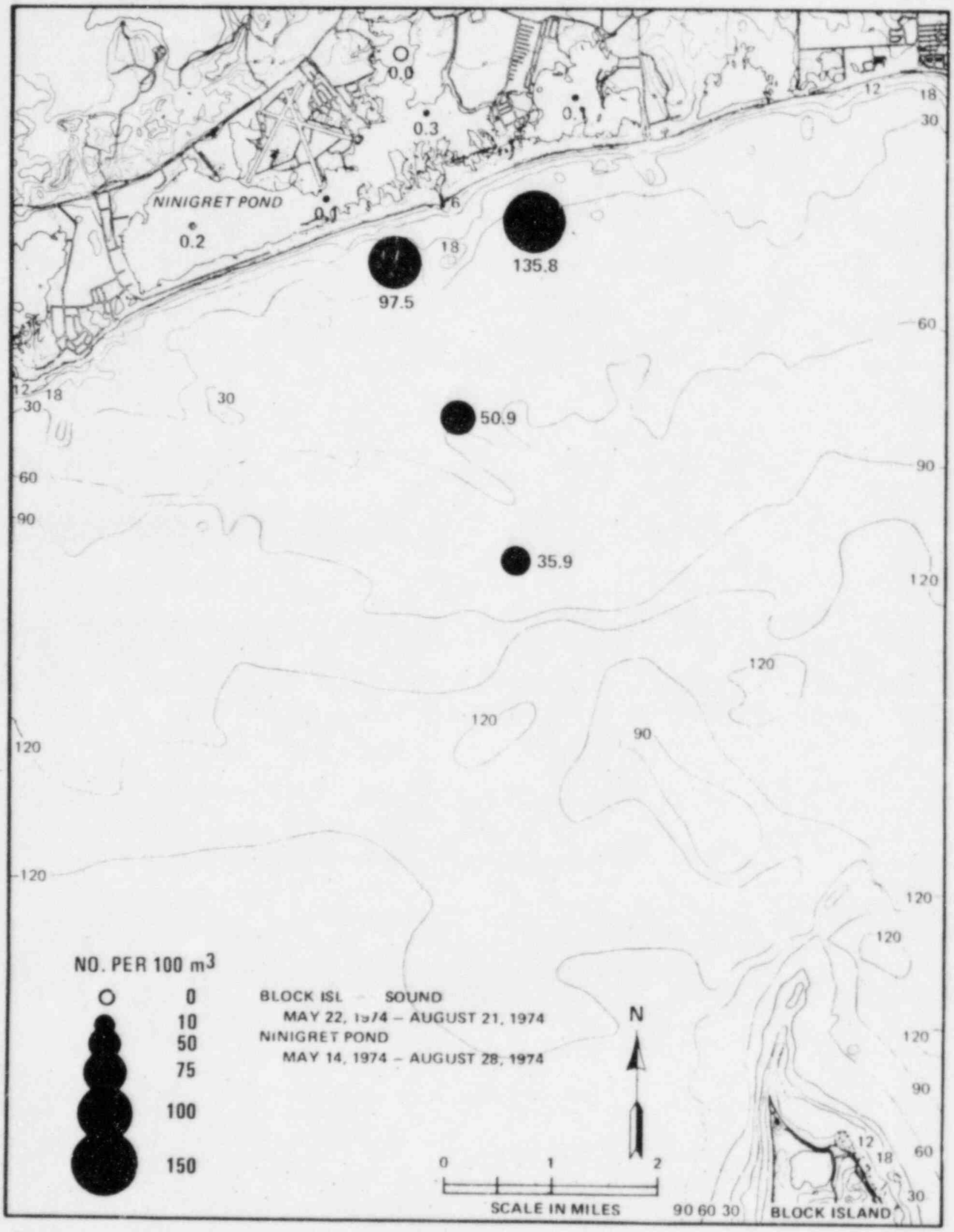
NEP 1&2



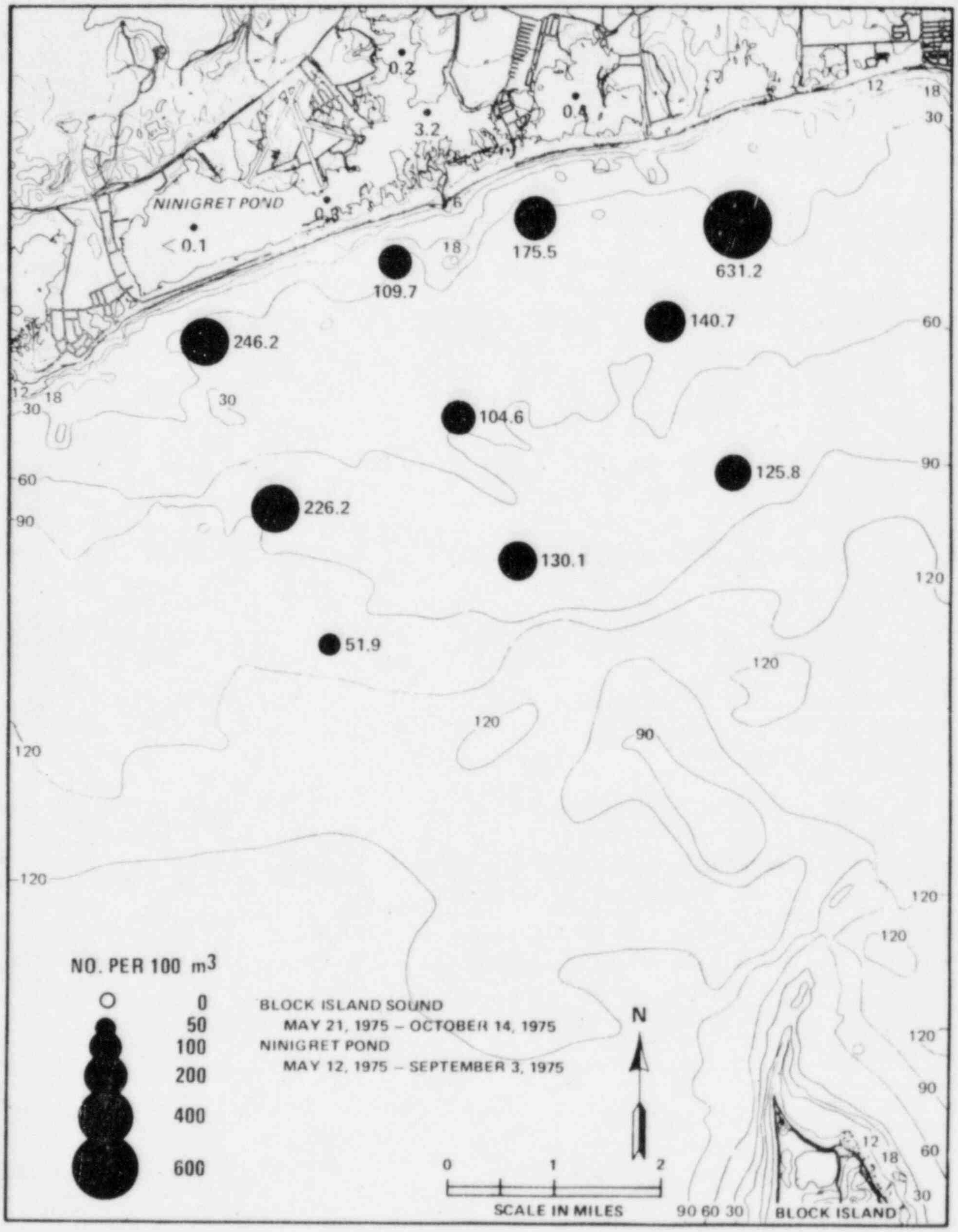
NEW ENGLAND POWER COMPANY N E P 1 & 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF LABRID-*LIMANDA* EGGS	
	FIGURE G.4.2-26	N E P 1 & 2



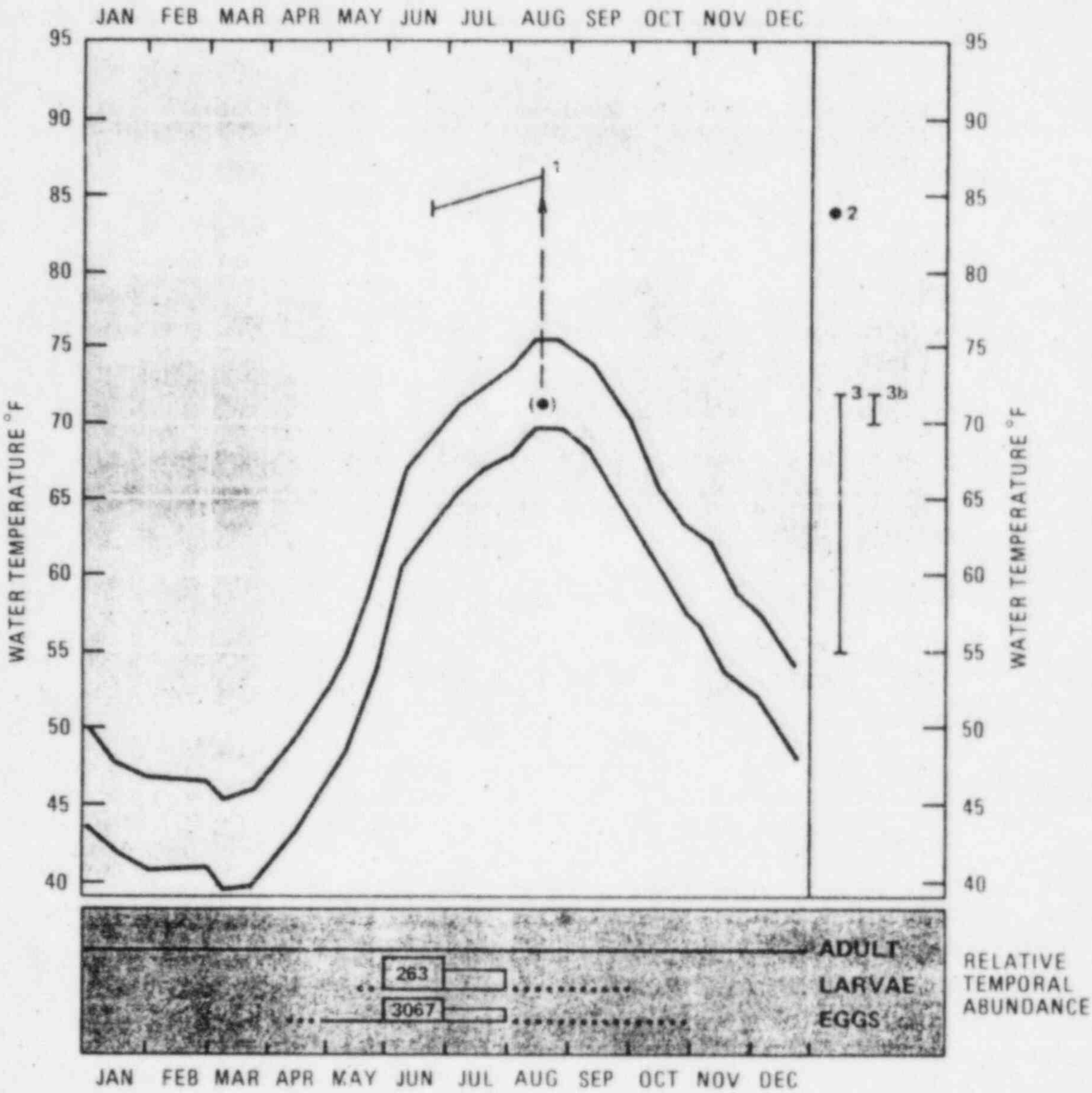
NEW ENGLAND POWER COMPANY NEP 1 & 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF LABRID-*LIMANDA* EGGS	
	FIGURE G.4.2-27	NEP 1 & 2



NEW ENGLAND POWER COMPANY NEP 1& 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF CUNNER LARVAE
	FIGURE G.4.2-28 — NEP 1& 2

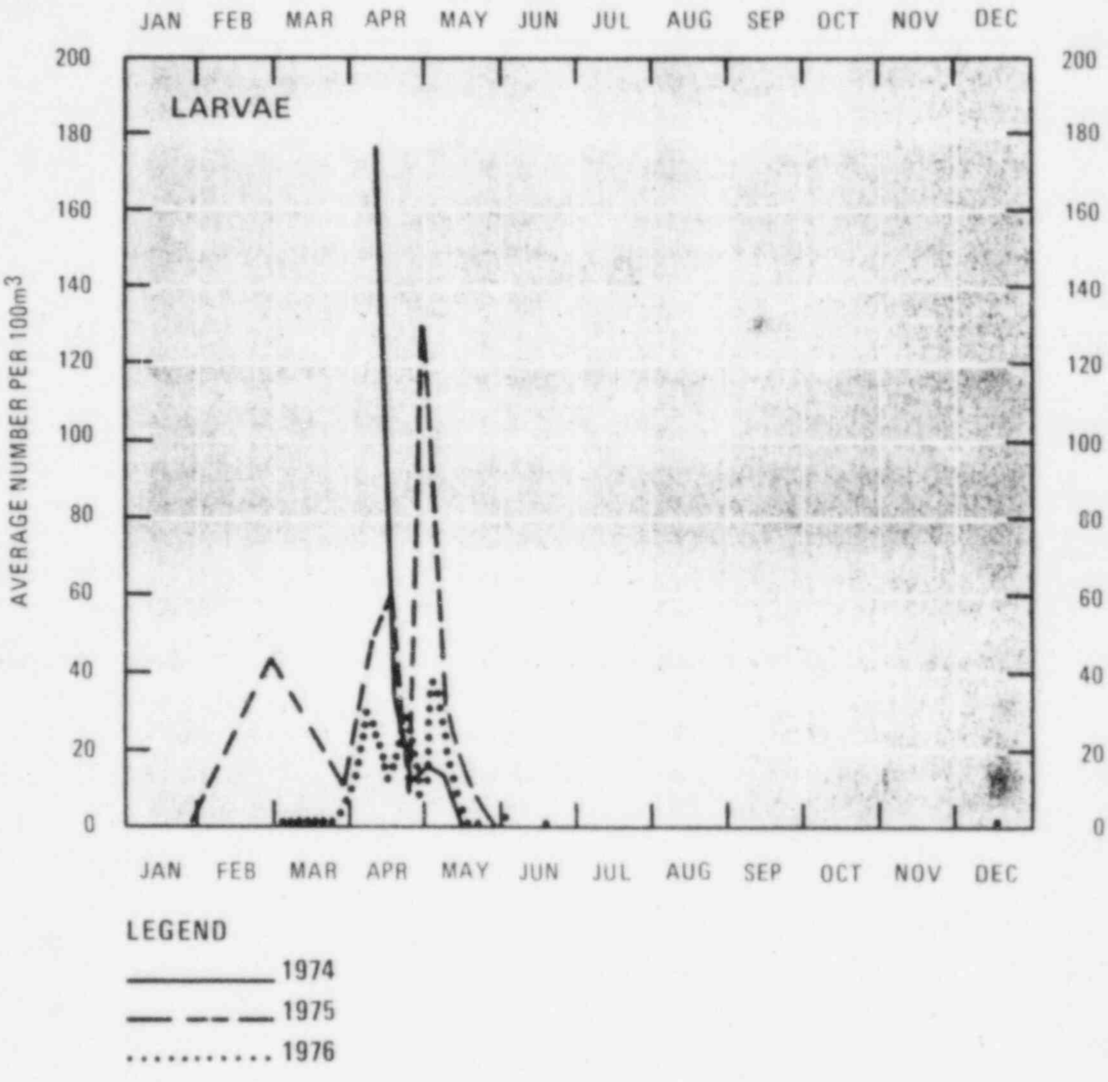


NEW ENGLAND POWER COMPANY N E P 1 & 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF CUNNER LARVAE
	FIGURE G.4.2-29 — N E P 1 & 2

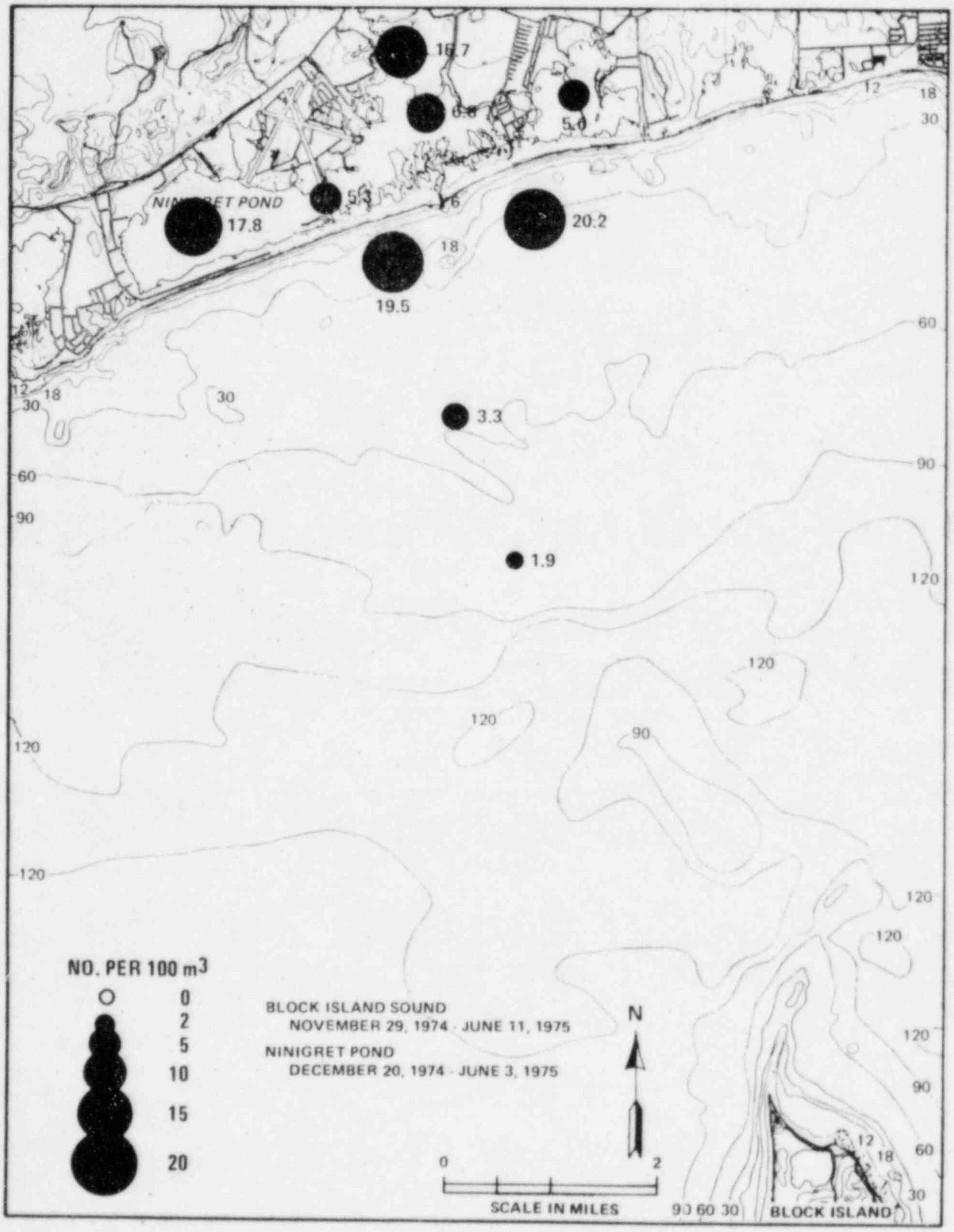


1. UPPER TEMPERATURE LIMITS (HAUGAARD AND IRVING, 1943)
2. UPPER LETHAL TEMPERATURE (de SYLVA, 1969)
3a. SPAWNING RANGE (BIGELOW AND SCHROEDER, 1953)
b. HATCHING TEMPERATURE

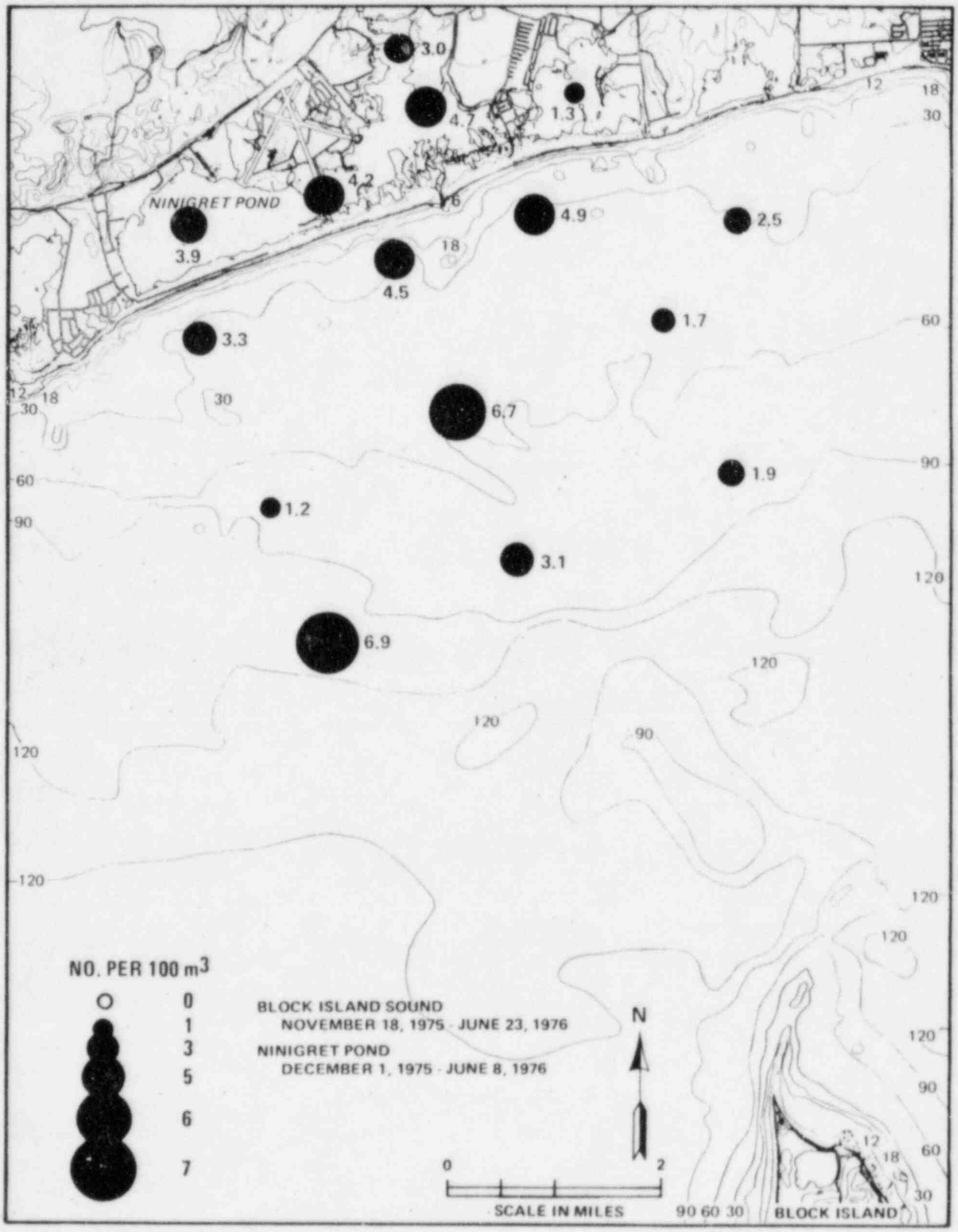
NEW ENGLAND POWER COMPANY NEP 1 & 2 Environmental Report	CUNNER RELATIVE TEMPORAL ABUNDANCE AND THERMAL CHARACTERISTICS
	FIGURE G.4.2-30 — NEP 1 & 2



NEW ENGLAND POWER COMPANY NEP 1 & 2 Environmental Report	SAND LANCE TEMPORAL ABUNDANCE AT BLOCK ISLAND SOUND STATION A	
	FIGURE G.4.2-31	NEP 1 & 2



NEW ENGLAND POWER COMPANY NEP 1& 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF SAND LANCE LARVAE
	FIGURE G.4.2-32 | NEP 1& 2

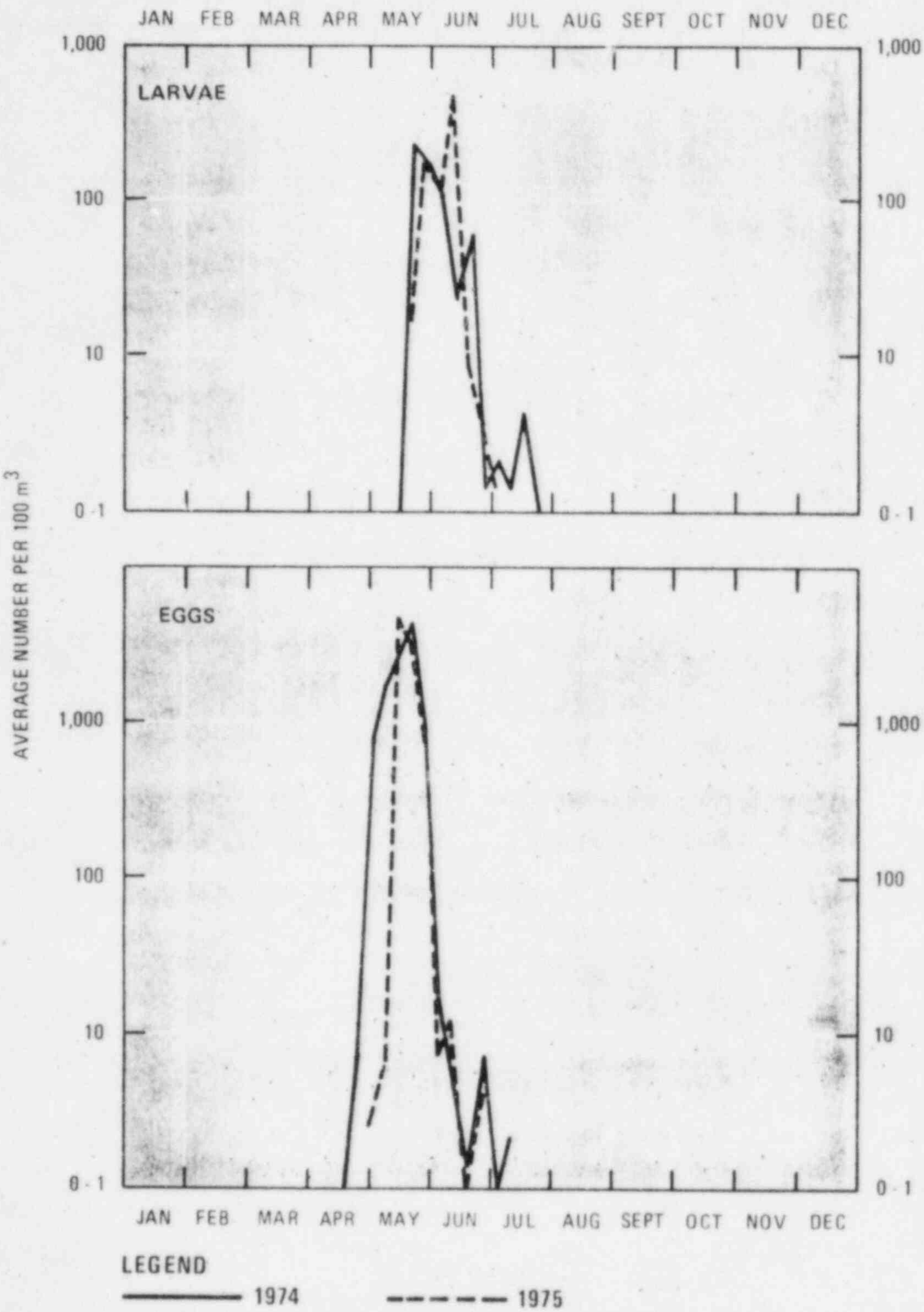


NEW ENGLAND POWER COMPANY
NEP 1& 2
Environmental Report

DISTRIBUTION AND AVERAGE DENSITY OF SAND LANCE LARVAE

FIGURE G.4.2-33

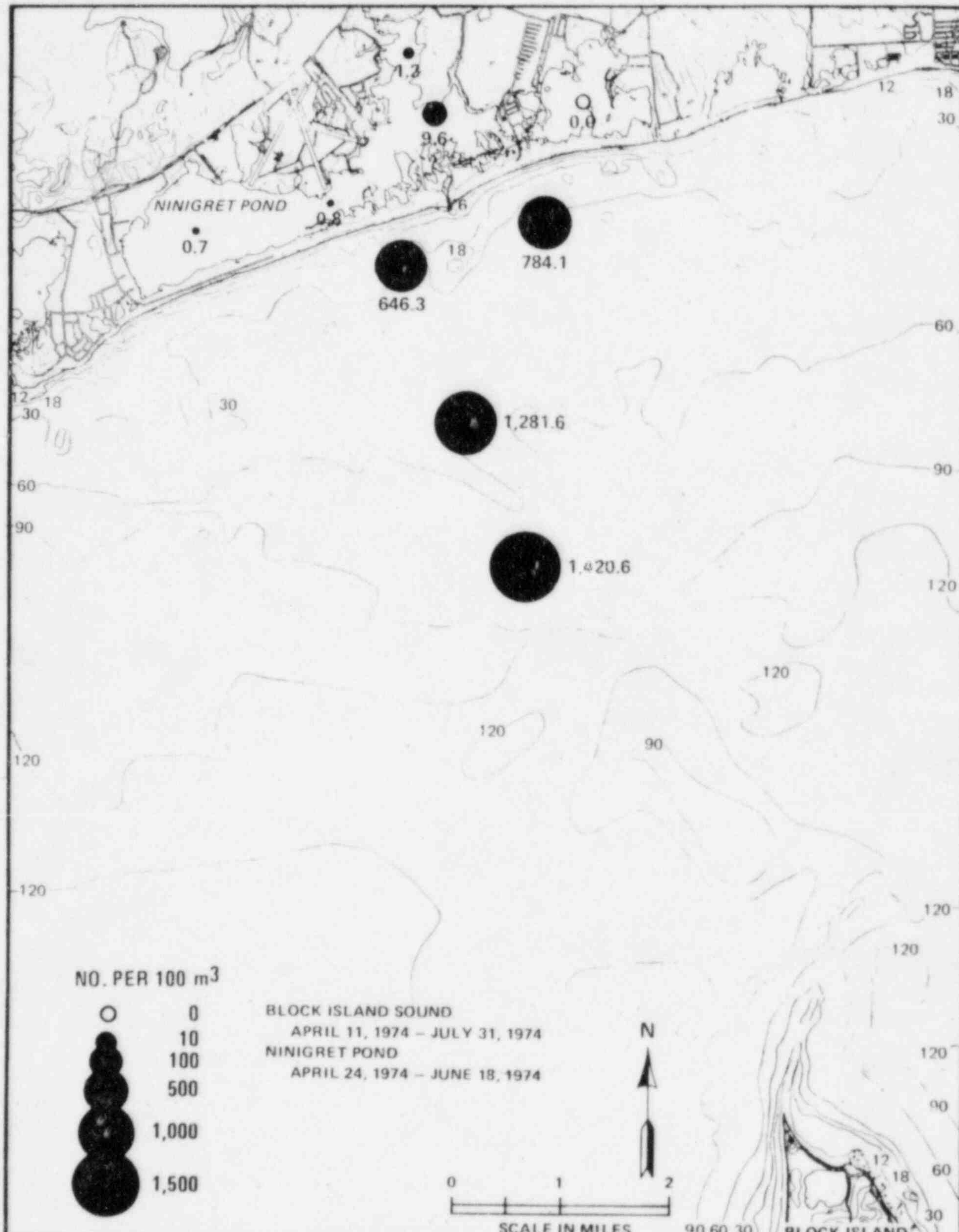
NEP 1& 2



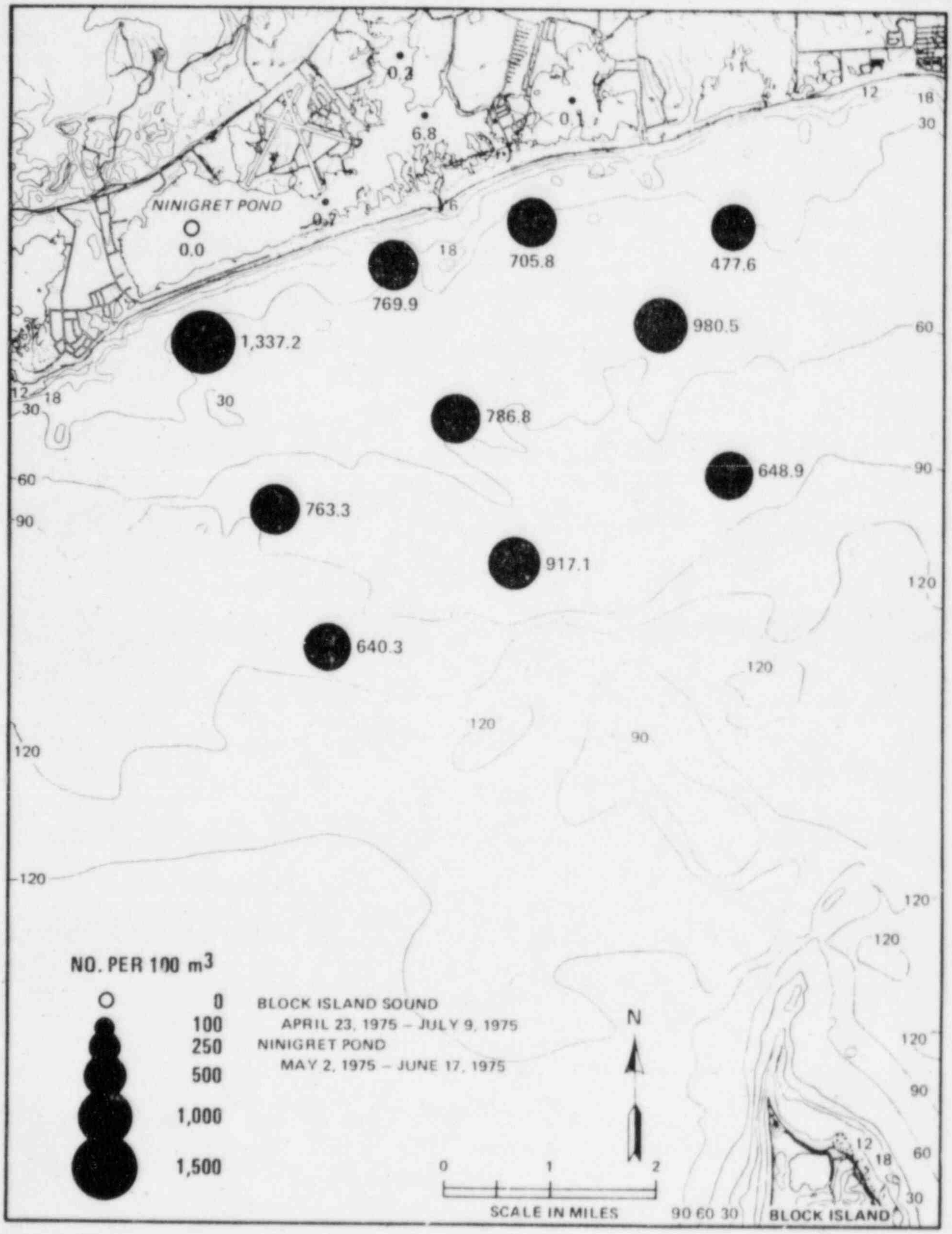
NEW ENGLAND POWER COMPANY
NEP 1 & 2
Environmental Report

ATLANTIC MACKEREL
TEMPORAL ABUNDANCE AT
BLOCK ISLAND SOUND STATION A

FIGURE G.4.2-34



NEW ENGLAND POWER COMPANY NEP 1&2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF ATLANTIC MACKEREL EGGS
	FIGURE G.4.2-35 — NEP 1&2

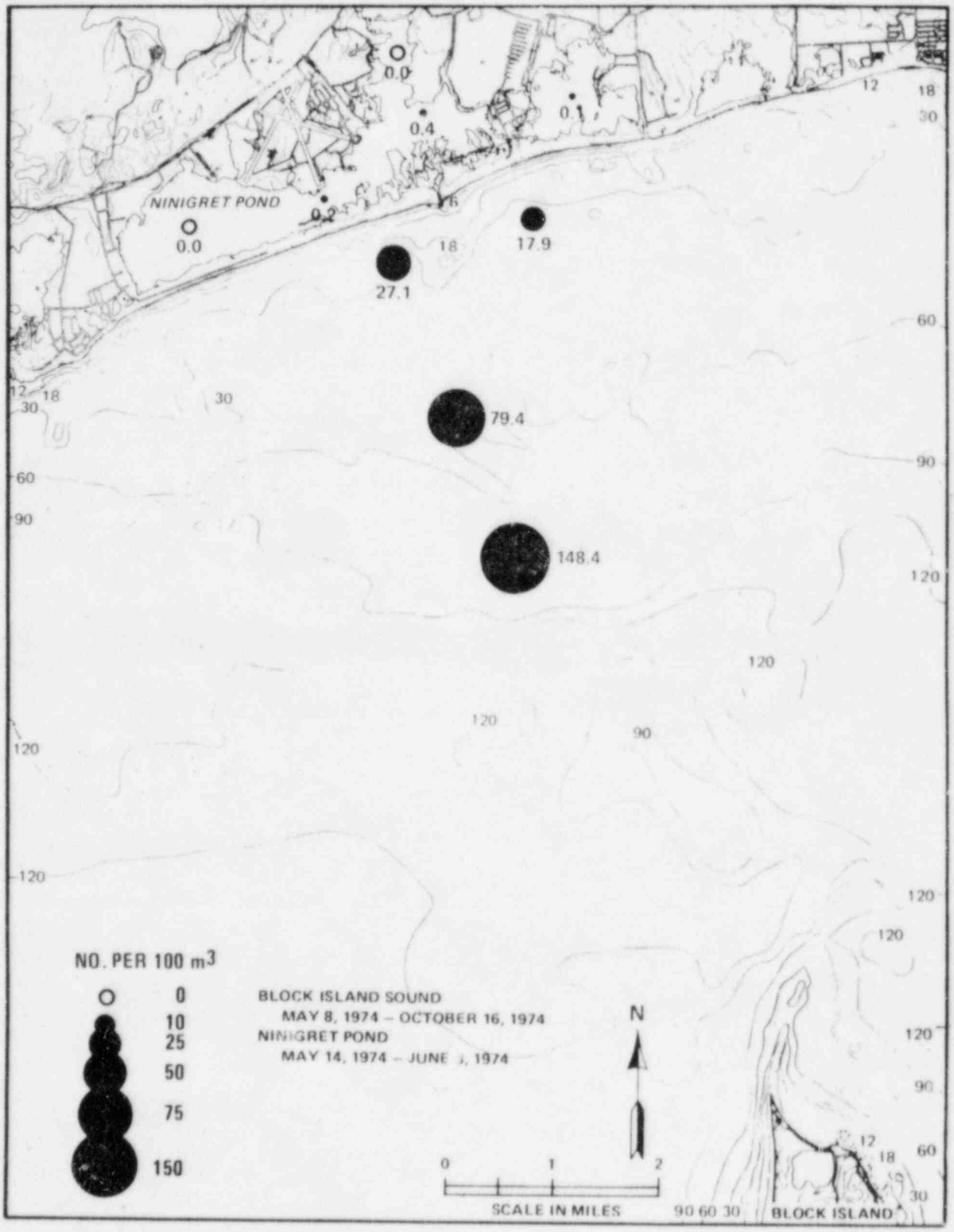


NEW ENGLAND POWER COMPANY
NEP 1& 2
Environmental Report

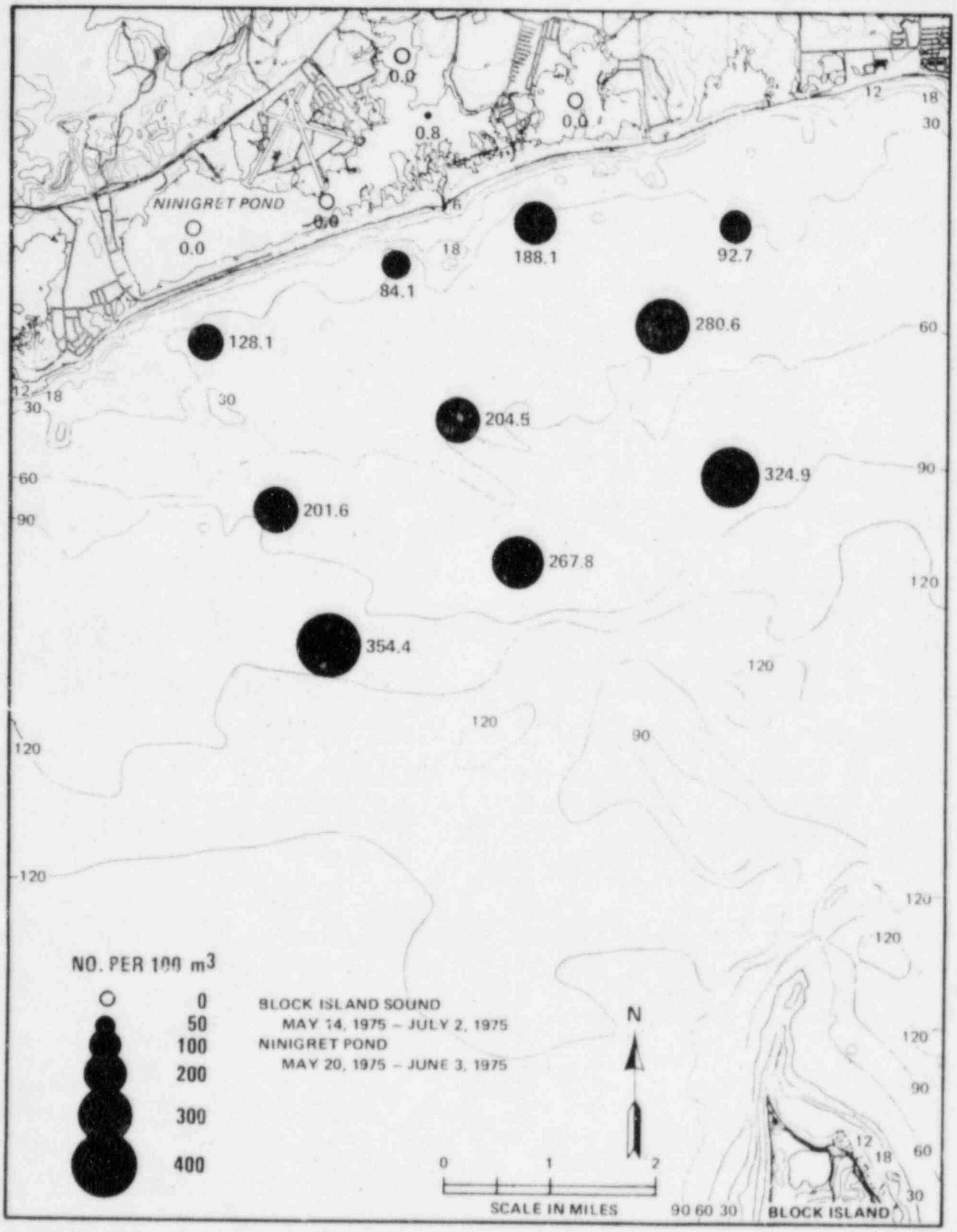
DISTRIBUTION AND AVERAGE DENSITY OF ATLANTIC MACKEREL EGGS

FIGURE G.4.2-36

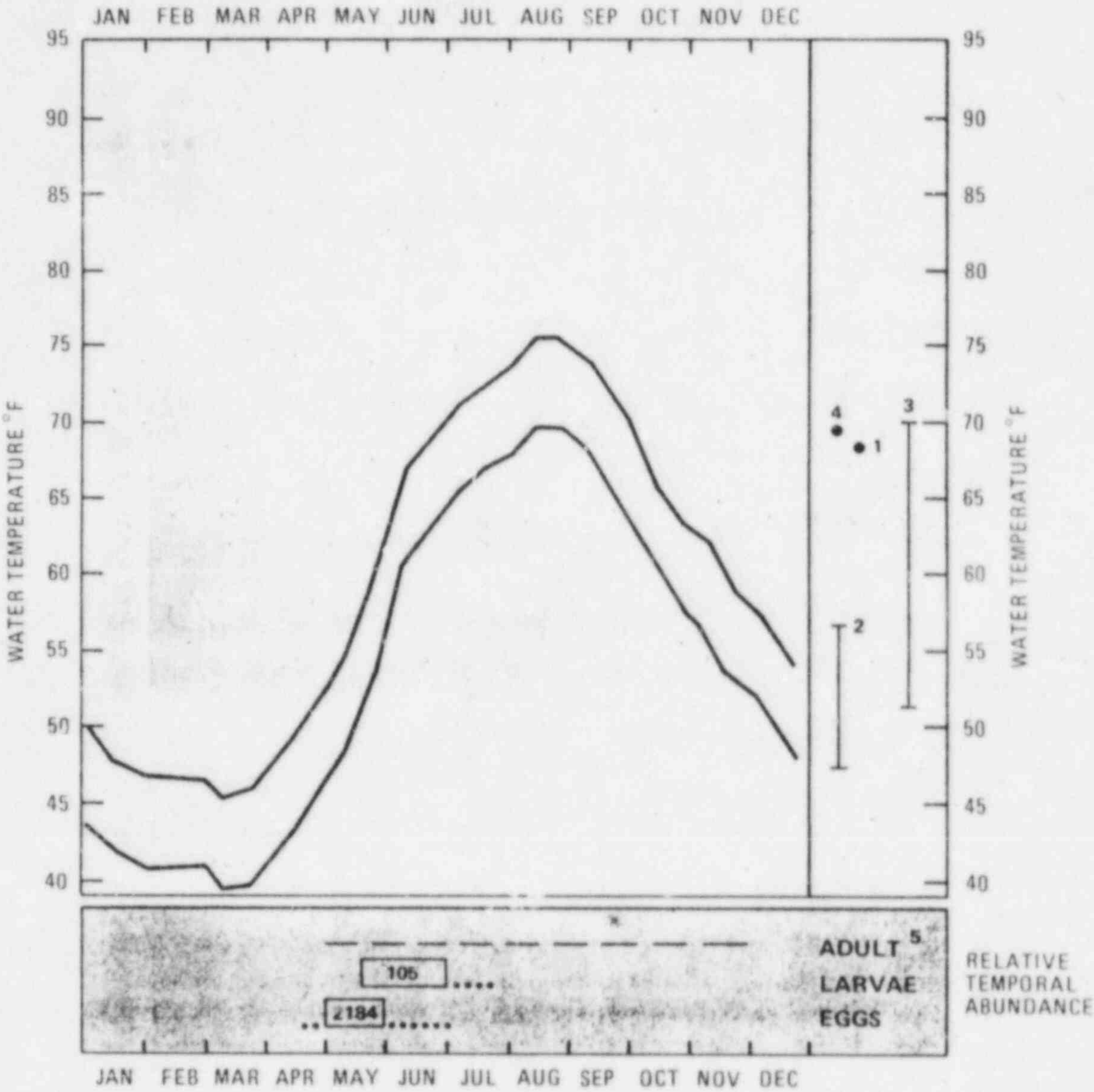
NEP 1& 2



NEW ENGLAND POWER COMPANY NEP 1& 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF ATLANTIC MACKEREL LARVAE	
	FIGURE G.4.2-37	NEP 1& 2



NEW ENGLAND POWER COMPANY NEP 1&2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF ATLANTIC MACKEREL LARVAE	
	FIGURE G.4.2-38	NEP 1&2



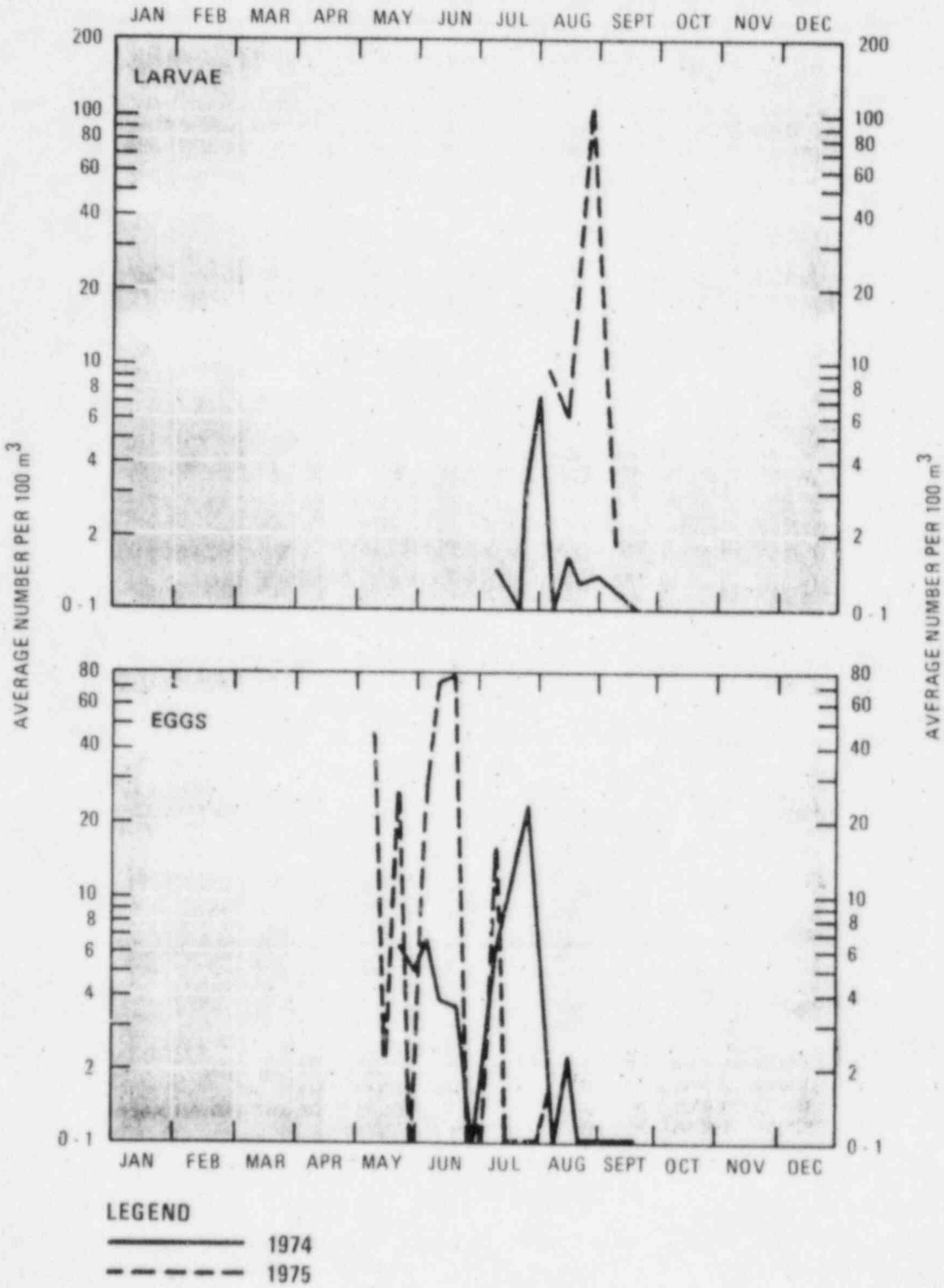
1. HIGHEST TEMPERATURE WHERE FOUND (BIGELOW AND SCHROEDER, 1953)
2. MOST INTENSIVE SPAWNING TEMPERATURE RANGE (SETTE, 1943)
3. NORMAL DEVELOPMENT TEMPERATURE RANGE FOR EGGS (BIGELOW AND SCHROEDER, 1953)
4. UPPER TOLERANCE LIMIT OF EMBRYO (ALTMAN AND DITTMAR, 1966; CITE WORK DONE BY MOORE (1940).
5. TEMPORAL OCCURRENCE OF ADULTS (COASTAL AND OFFSHORE ENVIRONMENTAL INVENTORY, 1973)

NEW ENGLAND POWER COMPANY
NEP 1 & 2
Environmental Report

ATLANTIC MACKEREL
RELATIVE TEMPORAL ABUNDANCE AND THERMAL CHARACTERISTICS

FIGURE G.4.2-39

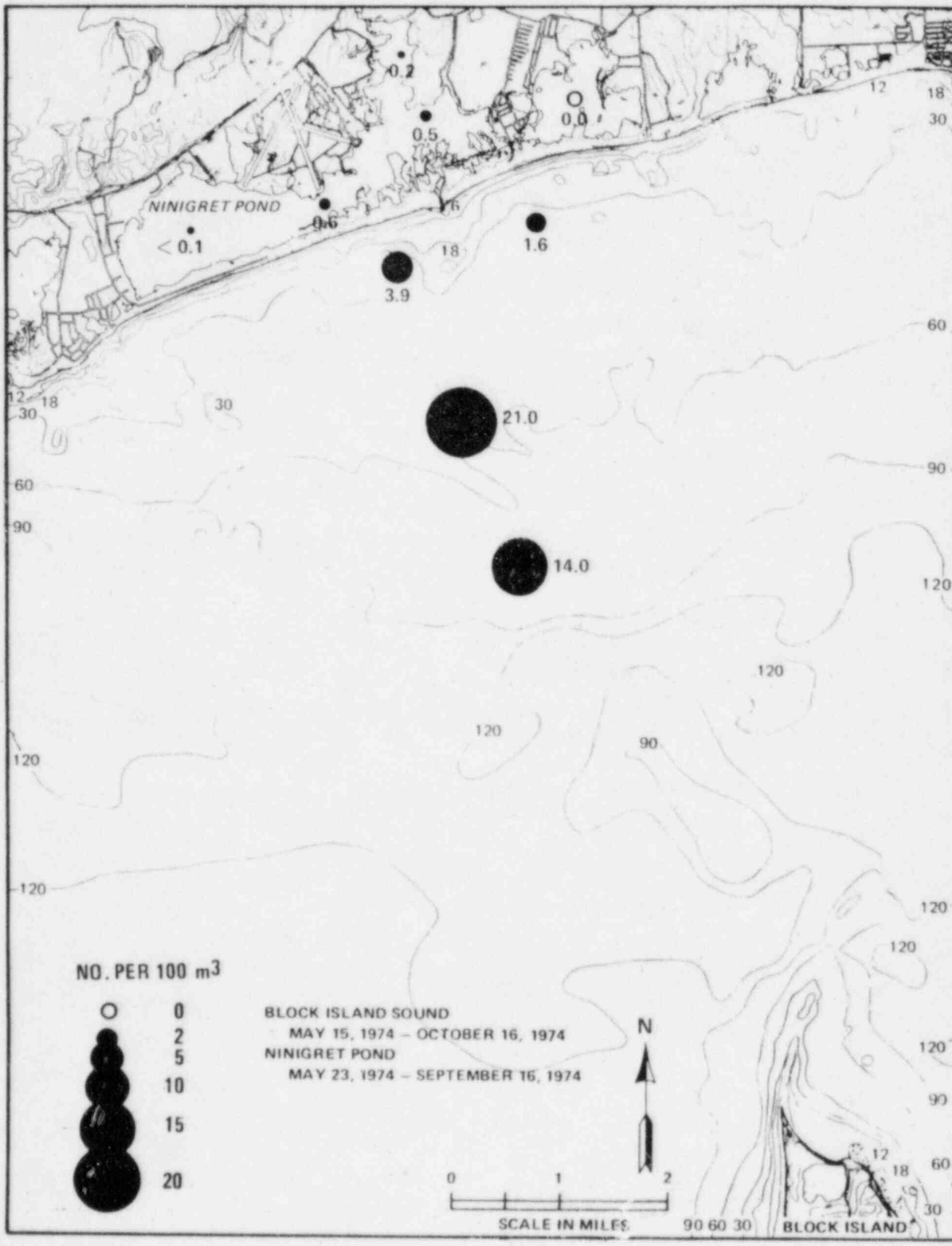
NEP 1 & 2



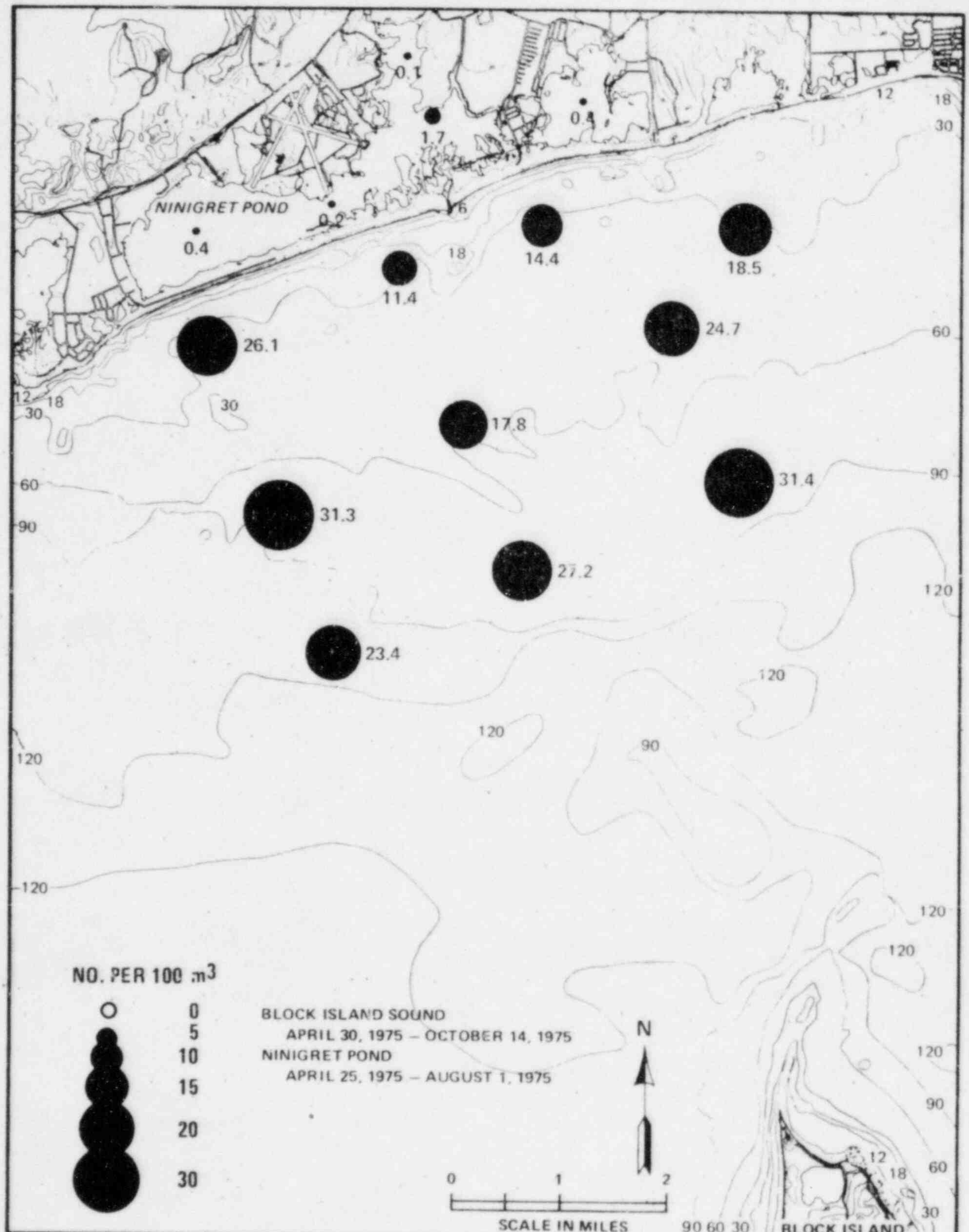
NEW ENGLAND POWER COMPANY
N E P 1 & 2
Environmental Report

BUTTERFISH
TEMPORAL ABUNDANCE AT
BLOCK ISLAND SOUND STATION A

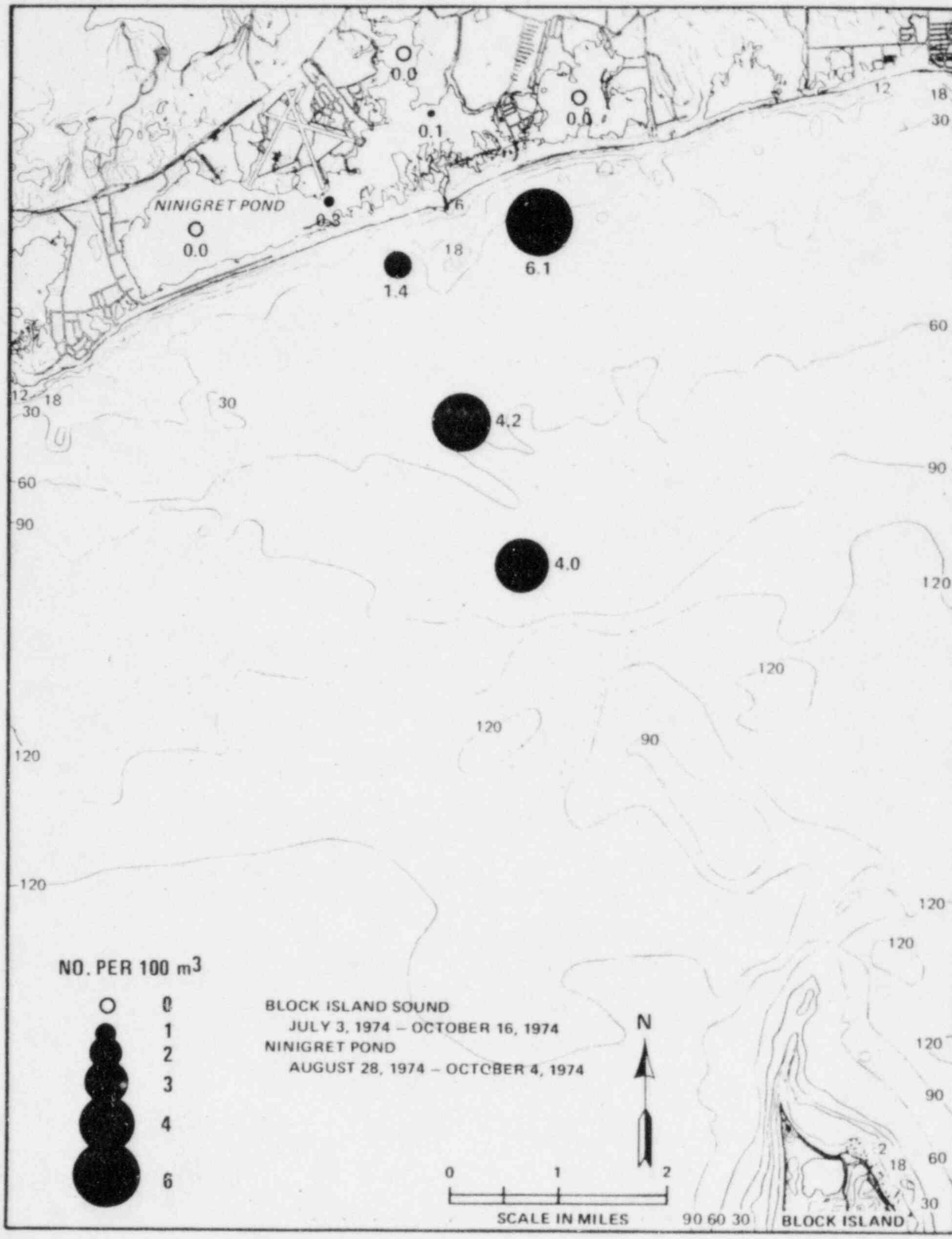
FIGURE G.4.2-40



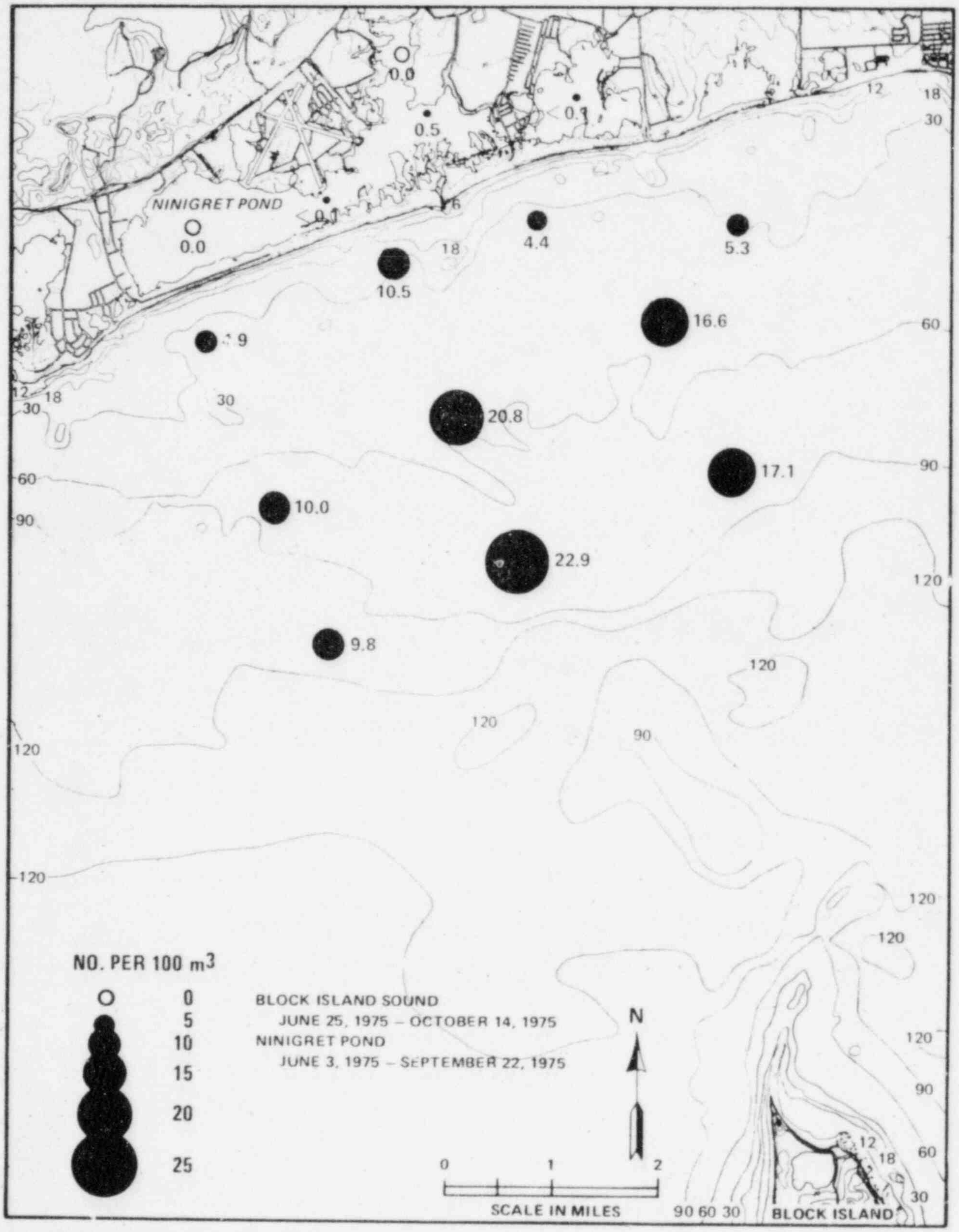
NEW ENGLAND POWER COMPANY NEP 1 & 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF BUTTERFISH EGGS	
	FIGURE G.4.2-41	NEP 1 & 2



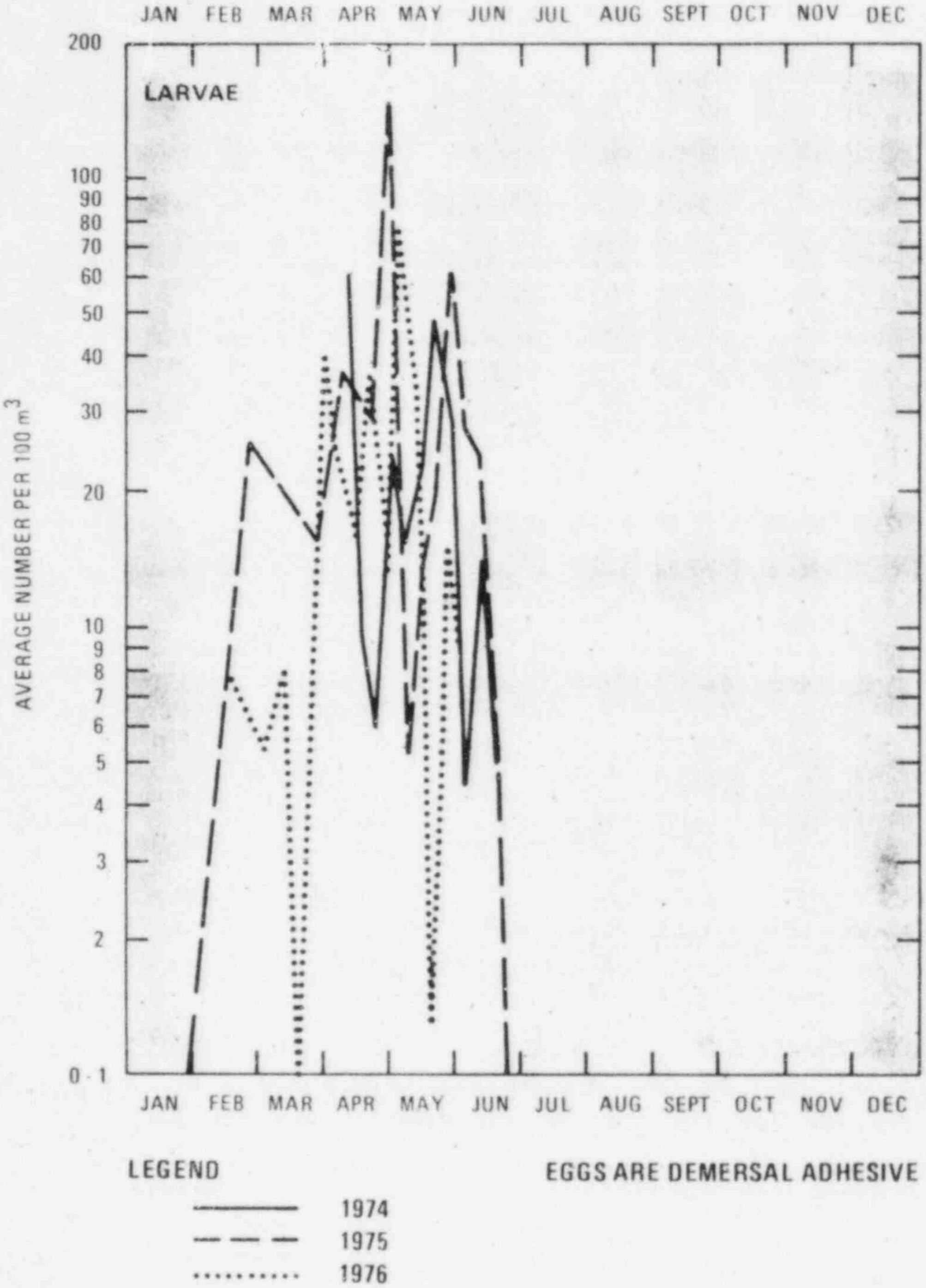
NEW ENGLAND POWER COMPANY NEP 1 & 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF BUTTERFISH EGGS	
	FIGURE G.4.2-42	NEP 1 & 2



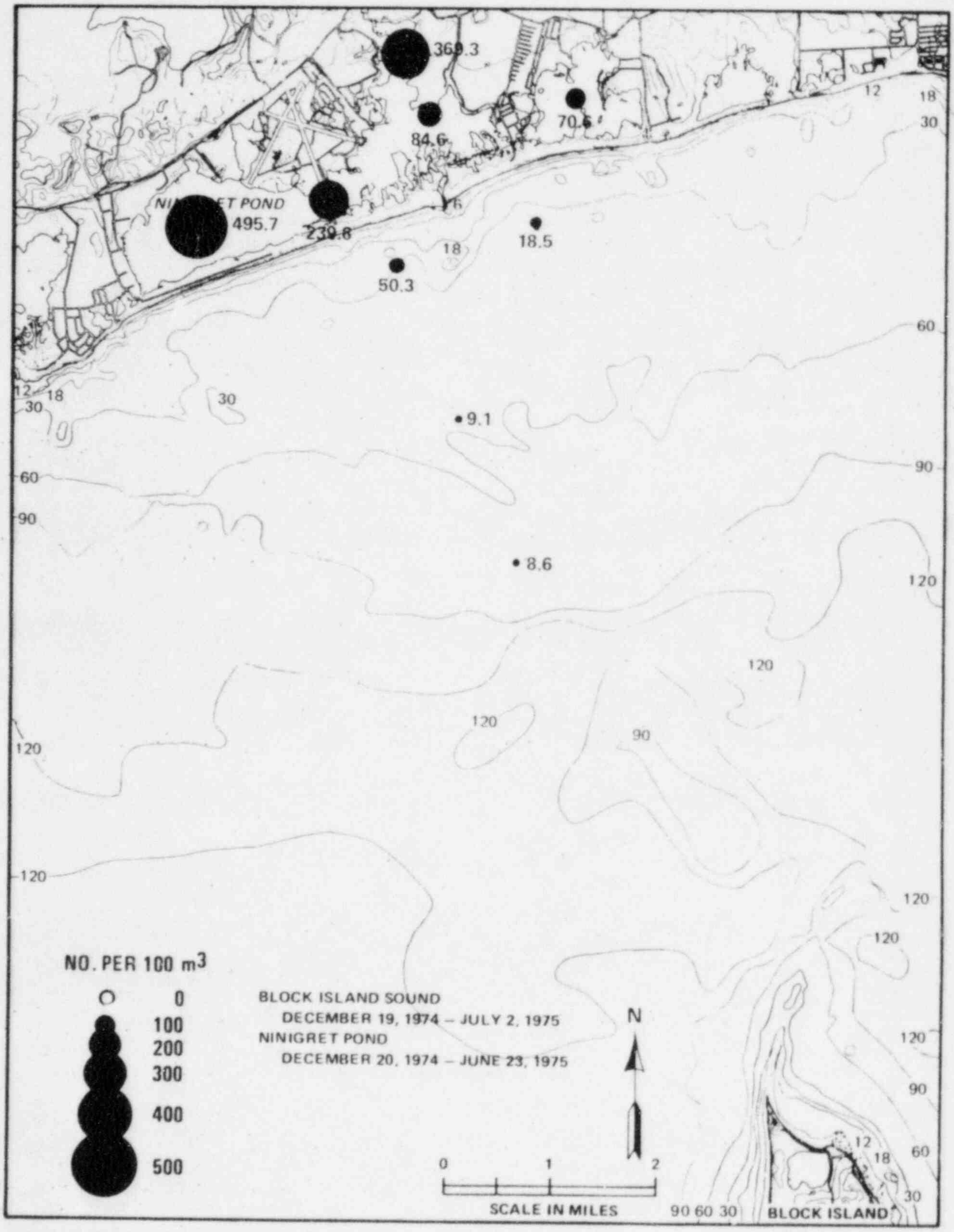
NEW ENGLAND POWER COMPANY NEP 1& 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF BUTTERFISH LARVAE
	FIGURE G.4.2-43 — NEP 1& 2



NEW ENGLAND POWER COMPANY NEP 1& 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF BUTTERFISH LARVAE	
	FIGURE G.4.2-44	NEP 1& 2



NEW ENGLAND POWER COMPANY NEP 1& 2 Environmental Report	WINTER FLOUNDER TEMPORAL ABUNDANCE AT BLOCK ISLAND SOUND STATION A	
	FIGURE G.4.2-45	NEP 1& 2

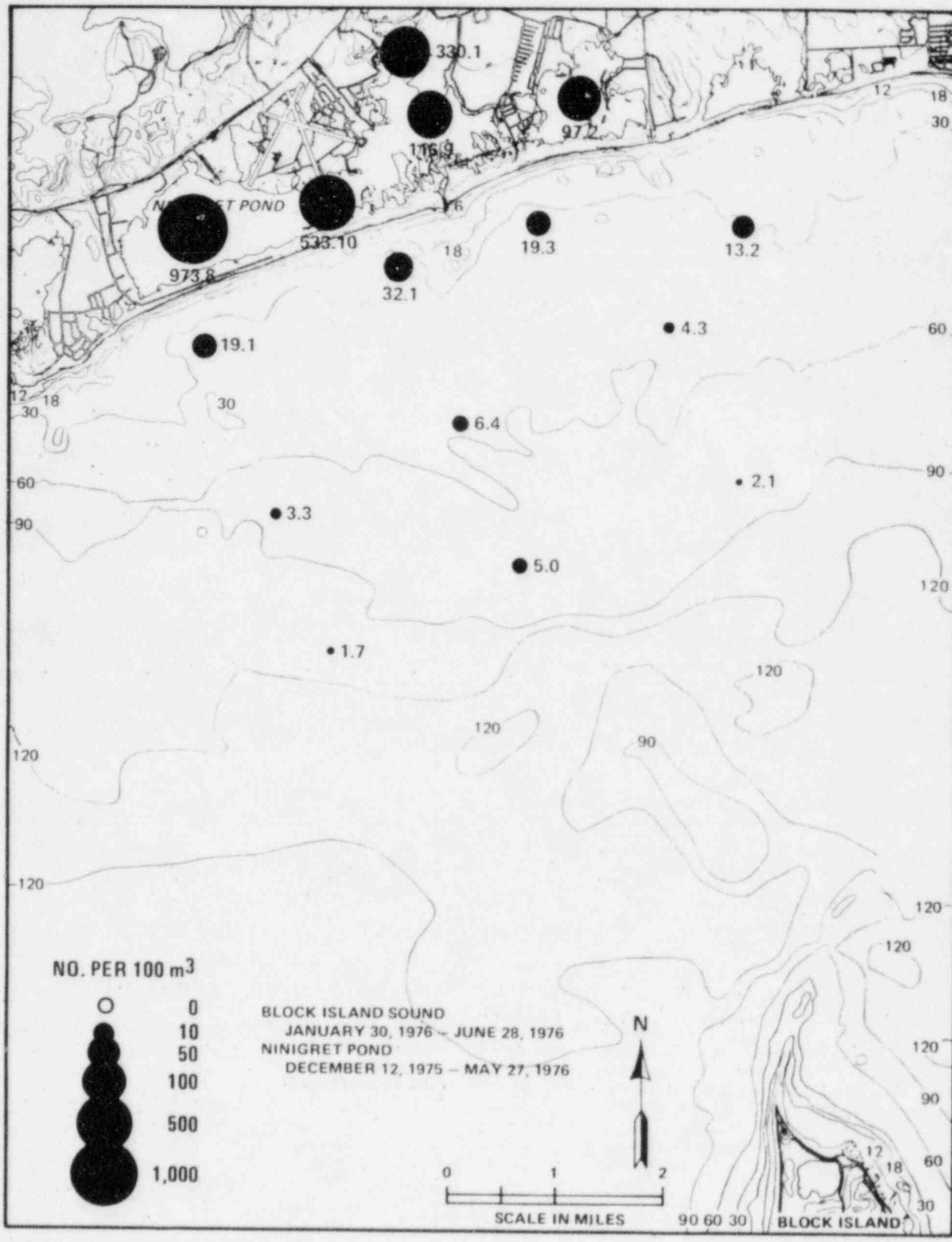


NEW ENGLAND POWER COMPANY
NEP 1& 2
Environmental Report

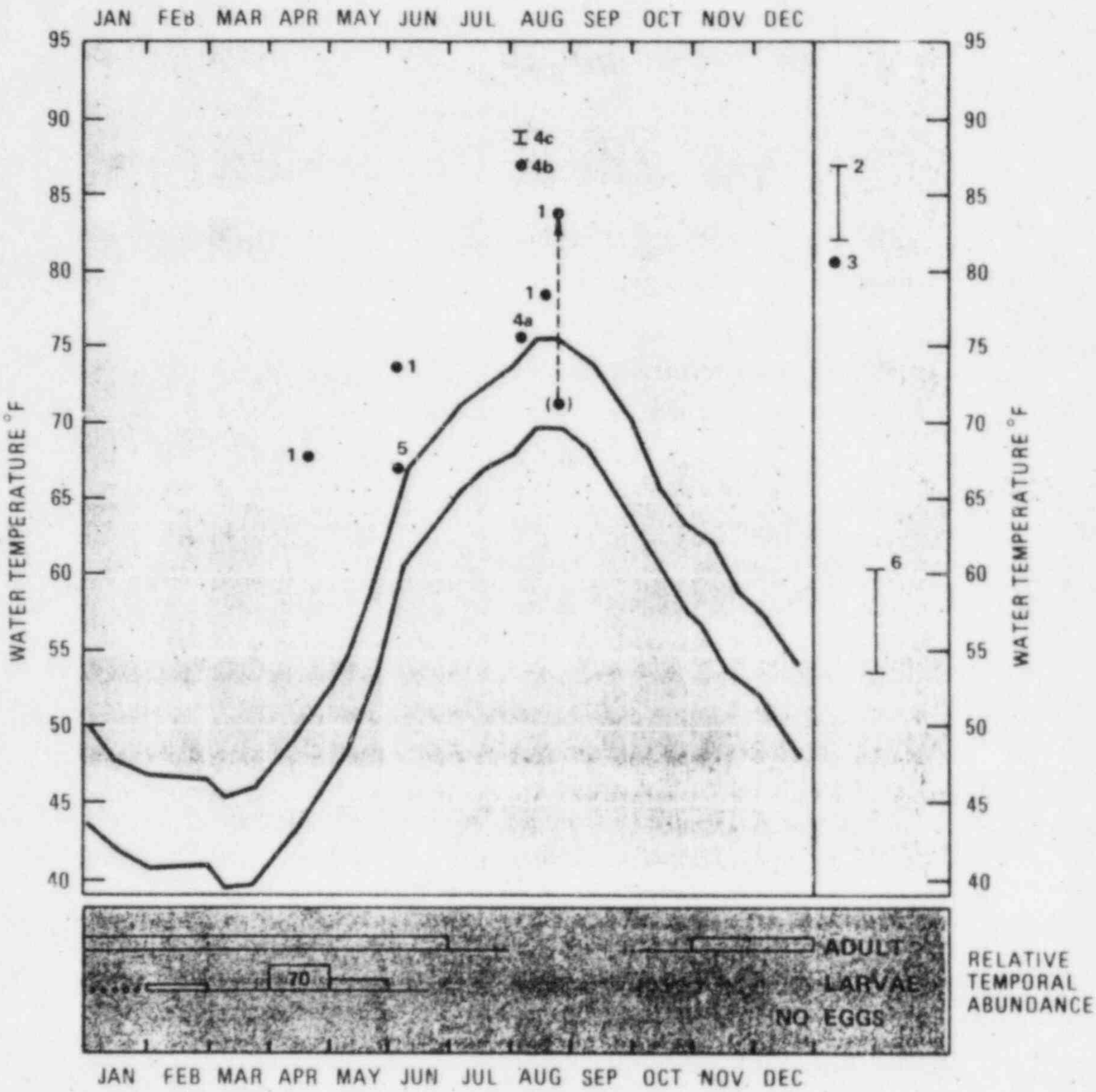
DISTRIBUTION AND AVERAGE DENSITY OF WINTER FLOUNDER LARVAE

FIGURE G.4.2-46

NEP 1& 2

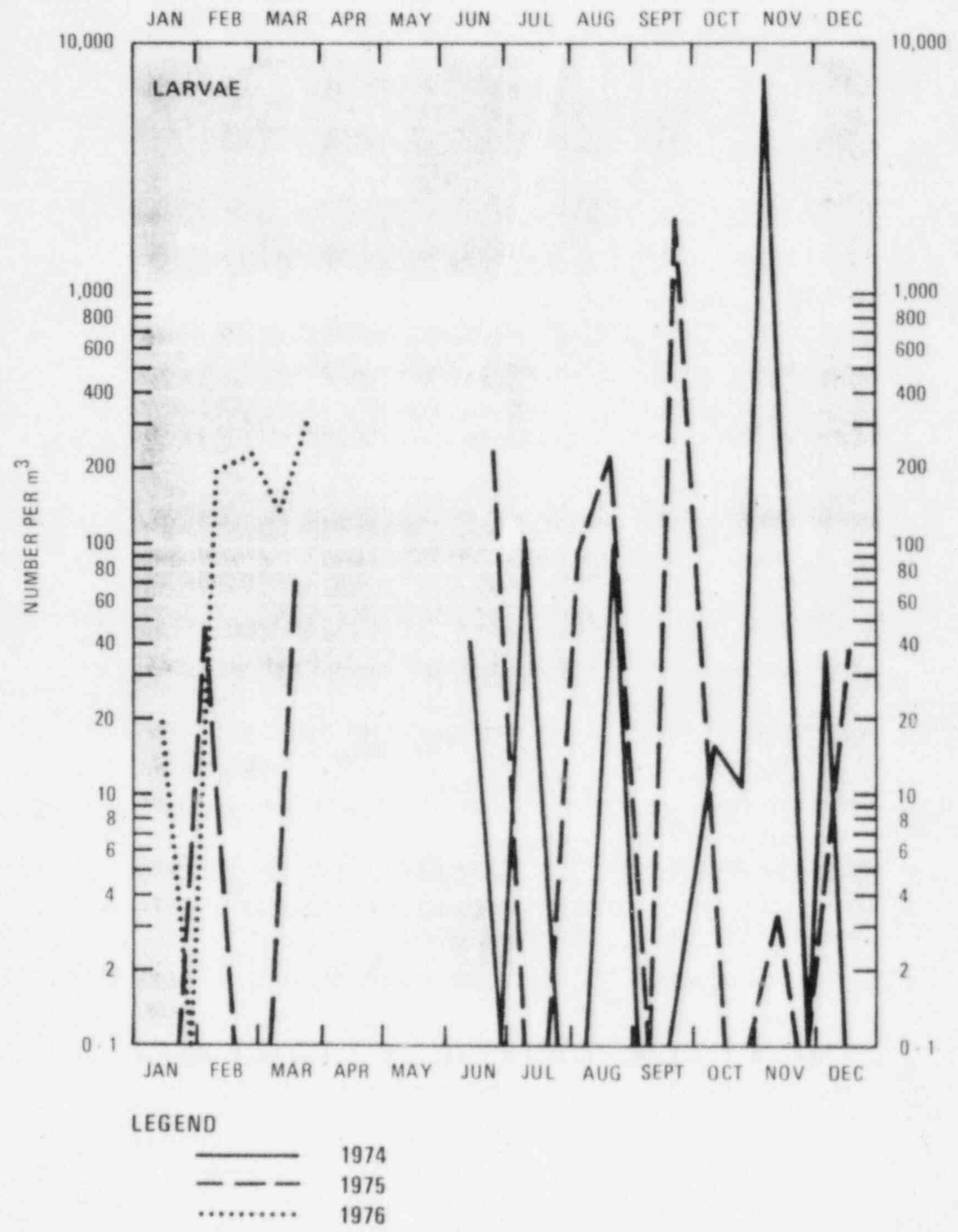


NEW ENGLAND POWER COMPANY NEP 1&2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF WINTER FLOUNDER LARVAE	
	FIGURE G.4.2-47	NEP 1&2



1. NO MORTALITY OF JUVENILES REPORTED FOR 1-HOUR TEST (HOFF AND WESTMAN, 1966)
2. INCIPIENT LETHAL TEMPERATURE RANGE FOR ADULT (HUNTSMAN AND SPARKS, 1924)
3. DISCRETE INCIPIENT LETHAL TEMPERATURE (McCRAKEN, 1963)
4a. TEMPERATURE AVOIDANCE RESPONSE INITIATED (GIFT AND WESTMAN, 1971)
b. AVOIDANCE BREAKDOWN BEHAVIOUR (SEE TEXT)
c. UPPER THERMAL TOLERANCE LIMIT (SEE TEXT)
5. PREFERENCE TEMPERATURE (MELDRIM AND GIFT, 1971)
6. GROWTH TEMPERATURE RANGE FOR 1-YEAR OLDS (FRAME, 1973)

NEW ENGLAND POWER COMPANY NEP 1&2 Environmental Report	WINTER FLOUNDER RELATIVE TEMPORAL ABUNDANCE AND THERMAL CHARACTERISTICS
FIGURE G.4.2-48	NEP 1&2

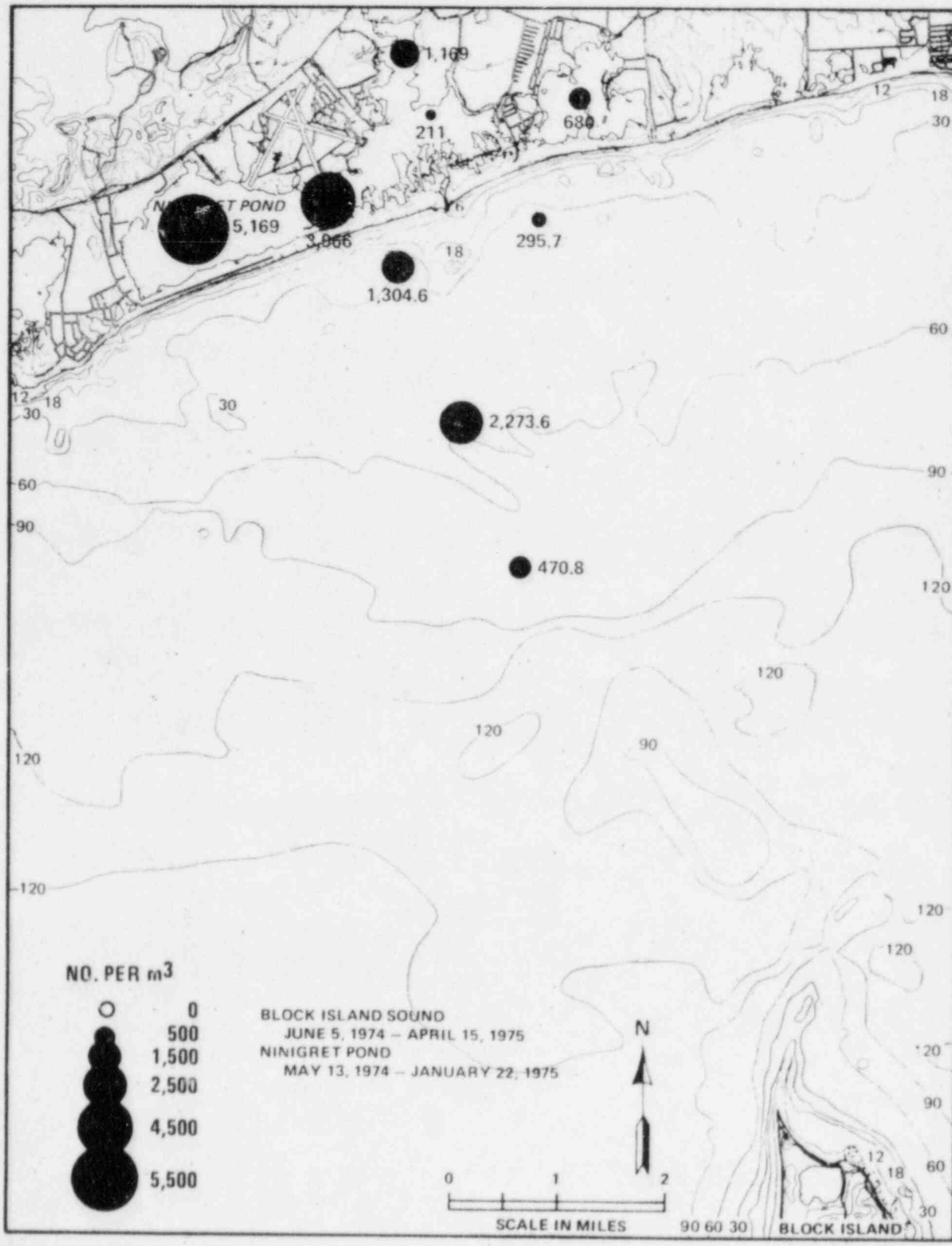


NEW ENGLAND POWER COMPANY
N E P 1 & 2
Environmental Report

BLUE M' SSEL
TEMPO' AL ABUNDANCE AT
BLOCK ISLAND SOUND STATION A

FIGURE G.4.2-49

N E P 1 & 2

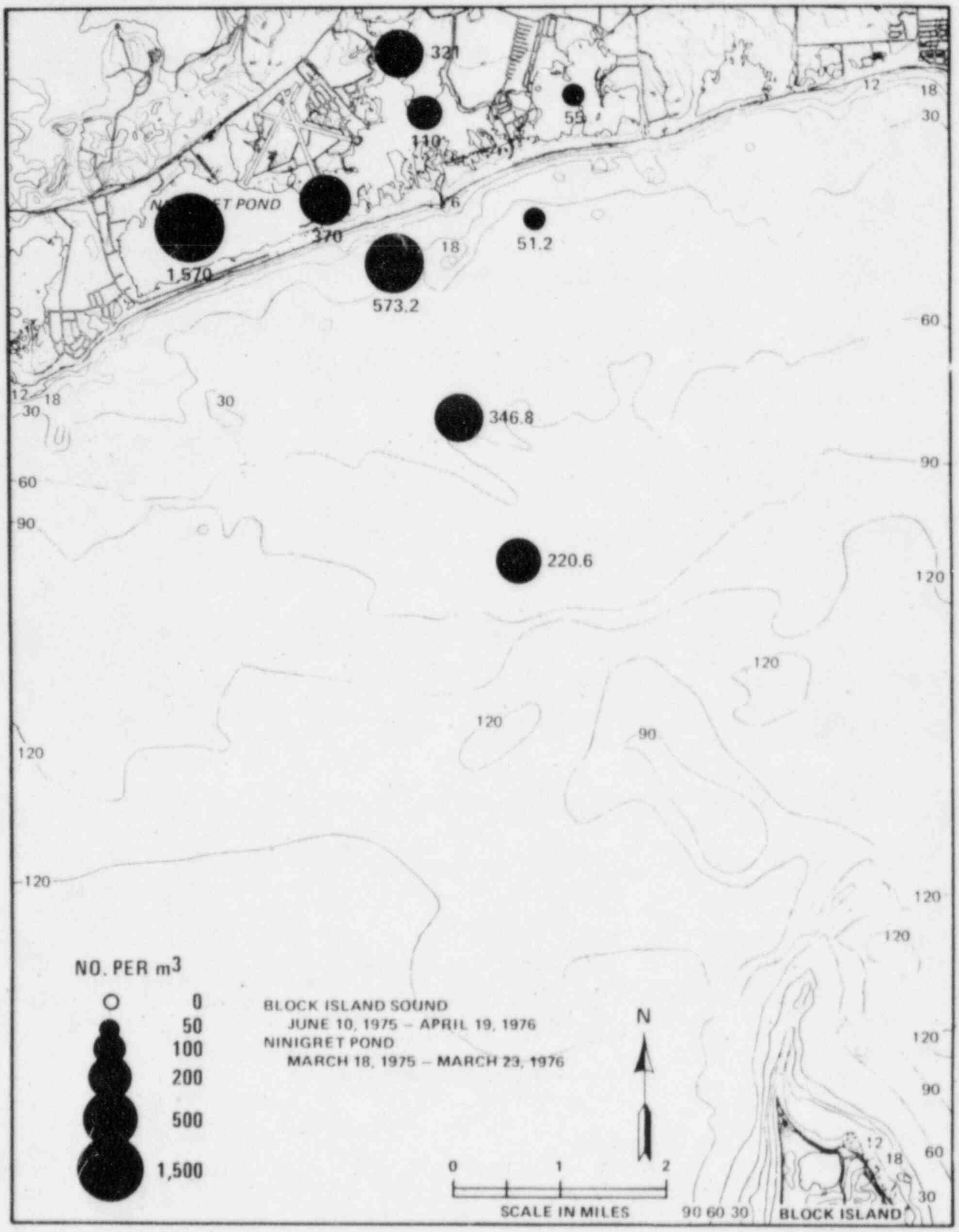


NEW ENGLAND POWER COMPANY
NEP 1 & 2
Environmental Report

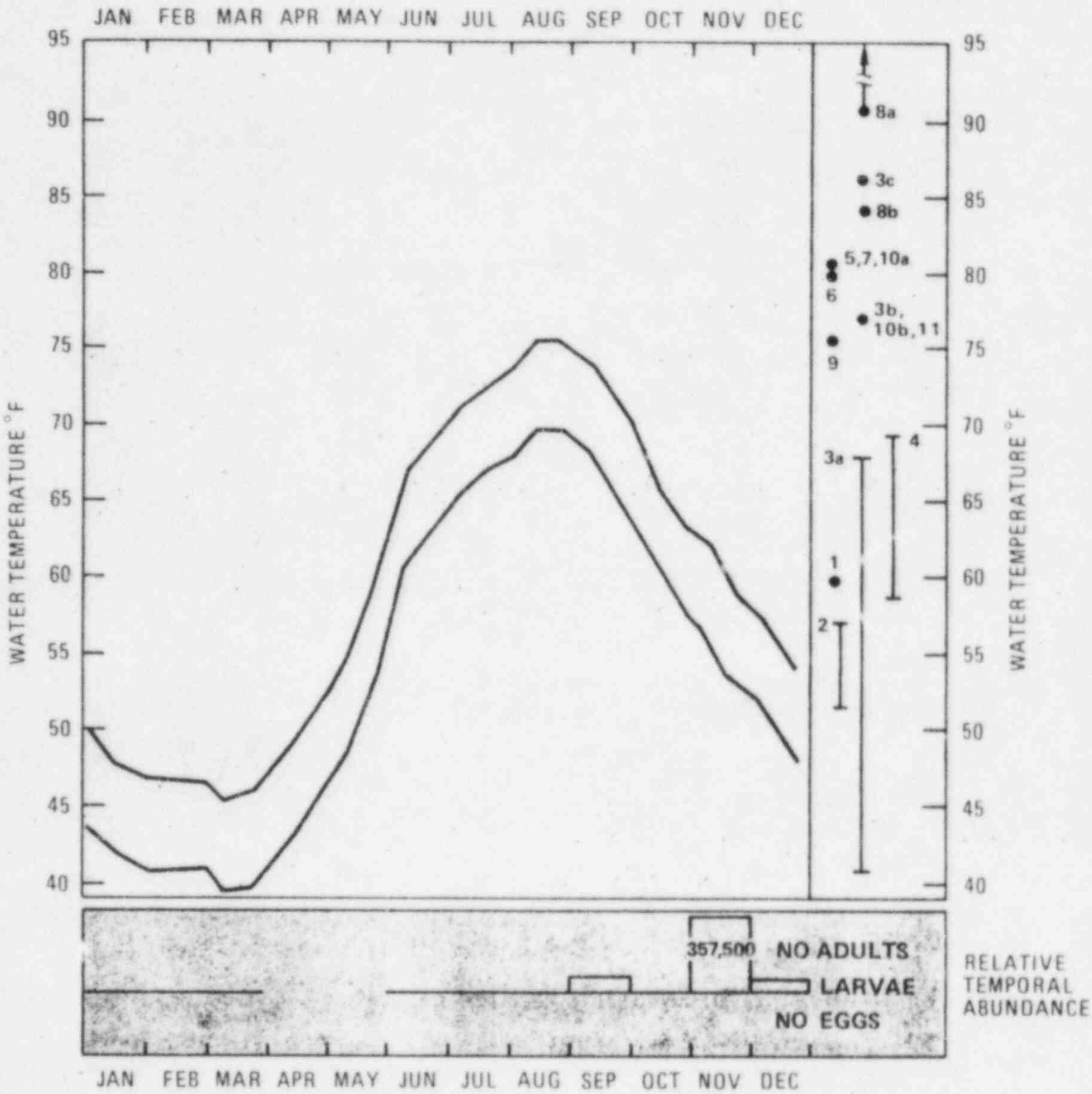
DISTRIBUTION AND AVERAGE DENSITY OF BLUE MUSSEL LARVAE PER m^3

FIGURE G.4.2-50

NEP 1 & 2

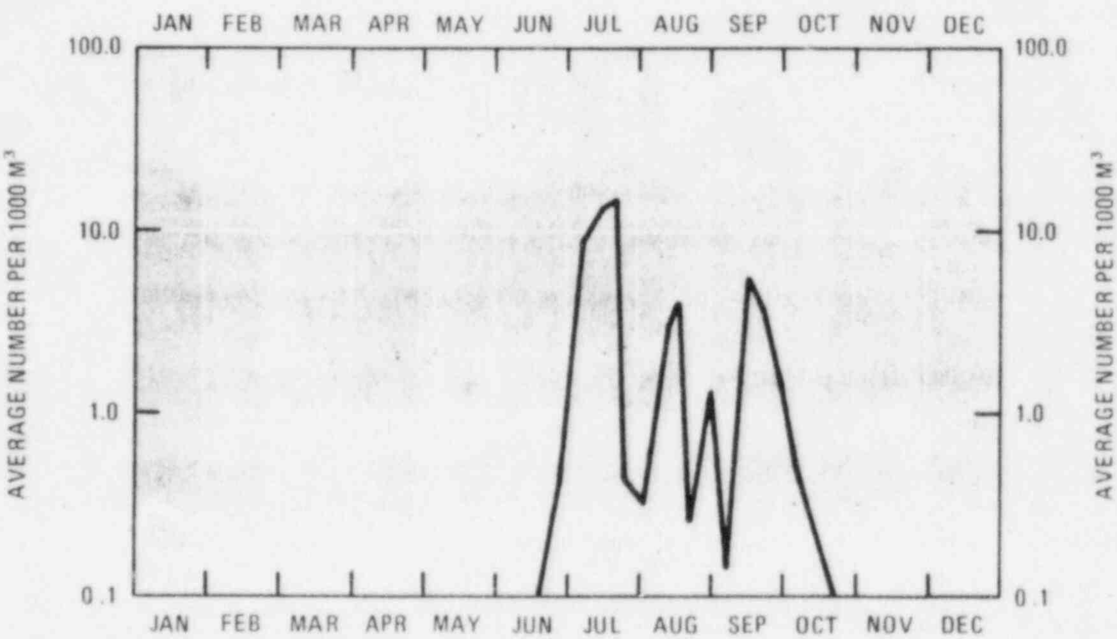


NEW ENGLAND POWER COMPANY NEP 1& 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF BLUE MUSSEL LARVAE PER m^3	
	FIGURE G.4.2-51	NEP 1& 2



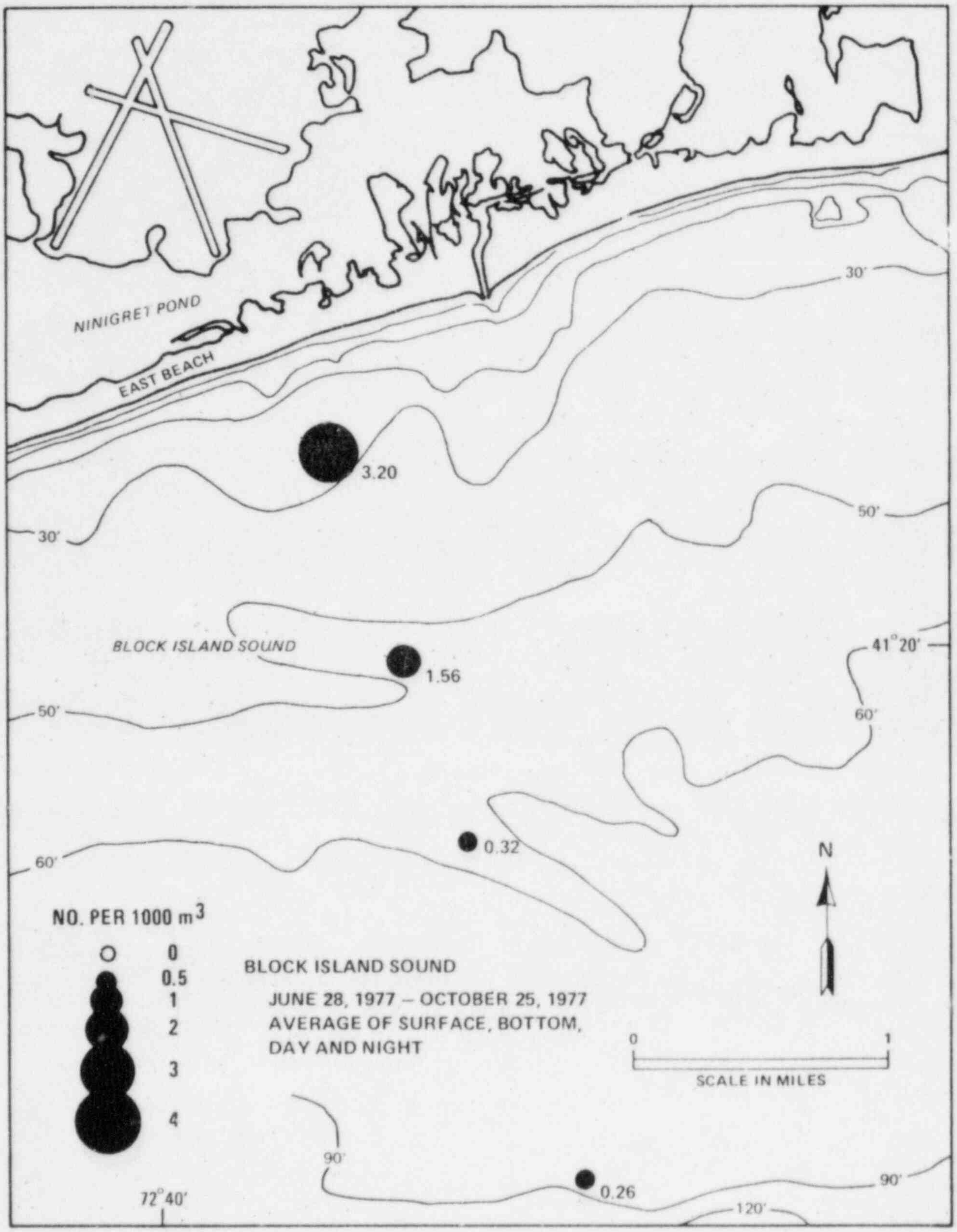
1. MINIMAL SPAWNING TEMPERATURE (ENGLE AND LOOSANOFF, 1944)
2. OPTIMAL TEMPERATURE RANGE FOR LARVAE SURVIVAL AND GROWTH (LOUGH, 1974)
3a. TEMPERATURE RANGE FOR LARVAE SURVIVAL (BRENKO AND CALABRESE, 1969)
  b. ERRATIC SURVIVAL OF LARVAE OBSERVED
  c. TEMPERATURE AT WHICH MORTALITY OF LARVAE OBSERVED
4. TEMPERATURE RANGE FOR SETTLEMENT OF PEDIVELIGER LARVAE (ENGLE AND LOOSANOFF, 1944)
5. INTOLERANCE OF JUVENILE MUSSELS FOUND (GONZALEZ, 1973)
6. TEMPERATURE LIMIT FOR SOUTHERN BOUNDARY (HUTCHINS, 1947)
7. TEMPERATURE LIMIT FOR NATURAL RANGE (READ AND CUMMINGS, 1967)
8a. UPPER TOLERANCE TEMPERATURE FOR *MYTILUS*: 105.4°F (HENDERSON, 1929)
  b. 24-HR MEDIAN TEMPERATURE TOLERANCE
9. ADULTS SUSCEPTIBLE TO PREDATION (PEARCE, 1969)
10a. TEMPERATURE WHERE MORTALITY OF ADULTS REPORTED (GONZALEZ, 1973)
  b. TEMPERATURE FOR CESSATION OF FEEDING
11. WATER FILTRATION CAPACITY AFFECTED (WIDDOWS, 1973)

NEW ENGLAND POWER COMPANY N E P 1 & 2 Environmental Report	BLUE MUSSEL RELATIVE TEMPORAL ABUNDANCE AND THERMAL CHARACTERISTICS
	FIGURE G.4.2-52 — N E P 1 & 2

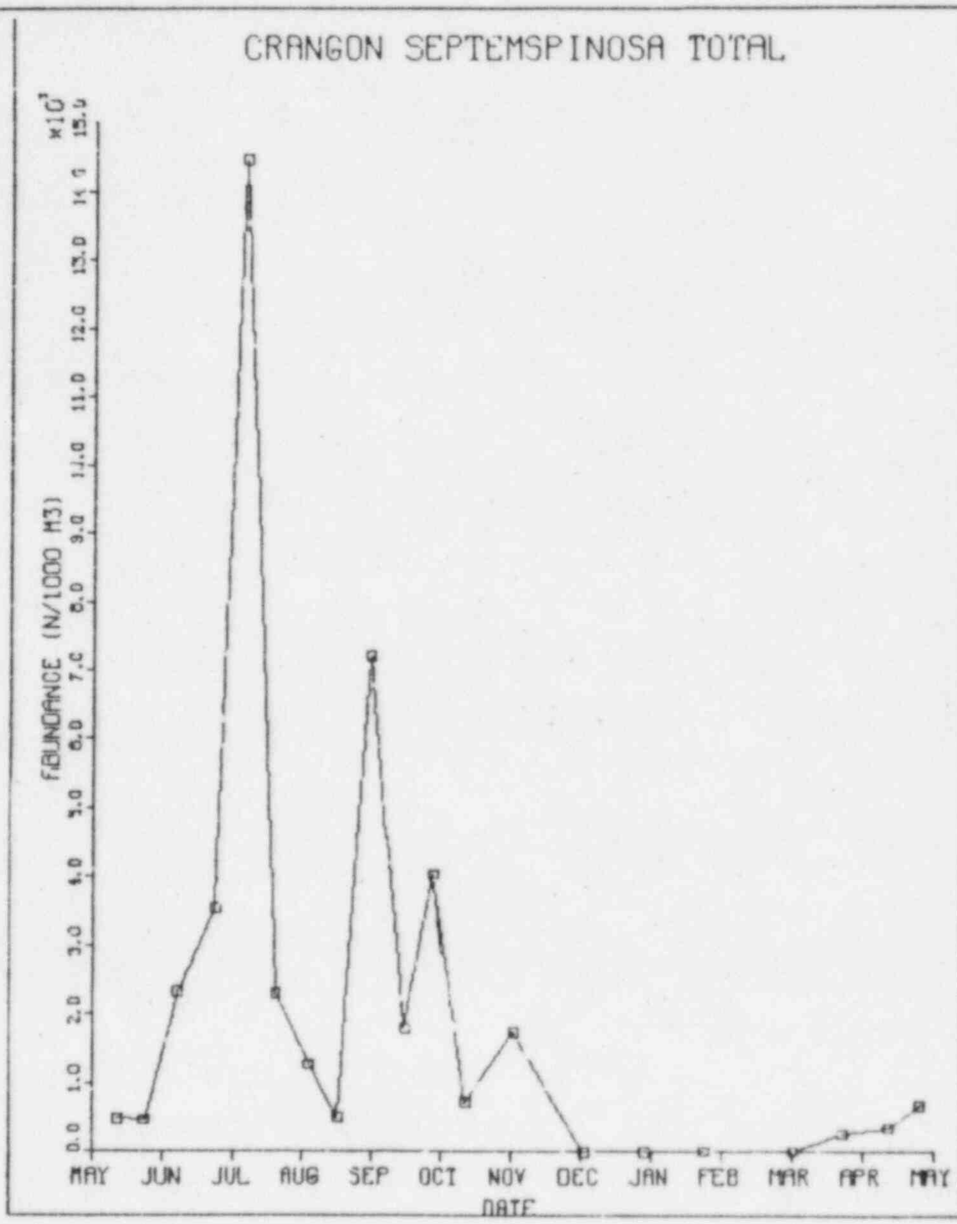


NOTE:
AVERAGE OF SURFACE, BOTTOM, DAY, AND NIGHT (1977)

NEW ENGLAND POWER COMPANY NEP 1&2 Environmental Report	SQUID JUVENILE TEMPORAL ABUNDANCE AT BLOCK ISLAND SOUND STATION EB-B
	FIGURE G.4.2-53 — NEP 1&2



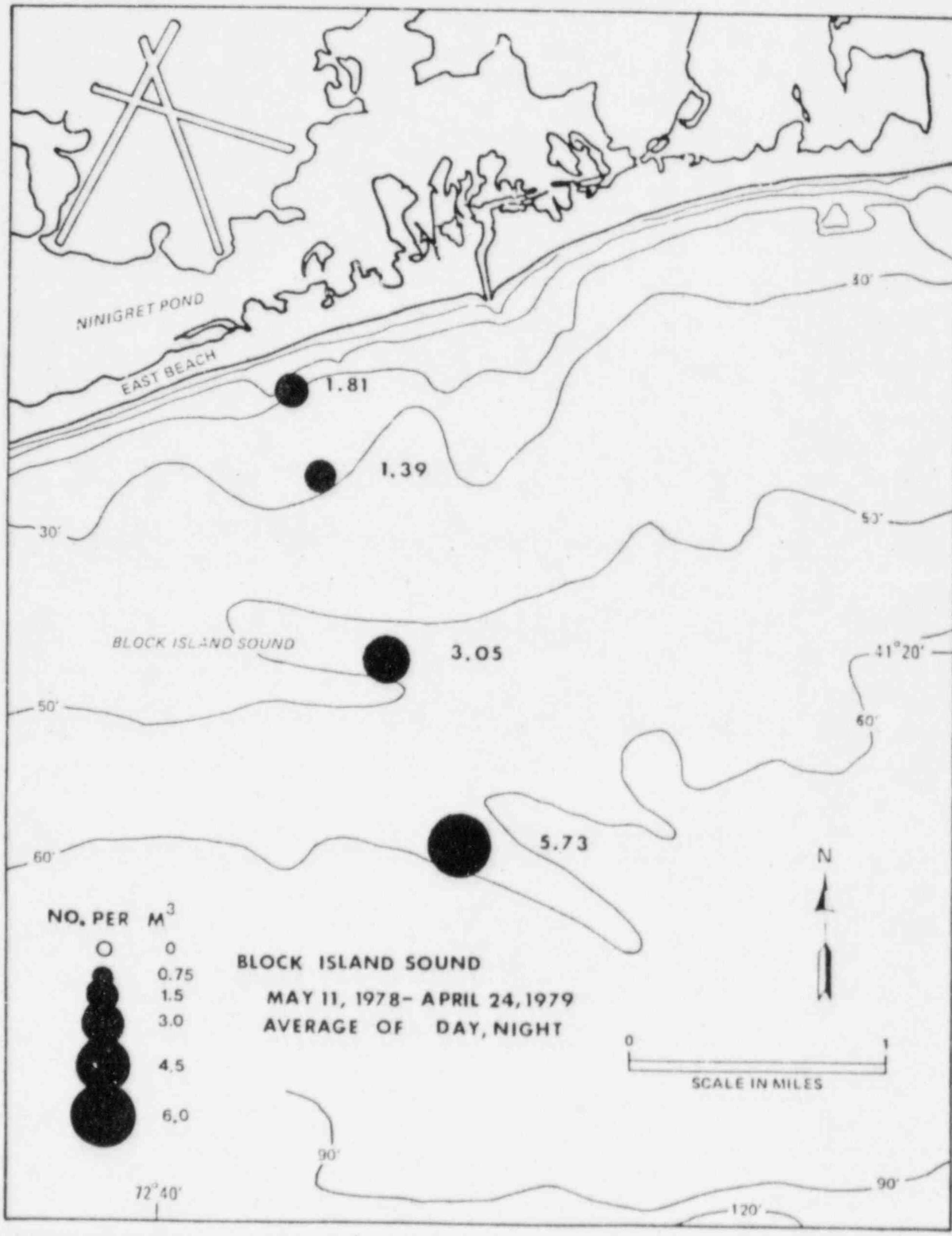
NEW ENGLAND POWER COMPANY NEP 1 & 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF SQUID JUVENILES	
	FIGURE G.4.2-54	NEP 1 & 2



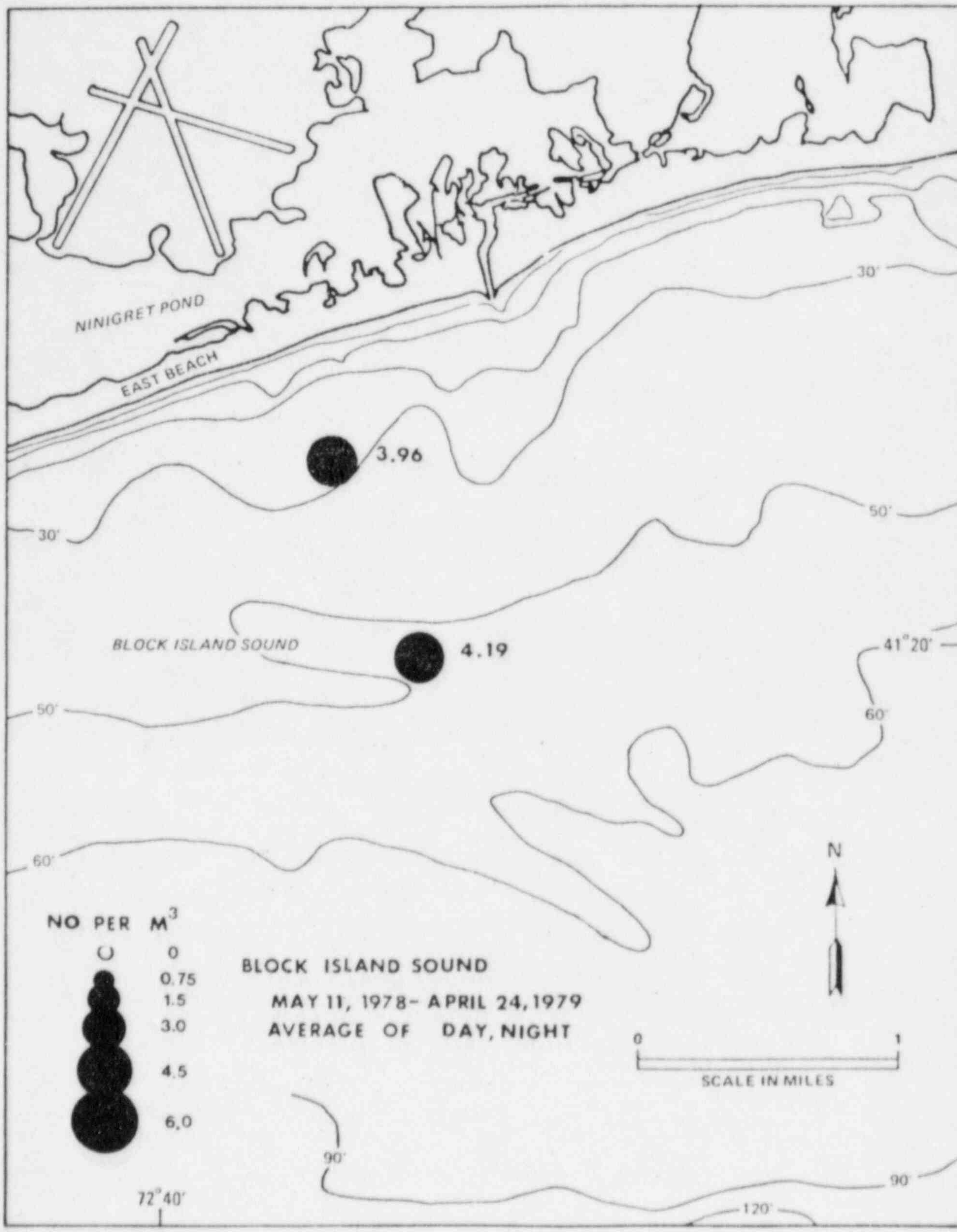
NOTE:

AVERAGE OF SURFACE, BOTTOM, DAY, AND NIGHT

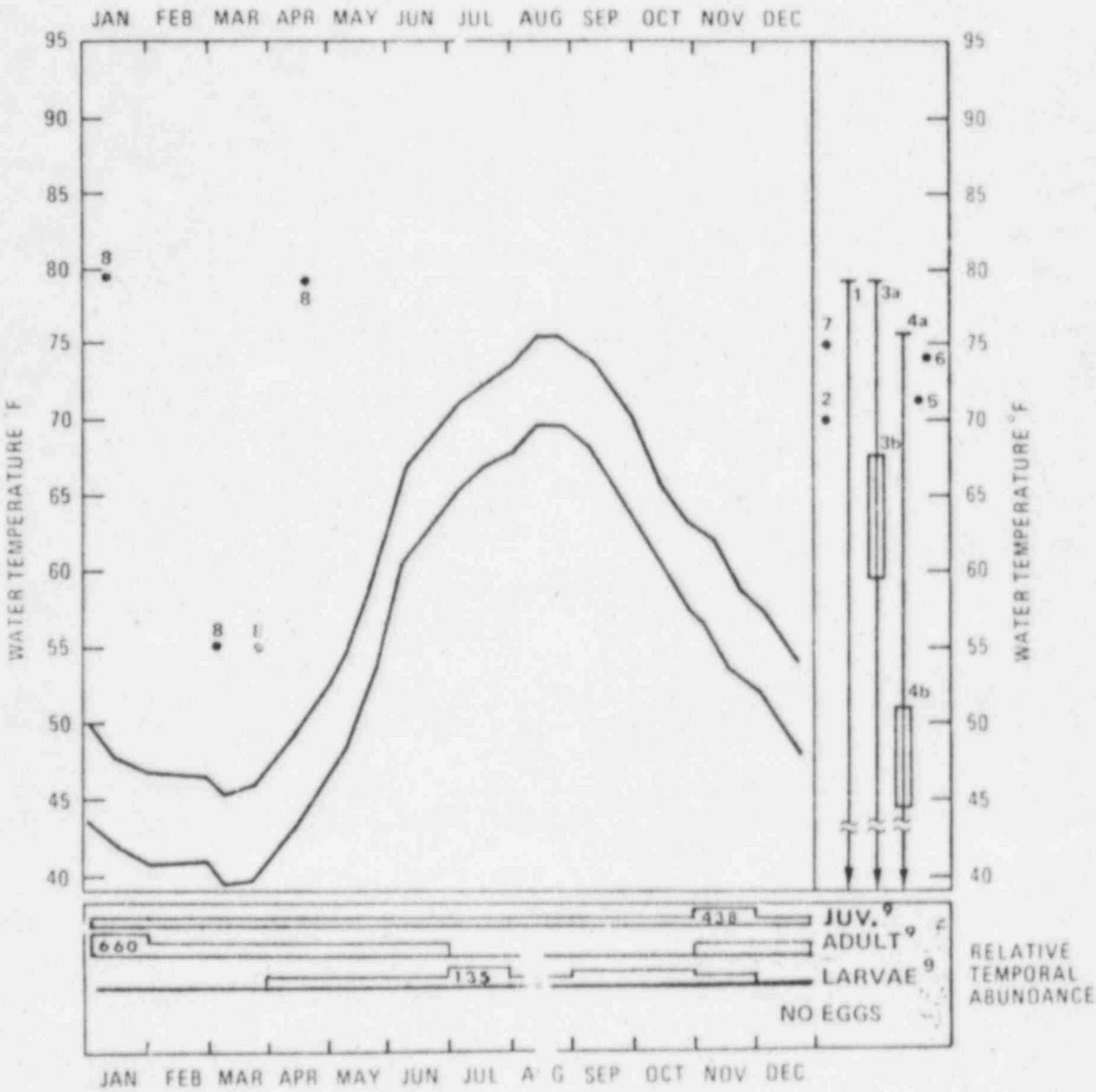
NEW ENGLAND POWER COMPANY NEP 1&2 Environmental Report	TEMPORAL ABUNDANCE AT BLOCK ISLAND SOUND STATION EB-B
	FIGURE G.4.2-55 — NEP 1&2



NEW ENGLAND POWER COMPANY NEP 1& 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY of Sand Shrimp Larvae per M3 (Surface)	
	FIGURE G.4.2-56	NEP 1& 2



NEW ENGLAND POWER COMPANY NEP 1&2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY of Sand Shrimp Larvae per M3 (Bottom)	
	FIGURE G.4.2-57	NEP 1&2



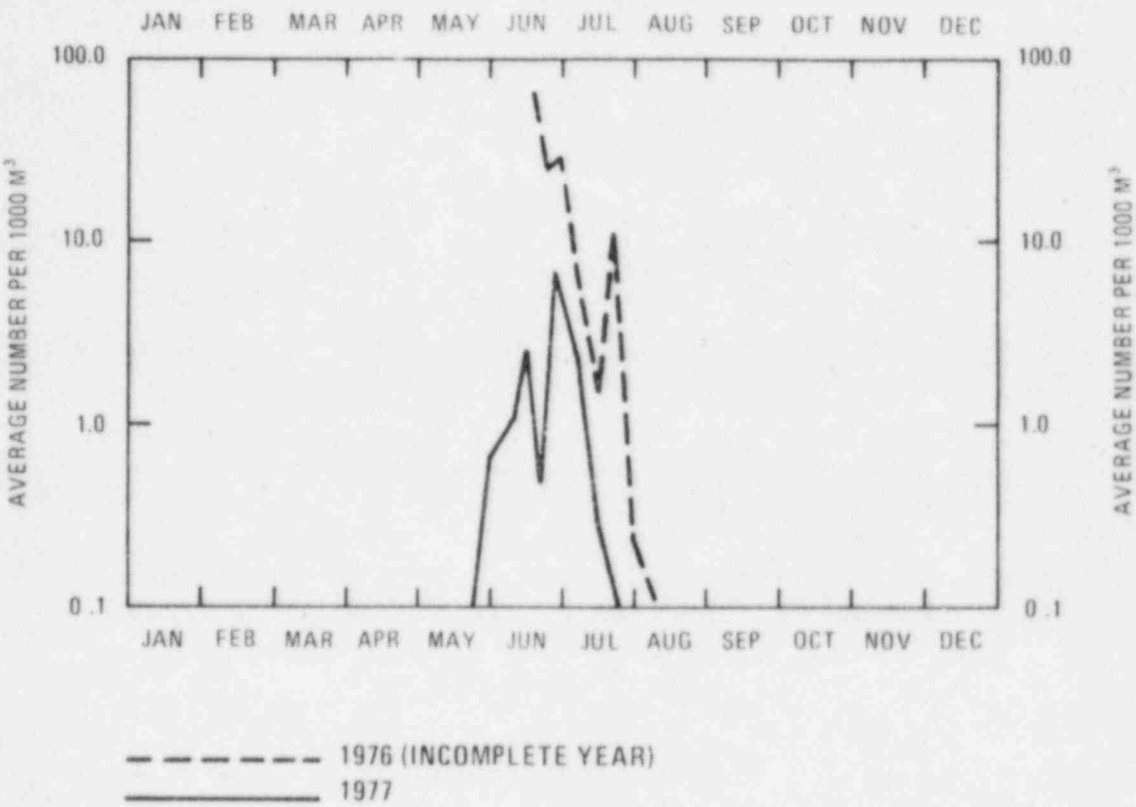
1. TEMPERATURE RANGE WHERE SA[illegible] SHRIMP HAVE BEEN CAPTURED (PRICE, 1962)
2. DISCRETE INCUBATION TEMPER[illegible]URE (6-7 DAYS) (PRICE, 1961)

3a. LARVAL TEMPERATURE RANGE (SANDIFER, 1975)
 b. TEMPERATURE RANGE WHERE MOST ABUNDANT

4a. TEMPERATURE RANGE FOR ADULTS (HAEFNER, 1976)
 b. TEMPERATURE RANGE WHERE MOST ABUNDANT

5. MAXIMUM TEMPERATURE WHERE SAND SHRIMP WERE FOUND (HAEFNER, 1969)
6. GREATEST MORTALITY IN LOW DISSOLVED OXYGEN STUDIES (HAEFNER, 1970)
7. TEMPERATURE WHERE FEBRUARY ACCLIMATED SAND SHRIMP DIED (VERNBERG AND VERNBERG, 1970)
8. PREFERRED TEMPERATURE FOR ADULTS (MELDRIM, ET AL., 1974)
9. TEMPORAL OCCURRENCE OF JUVENILES, ADULTS, AND LARVAE

NEW ENGLAND POWER COMPANY NEP 1 & 2 Environmental Report	SAND SHRIMP RELATIVE TEMPORAL ABUNDANCE AND THERMAL CHARACTERISTICS	
	FIGURE G.4.2-58	NEP 1 & 2

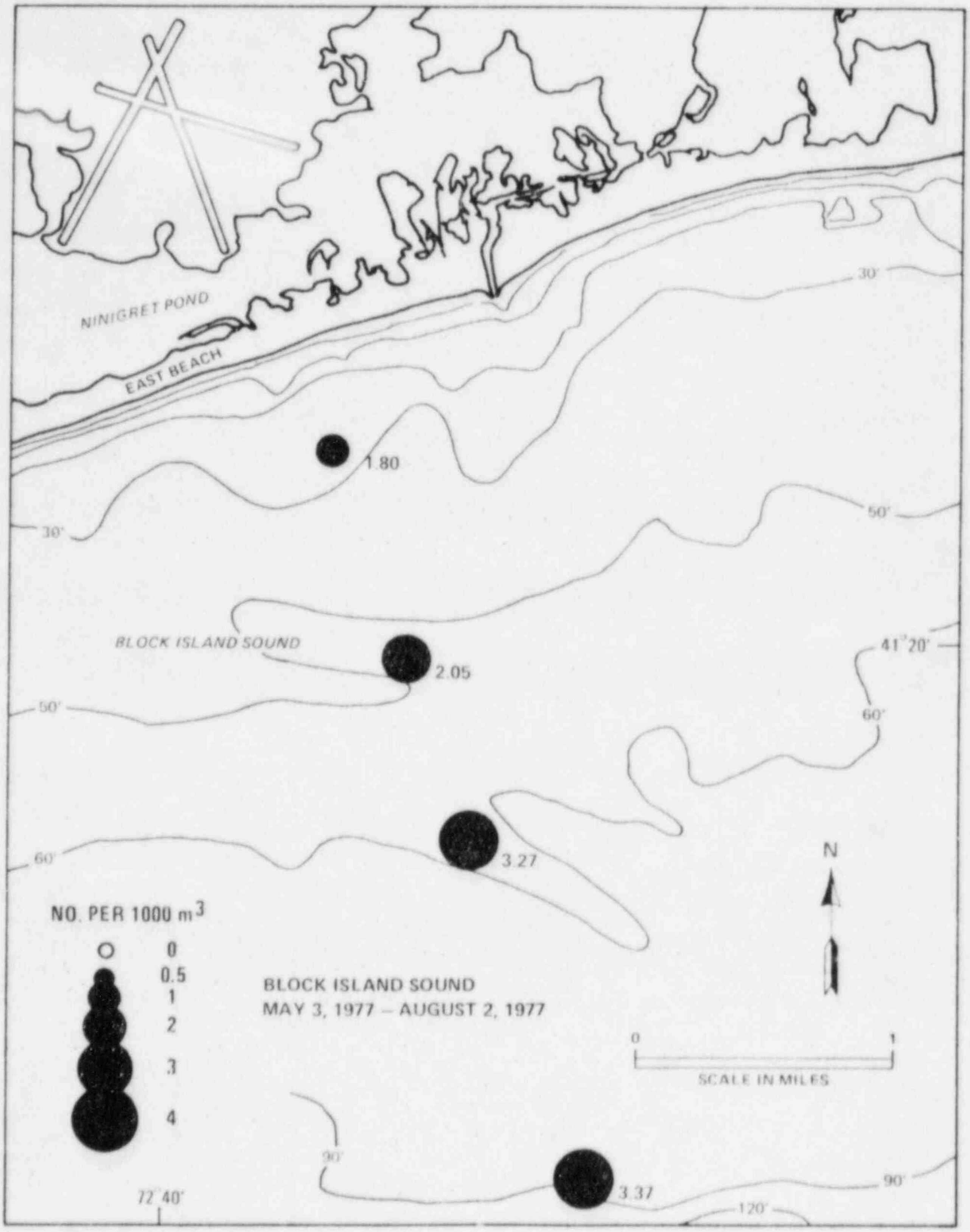


NOTE:

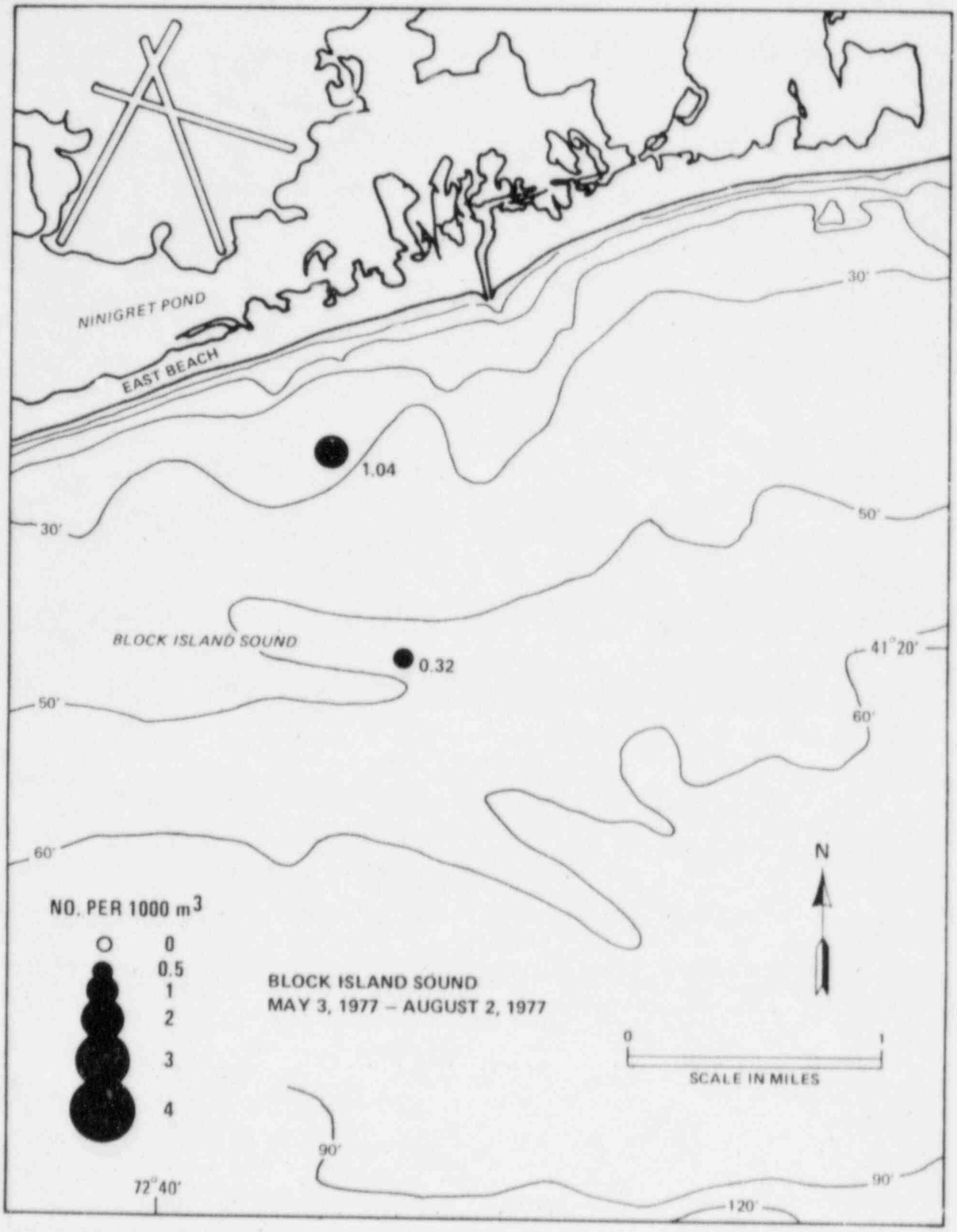
1977 AVERAGE OF STAGE I - IV, DAY, SURFACE DURING 1977

1976 AVERAGE OF STAGE I - IV, SURFACE, BOTTOM, DAY AND NIGHT AT STATION EB-8 DURING 1976

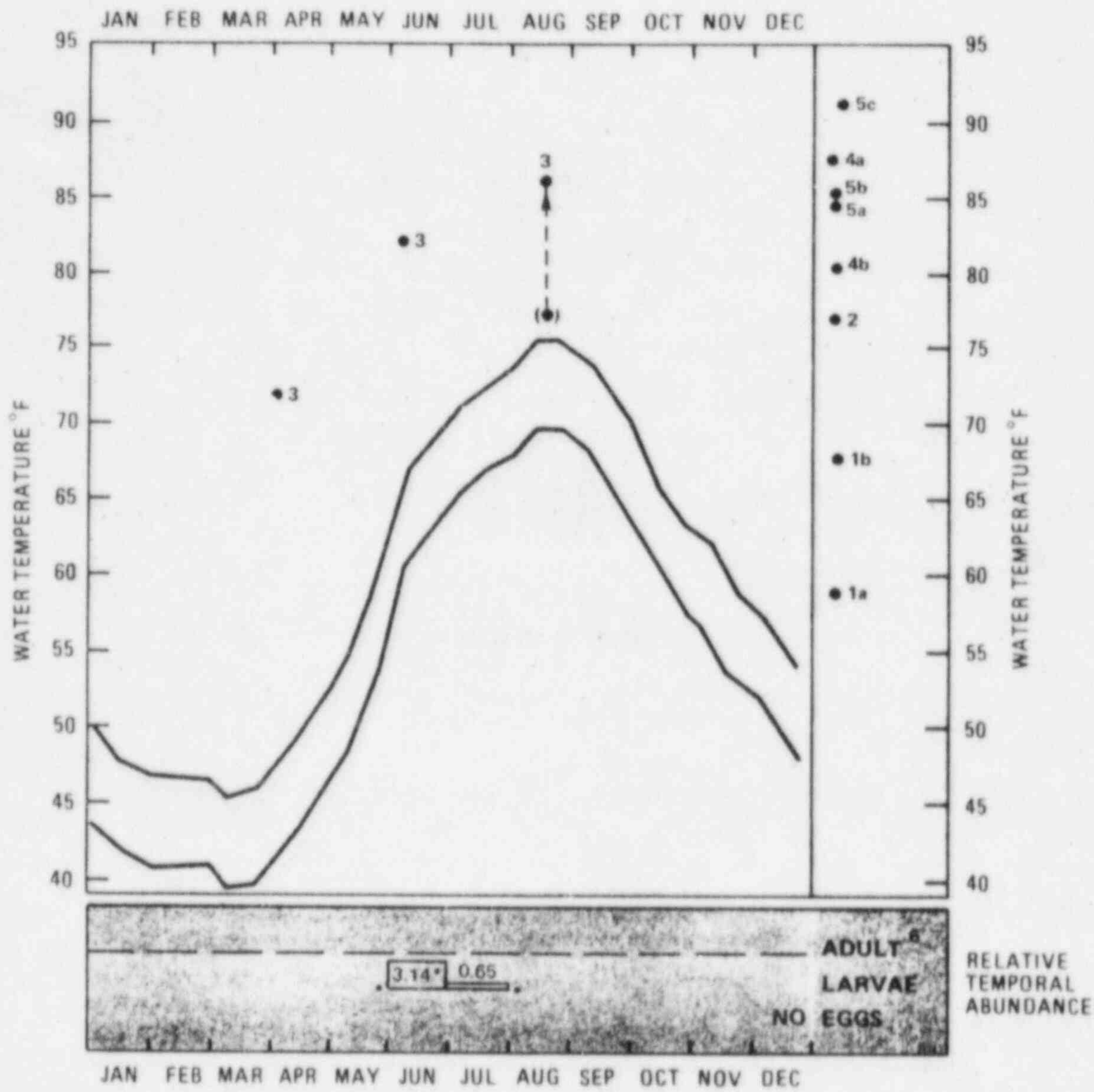
NEW ENGLAND POWER COMPANY NEP 1&2 Environmental Report	LOBSTER & TEMPORAL ABUNDANCE IN BLOCK ISLAND SOUND
	FIGURE G.4.2-59 — NEP 1&2



NEW ENGLAND POWER COMPANY N E P 1 & 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF LOBSTER LARVAE (SURFACE) 1977	
	FIGURE G.4.2-60	N E P 1 & 2



NEW ENGLAND POWER COMPANY N E P 1 & 2 Environmental Report	DISTRIBUTION AND AVERAGE DENSITY OF LOBSTER LARVAE (BOTTOM) 1977	
	FIGURE G.4.2-61	N E P 1 & 2



1a. COMMENCEMENT OF HATCHING AT MASSACHUSETTS STATE LOBSTER HATCHERY
b. MOST INTENSIVE HATCHING
2. UPPER LIMIT DEVELOPMENT AND GROWTH TEMPERATURE FOR EMBRYOS AND POST-LARVAL STAGES (PERKINS, 1972; HUGHES et. al., 1972)
3. UPPER LETHAL TEMERATURES FOR ADULTS (McLEESE, 1956)
4a. NO LARVAL MORTALITY FOR SHORT EXPOSURE PERIOD (PERKINS, et. al. UNDATED)
b. MINIMAL MORTALITY OBSERVED AT SIX-HOUR EXPOSURE
5a. LOBSTER LARVAE SURVIVAL (TL50) FOR 24 HOURS (BOSTON EDISON, 1975)
b. LOBSTER LARVAE SURVIVAL (TL50) FOR 2 HOURS
c. LOBSTER LARVAE SURVIVAL (TL50) FOR 1 HOUR
SUSPECTED

*NUMBER/1000 M^3

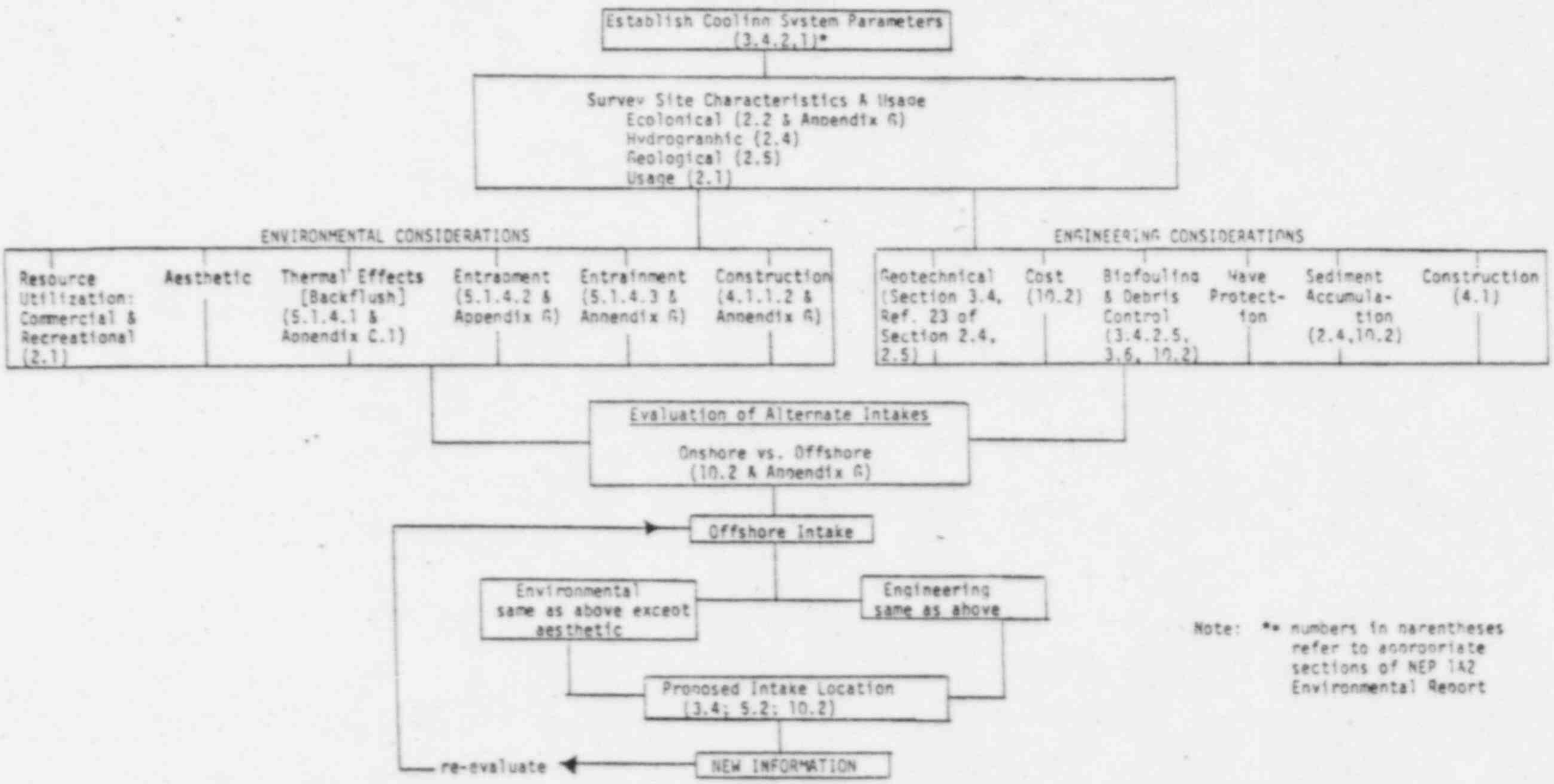
NEW ENGLAND POWER COMPANY
NEP 1&2
Environmental Report

AMERICAN LOBSTER
RELATIVE TEMPORAL ABUNDANCE
AND THERMAL CHARACTERISTICS

FIGURE G.4.2-62

NEP 1&2 INTAKE DESIGN AND LOCATION

DECISION MATRIX



Note: * numbers in parentheses refer to appropriate sections of NEP 1&2 Environmental Report

Figure G.5.0-1

TABLE G.2.2-1

SUMMARY OF BLOCK ISLAND SOUND BIOLOGICAL SAMPLING PROGRAM

Taxa	BIS Stations(1)	Depths	Monthly Frequency	Replicates	Collecting Equipment and Comments
Phytoplankton					
1974(2)	A,B/C,D(3)	3	2/1	3	1 liter Van Dorn Sampler
1975	A,B/C,D	3	2/1	2	1 liter Van Dorn Sampler
Zooplankton					
1974	A,B/C,D(4)	3	2/1	3	250 liters pumped through a No. 20 mesh net
1975	A,B/C,D	3	2/1	2	250 liters pumped through a No. 30 mesh net
Lobster Larvae					
1976	BIS-A, BIS-B	Surface	Weekly	2	1m x 2m neuston net with 1mm mesh. Preliminary survey, incomplete coverage of spawning season. Day and night surveys.
1977	EB-B,EB-C	2	Weekly	3	2m x 2m x 8m long tucker net with 0.950mm mesh; day and night
	EB-D,EB-E	Surface	Weekly	3	
	EB-B→EB-E	All	Weekly	1	Oblique tow with 2m x 2m x 8m long tucker net with 0.950mm mesh
Squid Juveniles					
1977	EB-B,EB-C, EB-D,EB-E	2	Weekly	3	2m x 2m x 8m long tucker net with 0.950mm mesh. Surface and near-bottom towing; day and night
	EB-B→EB-E	1	Weekly	1	Oblique tow with 2m x 2m x 8m long tucker net with 0.950mm mesh
Sand Shrimp					
1978-1979					
Larvae	EB-B,EB-C	2	Note (9)	3	0.75m x 0.75m x 6m long tucker net with 0.333mm mesh. Surface and near-bottom towing; day and night
	EB-A,EB-D	Surface	Note (9)	3	
Adults	EB-C	Bottom	Note (9)	3	12 ft. semi-balloon shrimp trawl. Day and night

TABLE G.2.2-1 (Cont.)

SUMMARY OF BLOCK ISLAND SOUND BIOLOGICAL SAMPLING PROGRAM

Taxa	BIS Stations(1)	Depths	Monthly Frequency	Replicates	Collecting Equipment and Comments
Ichthyoplankton					
1974	A,B,C,D(5)	All	Note (6)	3	Oblique Bongo (.333μ and .505μ mesh) tows
1975	A→P	All	Note (6)	1	Oblique Bongo
Benthos					
1974	Note (7)	-	Quarterly	3	Divers troweled out an 0.5 x 0.5m square to a depth of 10 cm
1975	Note (7)			2	0.04 m^2 Van Veen Sampler
Finfish					
1974	A,B,C	Bottom	Note (8)	2	38' otter trawl
	A	0-10'	Note (8)	1	500' experimental gill net set on bottom
1975	A,C	Bottom	2	2	Commercial Dragger

(1) See Figure G.2.0-1.
(2) 1974 represents April 1974 through March 1975; 1975 represents April 1975 through March 1976.
(3) The "/" indicates two sampling strategies. Letters to the left and right of the "/" correspond to similarly located numbers in the monthly frequency column.
(4) Night samples were also taken at A and B at roughly monthly intervals.
(5) Duplicate, depth profiling .505 mesh tucker trawl collections were taken five times during the summer at stations A, B and C.
(6) Weekly April-August and then monthly (weekly during March 1976).
(7) 3 parallel transects were sampled at 10' contour intervals to 80' (1974) and 10'-80' (1975).
(8) Otter trawl - bimonthly April-August; Gill net - bimonthly Sept. and Oct.; Monthly thereafter.
(9) Twice per month, day and night, from April through November, and once per month, at night, from December through March.

Table G.2.2-2

SUMMARY OF NINIGRET POND BIOLOGICAL SAMPLING PROGRAM

Taxa	Stations[1]	Depths	Monthly Frequency	Replicates	Collecting Equipment and Comments
Phytoplankton					
1974[2]	A,B,C,D,E/F[3]	2	2/1	3	1 liter Van Dorn Sampler
1975	A,B,C,D/E,F	2	2/1	2	1 liter Van Dorn Sampler
Zooplankton					
1974	A,B,C,D,E/F	2	2/1	3	250 liters pumped through a No. 20 mesh net
1975	A,B,C,D,E,F	2	Note (6)	2	250 liters pumped through a No. 30 mesh net
Ichthyoplankton					
1974	A,B,C,D,E	all	Note (4)	2	oblique Tucker (.333μ mesh) tow
1975	A,B,C,D,E	all	Note (4)	2	oblique Tucker (.333μ mesh) tow
Benthos					
1974	A,B,C,D,E	—	quarterly	3	Divers troweled out on 0.5 x 0.5m square to a depth of 10 cm
1975	A,B,C,D,E	—	quarterly	3	0.04 m^2 Van Veen Sampler
Finfish					
1974	A,B,C,D,E	Bottom	2	2	19 foot ballon trawl
	Near A,B,C,D	—	Note (5)	1	60 foot beach seine
1975	As in 1974 except otter trawl frequency reduced as in note (5).				
	2	Bottom	8[7]	1	Commercial gill net

(1) See Figure G.2.0-1.

(2) 1974 represents April 1974 through March 1975; 1975 represents April 1975 through March 1976.

(3) The "/" indicates two sampling strategies. Letters to the left and right of the "/" correspond to similarly located numbers in the monthly frequency column.

(4) Weekly April — August and then bimonthly (weekly in March 1976).

(5) Bimonthly April — August and then monthly (bimonthly May — August in 1976).

(6) April 2, May 3; June and August 4; July 5; Sept — March 2, Jan 0.

(7) September through March.

Table G.2.2-3
FINFISH SPECIES OBSERVED IN ICHTHYOPLANKTON COLLECTIONS

Common Name	Scientific Name	Ninigret Pond 1974	Ninigret Pond 1975	Block Island Sound 1974	Block Island Sound 1975
American eel	*Anguilla rostrata*	J*	J		J
Conger eel	*Conger oceanicus*				L
Alewives	*Alosa* spp.	L		L	L
Atlantic menhaden	*Brevoortia tyrannus*	E/L	E/L	E/L	E/L
Atlantic herring	*Clupea harengus harengus*	L	L	L	L
Anchovies	*Anchoa* spp.	L	L	L	L
Striped anchovy	*Anchoa hepsetus*			E	E
Bay anchovy	*Anchoa mitchilli*	E	E	E	E
Rainbow smelt	*Osmerus mordax*	E	E/L		E
Goosefish	*Lophius americanus*	E	E/L	L	E/L
Codfishes	Gadidae	E		E	
Cusk	*Brosme brosme*			L	
Fourbeard rockling	*Enchelyopus cimbrius*	E/L	E/L	E/L	E/L
Atlantic cod	*Gadus morhua*	E	E/L	L	E/L
Haddock	*Melanogrammus aeglefinus*			L	L
Silver hake (whiting)	*Merluccius bilinearis*	E	E/L	E/L	E/L
Pollock	*Pollachius virens*		L	L	E/L
Hakes	*Urophycis* spp.	E/L		E/L	E/L
Cusk-eels-eel pouts	Ophidiidae Zoarcidae	L	L	L	L
Atlantic needlefish	*Strongylura marina*	L	E		
Killifishes	*Fundulus* spp.	E/L	E/L		
Mummichog	*Fundulus heteroclitus*				J
Silversides	*Menidia* spp.	E/L	E/L	L	
Tidewater silverside	*Menidia beryllina*		E/L		
Atlantic silverside	*Menidia menidia*		E		
Sticklebacks	Gasterosteidae	E/L	E		
Fourspine stickleback	*Apeltes quadracus*	E/L	L		
Threespine stickleback	*Gasterosteus aculeatus*	L	L		L
Sea horses	*Hippocampus* spp.	L		L	
Northern pipefish	*Sygnathus fuscus*	J	J	J	J
Black sea bass	*Centropristis striata*		L	L	L
Scup	*Stenotomus chrysops*			E/L	E/L
Weakfish	*Cynoscion regalis*	E/L	L	E/L	E/L
Northern kingfish	*Menticirrhus saxatilis*	E	E/L	E/L	L
Wrasses	Labridae	E	E	E	E
Tautog	*Tautoga onitis*	L	L	L	L
Cunner	*Tautogolabrus adspersus*	L	L	L	L
Radiated shanny	*Ulvaria subbifurcata*	L	L	L	L
Rock gunnel	*Pholis gunnellus*	L		L	L
Sand launces	*Ammodytes* spp.	L	L	L	L
Naked goby	*Gobiosoma bosci*		L/J		
Seaboard goby	*Gobiosoma ginsburgi*	L	L	L	L
Atlantic mackerel	*Scomber scombrus*	E/L	E/L	E/L	E/L
Butterfish	*Peprilus triacanthus*	E/L	L	E/L	E/L
Sea robins	*Prionotus* spp.	E/L	E/L	E/L	E/L
Sea raven	*Hemitripterus americanus*			L	
Sculpins	*Myoxocephalus* spp.	L	L	L	L
Sea snails	*Liparis* spp.	L	L	L	L
Smallmouth flounder	*Etropus microstomus*		E/L	L	E/L
Summer flounder (fluke)	*Paralichthys dentatus*	L	L	L	E/L
Fourspot flounder	*Paralichthys oblongus*		E/L	E/L	E/L
Windowpane	*Scophthalmus aquosus*	E/L	E/L	E/L	E/L
Yellowtail flounder	*Limanda ferruginea*	E/L	E/L	E/L	E/L
Witch flounder	*Glyptocephalus cynoglossus*			E/L	E/L
American plaice	*Hippoglossoides platessoides*			L	L
Winter flounder	*Pseudopleuronectes americanus*	L	E/L	L	E/L
Hogchoker	*Trinectes maculatus*	E/L	E/L	E/L	E/L
Northern puffer	*Sphoeroides maculatus*	L	L		L

*J = juvenile, E = eggs, L = larvae

Table G.2.2-4

MEAN CATCH (PER 100 M^3) OF SELECTED FISH EGGS TAKEN AT STATIONS NP A THROUGH NP E IN NINIGRET POND CALCULATED FOR MONTHLY PERIODS, APRIL 1974 — MARCH 1976

Upper Value Represents 1974-75 Catch; Lower Value; 1975-76

Species	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	% of Total
B. tyrannus	0	1.3	8.1	12.1	0	1.6	0.4	0	0	0	0**	0	1.8
	0	1.4	3.8	0.2	0.02	0	0.03	0.7	0	*	0	0	0.8
A. mitchilli	0	0.2	131.3	393.5	38.9	4.5	0	0	0	0	0	0	47.3
	0	0	159.3	243.3	10.8	0.1	0.1	0	0	*	0	0	45.9
Enchelyopus-Urophycis-Peprilus	1.0+	1.0	0.5	0.1	0.02	0	0	0	0	0	0.1+	0.8+	0.2
	4.1+	0.7	0.6	0.6	0	0	0	0	0	*	0.03+	0.6+	0.7
G. morhua	0.1	0.2	0	0	0	0	0	0	0.1	0.2	0.04	0.04	0.03
	0	0.02	0.08	0	0	0	0	0.04	0.2	*	0.03	0.2	0.04
Menidia spp.	0.7	42.5	103.3	9.7	0	0	0	0	0	0	0	0	11.4
	0	13.4	36.7	2.8	0	0	0	0	0	*	0	0	7.5
Labrid-*Limanda*	0	77.2	118.4	51.8	0.7	0.2	0	0	0	0	0	0	18.7
	0.02	44.4	116.9	137.8	2.1	0.6	0	0	0	*	0	0.02++	35.5
Labrid III	0	0	0	11.4	0.8	0.2	0	0	0	0	0	0	1.1
	0.03	4.7	7.7	22.7	0.1	0.1	0	0	0	*	0	0	3.6
S. scombrus	0.1	4.3	0.02	0	0	0	0	0	0	0	0	0	0.4
	0	2.3	0.1	0	0	0	0	0	0	*	0	0	0.3
Prionotus spp.	0	1.9	7.7	0.2	0.3	2.9	0	0	0	0	0	0	0.8
	0	1.4	2.4	7.9	0.9	0.1	0	0	0	*	0	0	1.4
Paralichthys-Scophthalmus	0.8	1.1	0.5	0.1	0	0.1	0.6	0	0	0	0**	0	0.2
	0	2.8	0.7	3.7	0	2.3	0.1	0.3	0	*	0	0	1.0
L. ferruginea III	2.4	0	0	0	0	0	0	0	0	0	—	—	0.2
	0.03	0	C	0	0	0	0	0	0	*	—	—	0.01
P. americanus	0	0	0	0	0	0	0	0	0	0	7.4**	1.6	0.3
	0	0	0	0	0	0	0	0	0	*	8.4	3.5	0.9
Total Eggs (includes all species collected)	13.0	133.8	374.8	485.5	41.5	10.0	1.0	0	0.1	0.2	7.7**	2.4	—
	4.2	75.7	336.4	422.1	14.4	3.3	0.3	1.1	0.2	*	8.5	3.7	—

*Pond frozen, no sampling.
**Station NP E frozen, not sampled.
+All considered to be *E. cimbrius* at this time.
++All considered to be *L. ferruginea* at this time.

Table G.2.2-5

MEAN CATCH (PER 100 M^3) OF SELECTED FISH LARVAE TAKEN AT STATIONS NP A THROUGH NP E IN NINIGRET POND CALCULATED FOR MONTHLY PERIODS, APRIL 1974 — MARCH 1976

Upper Value Represents 1974-75 Catch; Lower Value, 1975-76

Species	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	%of Total
B. tyrannus	0	0	0	0.2	0	1.6	0.2	0.1	0	0.04	0**	0	0.1
	0	0.1	0.1	1.8	0	0.1	0	1.0	0	*	0	0	0.2
Anchoa spp.	0	0	0.02	9.6	1.9	0.3	0	0	0	0	0	0	1.6
	0	0	1.1	11.3	5.2	1.0	0.04	0	0	*	0	0	0.9
Menidia spp.	0	4.5	32.8	10.9	1.0	0.04	0	0	0.03	0.1	0.05	0.07	6.0
	0.02	5.1	20.2	14.0	1.0	0	0	0	0.04	*	0	0.02	2.2
Ammodytes spp.	9.2	0.4	0	0	0	0	0	0	0	0.04	0.8	29.5	2.2
	23.6	1.1	0	0	0	0	0	0	0.4	*	3.8	11.0	1.7
C. ginsburgi	0	0	0.1	0.3	0.2	0.2	0	0	0	0	0	0	0.1
	0	0	1.7	5.2	1.3	0.1	0.04	0	0	*	0	0	0.4
Myoxocephalus spp.	0.6	0	0	0	0	0	0	0	0	0	0	1.1	0.1
	1.7	0.03	0	0	0	0	0	0	0	*	0.4	1.7	0.2
S. aquosus	0	0	0	0	0	0	0.1	0	0	0	0	0	0.01
	0	0.02	0.02	0	0	0	0.04	0	0	*	0	0	0.01
P. americanus	7.1	0.3	0.02	0	0	0	0	0	0	0.9	85.7	1418.8	87.8
	145.3	1.3	0.1	0	0	0	0	0	0	*	1257.4	1180.6	93.7
Total Larvae (includes all species collected)	20.5	7.9	34.5	23.0	3.9	3.4	0.4	0.2	0.03	1.3	86.9	1449.8	—
	172.3	13.2	25.7	41.5	8.2	3.1	0.2	1.1	0.5	*	1262.3	1193.7	—

*Pond frozen, no sampling.
**Station NP E frozen, not sampled.

Table G.2. 2-6

MEAN CATCH (PER 100 M³)OF SELECTED FISH EGGS TAKEN AT STATIONS BIS A THROUGH BIS D IN BLOCK ISLAND SOUND CALCULATED FOR MONTHLY PERIODS, APRIL 1974 — MARCH 1976 (Sheet 1 of 2)

Upper Value Represents 1974-75 Catch; Lower Value, 1975-76

Species	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	% of Total
B. tyrannus	0	0.5	0.3	0	0	0	0.1	0	0	0	0	0	0.01
	0	0.1	0.1	0	0	0	5.8	12.8	0	0	0	0	0.1
Anchoa mitchilli	0	0	12.1	1.3	0	0	0	0	0	0	0	0	0.2
	0	0	5.4	26.1	0	0	0	0	0	0	0	0	0.6
Enchelyopus-Urophycis-	16.8*	16.5	35.0	8.0	1.3	1.0	0	0	0.04*	0.07*	1.1*	14.2*	0.9
Peprilus	14.9	20.1	34.1	21.8	3.2	0.1	0	0	0.2*	0.9*	0.4*	18.1*	1.6
E. cimbrius III	—	7.0	5.4	1.6	0.4	0.1	0.2	0	0	0	0	0	0.2
	—	12.5	5.8	0.6	0.1	0	0	0	0	0	0	0	0.8
G. morhua	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	0.2	0	0	0	0	0	6.6	9.3	11.6	3.1	5.0	0.2
P. virens	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	0	0	0	0	0	0	0	0	0	0	0.4	0.01
Gadidae or Gadid-	2.1	1.4	0.6	0.04	0	0	0.3	35.0	9.2	4.6	4.0	2.5	0.2
Glyptocephalus	1.6	0.4	0	0	0	0	0	6.6⁺	9.3⁺	11.6⁺	3.1⁺	5.4⁺	(0.3)
Merluccius-Stenotomus-	0	10.1	16.8	6.0	0.1	0.7	0	0	0	0	0	0	0.4
Cynoscion	0	3.0	73.2	12.0	0.1	0	0	0	0	0	0	0	1.4
Urophycis spp. III	0	0.4	10.1	4.0	0.2	0.1	0.07	0	0	0	0	0	0.1
	0	0	2.5	3.5	1.0	0	0.2	0	0	0	0	0	0.2
Labrid-*Limanda*	14.9	305.3	1774.9	774.2	15.1	0	0	0	0	0	0	1.4**	34.5
	4.4	240.4	1623.4	635.0	6.2	1.5	0	0	0	0	0	1.9**	40.3

*All considered to be *E. cimbrius* at this time.
**All considered to be *L. ferruginea* at this time.
⁺To permit comparisons with 1974 — 1975, *G. morhua* and *P. virens* have been added.

Table G.2. 2-6 (Cont.)

MEAN CATCH (PER 100 M^3) OF SELECTED FISH EGGS TAKEN AT STATIONS BIS A THROUGH BIS D IN BLOCK ISLAND SOUND CALCULATED FOR MONTHLY PERIODS, APRIL 1974 — MARCH 1976 (Sheet 2 of 2)

Upper Value Represents 1974-75 Catch, Lower Value, 1975-76

Species	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	% of Total
Labridae III	0	136.6	827.7	142.0	5.8	3.1	0	0	0	0	0	0	12.9
	0.1	79.2	425.9	326.1	2.0	0.1	0	0	0	0	0	0	13.8
S. scombrus	6.3	3419.0	78.5	0.7	0	0	0	0	0	0	0	0	47.6
	1.5	2267.6	9.9	0.9	0	0	0	0	0	0	0	0	34.3
Prionotus spp.	0	2.7	29.3	26.8	8.9	2.8	0.07	0	0	0	0	0	0.8
	0	0.9	22.9	24.4	9.9	[illegible].9	0	0	0	0	0	0	1.0
E. microstomus	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	4.7	13.2	11.9	3.8	0	0	0	0	0	0	0.5
Paralichthys-Scophthalmus	1.8	46.8	56.0	12.3	1.1	58.6	3.5	0	0	0	0	0	1.6
	0.9	109.1	108.0	35.5	3.7	17.7	11.0	0	0	0	0	0	4.2
Total eggs (total includes all species collected)	41.9	3947.5	2888.2	979.6	33.2	66.4	2.1	35.1	9.2	4.7	5.1	18.1	—
	26.4	2736.8	2338.7	1120.0	38.9	24.1	16.9	19.4	9.5	12.9	3.9	25.4	—

Table G.2. 2-7

MEAN CATCH (PER 100 M^3)OF SELECTED FISH LARVAE TAKEN AT STATIONS BIS A THROUGH BIS D IN BLOCK ISLAND SOUND CALCULATED FOR MOTHLY PERIODS, APRIL 1974 — MARCH 1976 (Sheet 1 of 2)

Upper Value Represents 1974-75 Catch, Lower Value 1975-76

Species	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	% of Total
B. tyrannus	0	0.04	3.1	12.5	0.1	0	0.3	0.6	0.1	0	0	0	1.7
	0	0.7	24.2	3.1	0	0	2.8	11.6	0.4	0	0	0	1.2
C. harengus harengus	0.02	0	0	0	0	0	0	0	0	1.5	0.4	0.8	0.1
	0.2	0	0	0	0	0	0	0	2.5	1.0	0.2	0.4	0.1
Anchoa spp.	0	0	1.8	133.2	0.5	0	0	0	0	0	0	0	14.5
	0	0	0	176.6	57.8	1.5	0	0	0	0	0	0	12.8
E. cimbrius	0.1	9.1	6.9	4.2	0.01	0.2	0	0	0	0	0	0	2.0
	0.2	10.6	19.5	1.5	0.06	0.7	0	0	0	0	0	0	1.5
G. morhua	0.1	0.4	0.1	0	0	0	0	0.2	0.2	1.1	0.1	0.7	0.1
	1.0	0.9	0.1	0	0	0	0	0	0	0.5	0.2	0.8	0.2
P. virens	0	0.02	0	0	0	0	0	0.2	0	0.5	0	0.1	0.02
	0.2	0.3	0	0	0	0	0	0	0	0.3	0	0	0.04
Menidia spp.	0.03	0	0.1	0.1	0.02	0	0	0	0	0	0	0	0.02
	0	0	0	0	0	0	0	0	0	0	0	0	0
C. regalis	0	0	0	0.4	0.02	0	0	0	0	0	0	0	1.4
	0	0	0.1	1.1	0	0	0	0	0	0	0	0	0.1
T. onitis	0	0.07	36.8	33.4	0.1	0	0.1	0	0	0	0	0	7.3
	0	0.3	48.1	107.4	3.6	1.4	0	0	0	0	0	0	8.5
T. adsperus	0	0.2	103.9	112.8	0.7	0	0	0	0	0	0	0	21.1
	0	0.1	369.0	202.6	3.3	0.2	0	0	0	0	0	0	31.0
U. subbifurcata	1.1	9.7	2.4	0.01	0	0	0	0	0	0	0	0	1.3
	1.2	11.3	1.5	0	0	0	0	0	0	0	0	0	0.8
P. gunnellus	0	0.02	0	0	0	0	0	0	0	5.7	0.1	0.1	0.1
	0.01	0	0	0	0	0	0	0	0	7.6	0.8	0.2	0.1

Table G.2. 2-7 (Cont.)

MEAN CATCH (PER 100 M^3) OF SELECTED FISH LARVAE TAKEN AT STATIONS BIS A THROUGH BIS D IN BLOCK ISLAND SOUND CALCULATED FOR MONTHLY PERIODS, APRIL 1974 — MARCH 1976 (Sheet 2 of 2)

Upper Value Represents 1974-75 Catch, Lower Value 1975-76

Species	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	% of Total
Ammodytes spp.	33.6	2.8	0	0	0	0	0	0	0.8	1.4	18.2	17.1	3.3
	34.1	7.2	0.05	0	0	0	0	0	3.7	11.8	1.5	2.3	5.3
S. scombrus	0	85.1	275.1	3.3	0	0	0	0	0	0	0	0	33.1
	0	98.3	364.0	2.8	0	0	0	0	0	0	0	0	21.3
Myoxocephalus spp.	4.9	1.2	0	0	0	0	0	0	0	0.1	1.7	3.6	0.6
	4.3	1.0	0	0	0	0	0	0	0	0	0	3.9	0.8
Liparis spp.	4.4	9.7	0.5	0	0	0.06	0	0	0	0	0	1.2	1.4
	3.4	7.2	1.1	0	0	0	0	0	0	0	0	0.5	0.9
E. microstomus	0	0	0	0	0.02	0	0	0	0	0	0	0	0.01
	0	0	0	1.5	18.3	6.6	0.3	0	0	0	0	0	1.0
P. dentatus	0	0	0	0	0	0	0.4	0.2	0.1	0	0	0	0.01
	0	0	0	0	0	0	0.8	0.7	0.4	0	0	0	0.02
P. oblongus	0	0	0.2	0.3	0.02	0.1	0	0	0	0	0	0	0.05
	0	0	0	5.4	0.9	0.5	0	0	0	0	0	0	0.4
S. aquosus	0	8.9	4.1	1.5	0.04	0.9	2.1	0.4	0	0	0	0	0.7
	0	1.7	25.5	2.4	0.4	0.9	2.1	0.2	0	0	0	0	1.4
L. ferruginea	1.0	20.0	4.0	0.2	0.04	0	0	0	0	0	0	0	2.6
	7.5	21.1	2.1	0.3	0	0	0	0	0	0	0	0	2.1
P. americanus	10.5	19.8	5.1	0	0	0	0	0	0	0.1	10.4	21.3	3.9
	22.4	17.4	9.0	0	0	0	0	0	0	0	2.0	7.8	4.7
Total larvae (total	55.9	161.7	461.6	342.1	5.5	4.5	2.9	2.1	1.3	10.6	31[illegible]	45.0	—
includes all species collected)	74.5	177.8	864.6	608.8	122.0	15.1	6.2	12.9	7.0	21.2	4[illegible]	15.5	—

Table G.2.2-8
PERCENT ABUNDANCE OF ICHTHYOPLANKTON

Major Species	Eggs	Larvae
Mackerel	41%	27%
Cunner	37%*	26%
Anchovy	0.4%	14%
Tautog	11%*	8%
Winter Flounder	—	4%
Sand Launce	—	4%
Yellowtail Flounder	3%*	2%
	92%	85%

*Eggs not identifiable within these three; number represents ratio of larval abundance times the percent of eggs for the group.

Table G.2.3-1

FINFISH AND MACROINVERTEBRATES CAPTURED IN NINIGRET POND AND BLOCK ISLAND SOUND APRIL 1974 — MARCH 1976 (Sheet 1 of 2)

Common Name	Scientific Name	Ninigret Pond		Block Island Sound	
		1974	1975	1974	1975
Dusky shark	*Carcharhinus obscurus*			*	
Smooth dogfish	*Mustelus canis*			*	*
Spiny dogfish	*Squalus acanthias*			*	
Atlantic torpedo	*Torpedo nobiliana*			*	
Big skate	*Raja binoculata*				*
Little skate	*Raja erinacea*		*	*	*
Barndoor skate	*Raja laevis*			*	
Winter skate	*Raja ocellata*			*	
American eel	*Anguilla rostrata*	*	*	*	*
Blueback herring	*Alosa aestivalis*		*		*
Hickory shad	*Alosa mediocris*		*		
Alewife	*Alosa pseudoharengus*		*	*	*
American shad	*Alosa sapidissima*		*	*	*
Atlantic menhaden	*Brevoortia tyrannus*	*	*		
Atlantic herring	*Clupea harengus harengus*		*	*	*
Oyster toadfish	*Opsanus tau*	*	*		
Scup	*Stenotomus chrysops*	*	*	*	*
Weakfish	*Cynoscion regalis*		*	*	*
Northern kingfish	*Menticirrhus saxatilis*	*		*	
Spot	*Leiostomus xanthurus*		*		
Spotfin butterflyfish	*Chaetodon ocellatus*		*		
Tautog	*Tautoga onitis*	*	*	*	*
Cunner	*Tautogolabrus adspersus*	*	*	*	*
White mullet	*Mugil curema*		*		
Northern sennet	*Sphyraena borealis*		*		
Atlantic bonito	*Sarda sarda*		*		
Atlantic mackerel	*Scomber scombrus*		*		*
Chub mackerel	*Scomber jayonicus*		*		*
Butterfish	*Peprilus triacanthus*		*	*	*
Northern sea robin	*Prionotus carolinus*	*	*	*	*
Striped sea robin	*Prionotus evolans*			*	*
Sea raven	*Hemitripterus americanus*			*	*
Grubby	*Myoxocephalus aenaeus*		*		
Longhorn sculpin	*Myoxocephalus octodecemspinosus*	*	*	*	*
Smallmouth flounder	*Etropus microstomus*			*	
Summer flounder (fluke)	*Paralichthys dentatus*	*	*	*	*
Fourspot flounder	*Paralichthys oblongus*			*	*
Windowpane	*Scophthalmus aquosus*		*	*	*
Yellowtail flounder	*Limanda ferruginea*			*	*
Winter flounder	*Pseudopleuronectes americanus*	*	*	*	*
Hogchoker	*Trinectes maculatus*	*	*		
Goosefish	*Lophius americanus*			*	*
Atlantic cod	*Gadus morhua*		*	*	*
Haddock	*Melanogrammus aeglefinis*			*	*
Silver hake (whiting)	*Merluccius bilinearis*		*	*	*
Atlantic tomcod	*Microgadus tomcod*	*	*		

Table G.2.3-1 (Cont.)

FINFISH AND MACROINVERTEBRATES CAPTURED IN NINIGRET POND AND BLOCK ISLAND SOUND APRIL 1974 — MARCH 1976 (Sheet 2 of 2)

Common Name	Scientific Name	Ninigret Pond		Block Island Sound	
		1974	1975	1974	1975
Pollock	*Pollachius virens*		*		
Red hake	*Urophycis chuss*			*	*
Spotted hake	*Urophycis regis*	*		*	
White hake	*Urophycis tenuis*		*	*	
Ocean pout	*Macrozoarces americanus*			*	*
Atlantic needlefish	*Strongylura marina*	*	*		
Sheepshead minnow	*Cyprinodon variegatus*	*	*		
Mummichog	*Fundulus heteroclitus*	*	*		
Striped killifish	*Fundulus majalis*	*	*		
Silversides	*Menidia* spp.	*			
Tidewater silverside	*Menidia berryllina*	*	*		
Atlantic silverside	*Menidia menidia*	*	*	*	
Fourspine stickleback	*Apeltes quadracus*	*	*		
Threespine stickleback	*Gasterosteus aculeatus*	*	*		
Bluespotted cornet fish	*Fistularia tabacaria*		*		
Sea horse	*Hippocampus erectus*		*		
Northern pipefish	*Syngnathus fuscus*	*	*		
White perch	*Morone americana*		*		
Striped bass	*Morone saxatilis*		*	*	
Black sea bass	*Centropristis striata*		*	*	*
Snowy grouper	*Epinephelus niveatus*		*		
Bigeye	*Priacanthus arenatus*		*		
Bluefish	*Pomatomus saltatrix*	*	*	*	*
Crevalle jack	*Caranx hippos*	*	*	*	
Atlantic moonfish	*Vomer setapinnis*			*	
Banded rudderfish	*Seriola zonata*			*	
Orange filefish	*Aluterus schoepfi*	*	*	*	*
Planehead filefish	*Monacanthus hispidus*		*		*
Northern puffer	*Sphoeroides maculatus*				*
Squid	*Loligo pealei*			*	*
American lobster	*Homarus americanus*			*	*

Table G.2.3-2

CATCH OF TWO COMMERCIAL TRAWLERS JULY 1974 — MARCH 1976[1]

Total Tows: 497

Total Pounds: 459,546

Species	Percent of Catch by Weight
Silver Hake	29
Skate	17
Hake and Ling	12
Herring	10
Flounder[2]	8
Squid	4
Sculpin	3
Scup	3
Ocean Pout	2
Dogfish	2
Butterfish	1
Fluke	1
Cod	1
All Other	7

(1) Location shown in Figure G.2.3-1.
(2) Primarily winter flounder and windowpane.

Table G.2.3-3

PRINCIPLE NEKTON SPECIES TAKEN BY 45' STERN TRAWLER AT TWO TRANSETS[1] APRIL 1975 — MARCH 1976

Species	Inshore	Offshore	Combined	% of Total
Butterfish[2]	882	6428	7310	39.1
Windowpane[2]	801	1199	2000	10.7
Scup	337	1581	1918	10.3
Little Skate[3]	422	1329	1751	9.4
Squid	617	1134	1751	9.4
Winter Flounder[3]	125	1393	1518	8.1
Ocean Pout[3]	106	429	535	2.9
Longhorn Sculpin[3]	16	394	410	2.2
Red Hake	2	357	359	1.9
Silver Hake[3]	12	330	342	1.8
Northern Sea Robin	160	127	287	1.5
Summer Flounder	76	66	142	0.8
All other	131	255	386	2.1

(1) See Figure G.2.3-1.
(2) Analysis of variance indicates that this species is more abundant offshore with 95% confidence.
(3) Analysis of variance indicates that this species is more abundant offshore with 99% confidence.

Table G.3.2-1

Nearfield Thermal Plume Characteristics

Current Velocity (ft/sec)	Surface ΔT_{max} (^oF)	Volume Within Isotherm (Acre-ft)				
		30^oF	20^oF	10^oF	6^oF	3^oF
1	3.6	0.011	0.046	0.78	15	59
0.5	4.8	0.011	0.048	1.3	20	330
0.0	6.4	0.012	0.062	3.4	29	750

Table G3.2-2 Transient Plume Characteristics

CURRENT SPEED (FT/SEC)	ISOTHERM (°F) / DILUTION	30 / 1.23	20 / 1.85	10 / 3.70	4 / 9.25	3 / 12.3	2.5 / 14.8
1.0 Time = T/4	Distance from Discharge (ft)	12	19	48	----	2400	6300
	Travel Time (sec)	0.65	1.1	5.5	----	2040	3960
	Centerline Velocity (ft/sec)	18	12	4.6	----	1.15	1.09
	Surface Area (acres)	0	0	0	0	16	71
	Isotherm Volume (acre/ft)	0.011	0.046	0.78	----	350	997
0.5 Time = 5T/12	Distance from Discharge (ft)	12	20	57	2010	3600	5700
	Travel Time (sec)	0.65	1.2	7.6	1330	3500	4700
	Centerline Velocity (ft/sec)	18	11	3.9	0.83	0.65	0.49
	Surface Area (acres)	0	0	0	7.1	33	76
	Isotherm Volume (acre/ft)	0.011	0.048	1.3	191	580	1800
0.0 Time = T/2	Distance from Discharge (ft)	12	21	78	2250	3200	6000
	Travel Time (sec)	0.66	1.3	14	1450	3470	7900
	Centerline Velocity (ft/sec)	18	11	2.8	1.5	0.97	0.12
	Surface Area (acres)	0	0	0	12	33	131
	Isotherm Volume (acre/ft)	0.012	0.062	3.4	360	610	2270
0.5 Time = 7T/12	Distance from Discharge (ft)	12	20	57	1560	3400	4800
	Travel Time (sec)	0.65	1.2	7.6	1530	3300	6200
	Centerline Velocity (ft/sec)	18	11	3.9	0.85	0.64	0.63
	Surface Area (acres)	0	0	0	5.0	32	64
	Isotherm Volume (acre/ft)	0.011	0.048	1.3	170	640	1150

Table G.3.4-1

CHEMICAL DISCHARGED DURING STEAM GENERATOR BLOWDOWN

Chemical	Normal Blowdown Discharge (Eight Steam Generators at 5 GPM Each) – LB/Day	Maximum Blowdown Discharge (One Steam Generator at 100 GPM) – LB/Day
Chloride	0.48	1.2
Fluoride	0.48	1.2
Hydrazine	0.12	0.3
Silica	0.48	1.2
Ammonia	0.24	[illegible]
Copper	0.024	0.06
Dissolved Iron	0.24	0.6
Lead	0.0024	0.006

Table G.4.1-1
REPRESENTATIVE IMPORTANT SPECIES

Common Name	Scientific Name
Atlantic menhaden	*Brevoortia syrannus*
Bay anchovy	*Anchoa mitchilli*
Silver hake (whiting)	*Merluccius bilinearis*
Striped bass	*Morone saxatilis*
Bluefish	*Pomatomus saltatrix*
Scup	*Stenotomus chrysops*
Cunner	*Tautogolabrus adspersus*
Sand lance	*Ammodytes americanus*
Atlantic mackerel	*Scomber scombrus*
Butterfish	*Peprilus triacanthus*
Winter flounder	*Pseudopleuronectes americanus*
Blue mussel	*Mytilus edulis*
Hard clam	*Mercenaria mercenaria*
Squid	*Loligo pealei*
Sand shrimp	*Crangon septimspinosus*
American lobster	*Homarus americanus*
Eelgrass	*Zostera marina*

Table G.4.1-2
ENTRAINMENT OF EGGS AND LARVAE OF THE REPRESENTATIVE IMPORTANT SPECIES ASSUMING 100% POWER DURING STUDY PERIOD(1)

4

Species	Year	Eggs	Larvae
Atlantic Menhaden	1974	0	$2.027x10^7$
	1975	$8.592x10^6$	$3.789x10^7$
	Average	$4.296x10^6$	$2.908x10^7$
Bay Anchovy	1974	$1.029x10^7$	$5.243x10^8$
	1975	$1.126x10^8$	$5.131x10^8$
	Average	$6.147x10^7$	$5.187x10^8$
Silver Hake	1974	$3.054x10^7$	$8.614x10^5$
	1975	$1.108x10^8$	$4.281x10^6$
	Average	$7.069x10^7$	$2.571x10^6$
Striped Bass	—	—	—
Bluefish	—	—	—
Scup	1974	$2.946x10^7$	$2.169x10^6$
	1975	$1.299x10^8$	$7.429x10^6$
	Average	$7.969x10^7$	$4.799x10^6$
Cunner	1974	$6.883x10^9$	$4.142x10^8$
	1975	$6.202x10^9$	$7.471x10^8$
	Average	$6.543x10^9$	$5.806x10^8$
Sand Lance	1974-1975	—	$1.763x10^8$
	1975-1976	—	$4.577x10^7$
	Average	—	$1.110x10^8$
Atlantic Mackerel	1974	$3.558x10^9$	$2.038x10^8$
	1975	$2.766x10^9$	$2.748x10^8$
	Average	$3.162x10^9$	$2.393x10^8$
Butterfish	1974	$2.832x10^7$	$6.621x10^6$
	1975	$8.889x10^7$	$1.876x10^7$
	Average	$5.861x10^7$	$1.269x10^7$
Winter Flounder	1975	—	$4.577x10^8$
	1976	—	$2.221x10^8$
	Average	—	$3.399x10^8$
TOTAL ICHTHYOPLANKTON	Year 1	$1.054x10^{10}$	$1.806x10^9$
	Year 2	$9.419x10^9$	$1.874x10^9$
	Average	$9.979x10^9$	$1.840x10^9$
Mussel	1974-75	—	$6.393x10^{11}$
	1975-76	—	$2.799x10^{11}$
	Average	—	$4.597x10^{11}$
Hard Clam	—	—	(2)
Squid	1977	—	$1.983x10^6$
Sand Shrimp	1978-1979	—	$1.982x10^9$
American Lobster	1976 (3)	—	$1.251x10^6$
	1977	—	$4.948x10^5$
	Average	—	$8.729x10^5$
Eelgrass	—	—	—

(1) Numbers based on area under temporal abundance curve at BIS-A or EB-B (Figure G.2.0-1) times plant flow

(2) Density is extremely low

(3) Estimate from an incomplete year and surface samples only

(4) Revision 4 to Appendix G.

Table G.4.2-1
LOBSTER LIFE TABLE STATISTICS UNEXPLOITED POPULATION

Age Class	Fecundity Per Adult[1]	Survival Rate[2]	Relative Frequency
0	0	.00005951[3]	1,000,000
1	0	.86	59.51
2	0	.86	51.18
3	0	.86	44.01
4	0	.86	37.85
5	221	.86	32.55
6	1,679	.86	28.00
7	2,359	.86	24.08
8	3,129	.86	20.71
9	3,975	.86	17.81
10	4,890	.86	15.31
11	5,855	.86	13.17
12	6,865	.86	11.33
13	7,904	.86	9.74
14	8,939	.86	8.38
15	10,004	.86	7.20
16	11,052	.86	6.20
17	12,086	.86	5.33
18	13,117	.86	4.58
19	14,112	.86	3.94
20	15,108	0	3.39

[1] This column represents the first row of the Leslie matrix describing a stable population with a maximum age of 20.

[2] This column represents the subdiagonal of the above matrix.

[3]
$$S_o = \frac{1}{F_1 + \sum_{i=1}^{k}\left[F_{i+1}\left(\prod_{j=1}^{i} S_j\right)\right]}$$
as demonstrated by Vaughan and Saila (1976).

Table G.6.0-1

REPRESENTATIVE IMPORTANT SPECIES - IMPACT SUMMARY

Species	PLANT OPERATION Entrapment	Entrainment	Thermal	Cooling Water System Construction	Overall Cumulative Response
Atlantic menhaden	Entrapment potential: Medium to high. Overall impact considered negligible	No appreciable harm expected	No appreciable effect due to species' thermal tolerance capability	Negligible impact predicted	No appreciable harm predicted
Bay Anchovy	Medium to high. Overall impact considered small	No appreciable harm	Species very thermally tolerant; consequently, no impact expected.	No appreciable harm predicted	Overall impact considered minimal
Silver Hake	Entrapment potential considered minimal	Minimal impact predicted	Little or no effect expected	No adverse effects predicted	No appreciable harm predicted
Striped Bass	Entrapment potential considered negligible	Not applicable	Species very thermally tolerant; therefore, no impact predicted	Negligible impact predicted	Minimal impact expected
Bluefish	Minimal entrapment potential	Not applicable	No impact expected due to species' thermal tolerance	No construction effects expected	No appreciable harm predicted
Scup	Overall entrapment potential considered small	No significant impact	Negligible impact predicted	Minimal construction impacts expected	Minimal impact expected
Cunner	Potential of localized impact; however, overall impact considered minimal	3% pop. reductions negligible impact	Minimal impact expected	Possibility of temporary disruption; however, overall impact is small	Possibility of some localized impact or displacement
Sand Lance	Low to medium entrapment potential. Total impact considered small	Possibility of local entrainment effect	Possibility of some plume contact, both temporally and spatially. Total impact considered minimal	Possible temporary effect on localized egg densities. Overall impact small	Localized exclusion effect considered possible

Table G.6.0-1 (Continued)

REPRESENTATIVE IMPORTANT SPECIES - IMPACT SUMMARY

Species	PLANT OPERATION Entrapment	Entrainment	Thermal	Cooling Water System Construction	Overall Cumulative Response
Atlantic mackerel	Entrapment not considered a potential impact	Entrainment not of sufficient magnitude to disrupt normal population	Negligible thermal impact predicted	No appreciable construction effect predicted	Overall effects of plant operation considered small
Butterfish	Medium to high entrapment potential; however, minimal impact expected due to low numbers	Negligible entrainment impact predicted due to relatively low densities entrained	Minimal impact due to species' thermal tolerance	Construction effects considered temporary resulting in no appreciable impact	Cumulative impact considered not significant
Winter flounder	Minimal entrapment potential due to species' bottom affinity	As a result of low densities entrained, minimal effects predicted	Negligible thermal effects expected as a result of species' thermal tolerance	Temporary disruption in area of construction	Minimal effects resulting from construction and operation expected
Blue mussel	Not applicable	Overall entrainment effects considered slight	Some effect possible for a very small area. Overall thermal effects considered small, however	Possible temporary disruption, however, recolonization should occur	Possibility of some localized exclusion, however, effects considered negligible
Hard clam	Not applicable	Negligible entrainment effects due to low plankton densities	No thermal effect expected due to species' location in Ninigret Pond	Not applicable	Cumulative impact considered minimal
Long-finned squid	Negligible effects expected as a result of species' swimming ability	No egg entrainment; consequently minimal entrainment impact expected	No thermal effect expected due to thermal tolerance of squid	Possibility of some disruption of demersal eggs; however, only temporary effect	No appreciable impact as a result of plant construction or operation
Sand shrimp	Negligible effect due to organism's bottom affinity	Minimal entrainment impact expected	Possibility of some bottom plume contact; however, area considered small	Temporary disruption possible within area of construction	Possibility of small area affected by thermal discharge. Overall effects considered small

Table G.6.0-1 (Continued)

REPRESENTATIVE IMPORTANT SPECIES - IMPACT SUMMARY

Species	PLANT OPERATION Entrapment	Entrainment	Thermal	Cooling Water System Construction	Overall Cumulative Response
Eelgrass	Not applicable	Not applicable	Negligible	Not applicable	Cumulative effects predicted to be negligible
American lobster	Not applicable	Minimal impact resulting from entrainment	Thermal impact considered minimal	Temporary exclusion; however, construction effect considered small	Overall construction and operation effect considered minimal.

APPLICATION FOR A DEPARTMENT OF THE ARMY PERMIT

For use of this form, see EP 1145-2-1

The Department of the Army permit program is authorized by Section 10 of the River and Harbor Act of 1899, Section 404 of P. L. 92-500 and Section 103 of P. L. 92-532. These laws require permits authorizing structures and work in or affecting navigable waters of the United States, the discharge of dredged or fill material into waters of the United States, and the transportation of dredged material for the purpose of dumping it into ocean waters. Information provided in ENG Form 4345 will be used in evaluating the application for a permit. Information in the application is made a matter of public record through issuance of a public notice. Disclosure of the information requested is voluntary; however, the data requested are necessary in order to communicate with the applicant and to evaluate the permit application. If necessary information is not provided, the permit application cannot be processed nor can a permit be issued.

One set of original drawings or good reproducible copies which show the location and character of the proposed activity must be attached to this application (see sample drawings and checklist) and be submitted to the District Engineer having jurisdiction over the location of the proposed activity. An application that is not completed in full will be returned.

Revised 5/79

1. Application number (To be assigned by Corps)

23-78-269

2. Date

26 April 1978

Day Mo. Yr.

3. For Corps use only.

4. Name and address of applicant.

New England Power Company
20 Turnpike Road
Westborough, MA 01581

Telephone no. during business hours

A/C (617) 366-9011

A/C ( ) ________

5. Name, address and title of authorized agent.

Joseph Harrington
Project Manager - NEP 1&2
20 Turnpike Rd., Westborough, MA 01581

Telephone no. during business hours

A/C 617) 366-9011

A/C ( ) ________

6. Describe in detail the proposed activity, its purpose and intended use (private, public, commercial or other) including description of the type of structures, if any to be erected on fills, or pile or float-supported platforms, the type, composition and quantity of materials to be discharged or dumped and means of conveyance, and the source of discharge or fill material. If additional space is needed, use Block 14.

See attached information for:
6a. Offshore structures in Block Island Sound (pages 3,4 & 5)
6b. Barge unloading facility in Pt. Judith Pond (page 5)
6c. Site related work (page 6)

7. Names, addresses and telephone numbers of adjoining property owners, lessees, etc., whose property also adjoins the waterway.

Item 6a. See sheet 1.

Dept. of Environmental Management
83 Park Street
Providence, RI 02908

Sarah J. Browning (Does not adjoin waterway)
Post Road RFD#1
Bradford, RI 02808

Item 6b. See sheet 11
Item 6c. See Item 14 (pgs.6&7) & sheet 1

Bruce C. Glen
Post Road
Charlestown, RI 02813

U.S. Fish and Wildlife Service
Division of Refuges
1 Gateway Center
Newton Corner, MA 02158

8. Location where proposed activity exists or will occur.

Address: 6a., 6c. Naval Auxiliary Landing Field
6b. 128 Pond Street

Street, road or other descriptive location

6a. and 6c. Charlestown; 6b. South Kingstown

In or near city or town

6a, 6b, and 6c Washington RI (Charlestown) 02813 (So. Kingstown) 02881

County State Zip Code

Tax Assessors Description: (If known)

Map No. Subdiv. No. Lot No.

Sec. Twp. Rge.

9. Name of waterway at location of the activity.

6a. Block Island Sound
6b. Pt. Judith Pond
6c. Ninigret Pond

ENG Form 4345, 1 OCT 77 Edition of 1 Apr 74 is obsolete.

10. Date activity is proposed to commence. 6a. Fall 1983; 6b. Fall 1981; 6c. 1980

Date activity is expected to be completed 6a. Fall 1985; 6b. Spring 1982; 6c. 1982

11. Is any portion of the activity for which authorization is sought now complete? ☐ YES ☒ NO
If answer is "Yes" give reasons in the remark section. Month and year the activity was completed ______________________. Indicate the existing work on the drawings.

12. List all approvals or certifications required by other federal, interstate, state or local agencies for any structures, construction, discharges, deposits or other activities described in this application.

Issuing Agency	Type Approval	Identification No.	Date of Application	Date of Approval

See attached sheets (Pages 8 and 9)

13. Has any agency denied approval for the activity described herein or for any activity directly related to the activity described herein?

☐ Yes ☒ No (If "Yes" explain in remarks)

14. Remarks or additional information. Property owners, Item 6c, site related work.
See Sheet 1.

L. V. Gaddes
151 Oak Lawn Avenue
Cranston, RI 02920

Lawrence F. and Sarah A. Whittemore
P.O. Box 245
Charlestown, RI 02813
and
1161 Lairel Avenue
Winnetka, IL 60093

15. Application is hereby made for a permit or permits to authorize the activities described herein. I certify that I am familiar with the information contained in this application, and that to the best of my knowledge and belief such information is true, complete, and accurate. I further certify that I possess the authority to undertake the proposed activities.

Joseph Harrington
Signature of Applicant or Authorized Agent

The application must be signed by the applicant; however, it may be signed by a duly authorized agent (named in Item 5) if this form is accompanied by a statement by the applicant designating the agent and agreeing to furnish upon request, supplemental information in support of the application.

18 U. S. C. Section 1001 provides that: Whoever, in any manner within the jurisdiction of any department or agency of The United States knowingly and willfully falsifies, conceals, or covers up by any trick, scheme, or device a material fact or makes any false, fictitious or fraudulent statements or representations or makes or uses any false writing or document knowing same to contain any false fictitious or fraudulent statement or entry, shall be fined not more than $10,000 or imprisioned not more than five years, or both. Do not send a permit processing fee with this application. The appropriate fee will be assessed when a permit is issued.

Item 6

6a. Offshore Structures in Block Island Sound

New England Power Company has proposed constructing a two unit nuclear power station at the abandoned Naval Auxiliary Landing Field in Charlestown, Rhode Island (Sheets 7 and 8). The Offshore intakes and discharge diffuser are to be constructed in Block Island Sound as part of a once-through cooling system to provide for heat removal from the main condensers and service water heat exchangers (Sheets 2 and 3). The intake system includes three identical offshore submerged intakes, one 18 foot inside diameter tunnel, an intake transition structure and a pumphouse located on the site (Sheets 2 and 3). The discharge system includes a discharge transition structure, one 18 foot inside diameter tunnel, vertical riser shafts, and two 14 foot inside diameter discharge pipes with diffuser nozzles attached. The 200,000 cubic yards of material from tunnel construction will be disposed of at a suitable onshore location.

The intake structures will be located approximately 2000 feet south of East Beach where the water depth is approximately 30 feet (Sheets 1 and 4). The velocity of the water at the inlets will be no greater than 1.5 feet/second. The flow rate into each structure will be 285,000 gpm and is maintained during normal operation throughout the year. The water from the three intake structures will combine and flow through the 18 foot inside diameter tunnel, approximately 6,200 feet in length, to the plant site.

The discharge diffuser will receive the water, heated to a nominal 37°F above the ambient, from the plant through the discharge tunnel that will extend approximately 6,400 feet from the plant site. The discharge diffuser will consist of two parallel 14 foot diffuser pipes buried in an excavated trench with nozzles attached to the pipes and protruding above the ocean bottom. Vertical riser shafts will connect the diffuser pipes to the horizontal tunnel. One of the diffuser pipes will extend 600 feet seaward from the vertical riser shafts; the other will extend 1,200 feet seaward. Each diffuser will have 17 equally spaced two foot diameter nozzles, each having an exit velocity of 18 fps. The nozzles for the 600 foot diffuser will start at the vertical riser shafts and the nozzles for the 1,200 foot diffuser will start 600 feet seaward of the riser shafts.

Construction Techniques

The construction of the tunnels through the rock will be accomplished by conventional methods (drilling and blasting) or by using a tunnel boring machine; both methods working from the plant site. Dewatering effluent from the tunneling operation will be processed for separation of any contaminants such as oils, diesel fuels, etc. The processed water will then be pumped to a settling basin as described in Applicant's application for a NPDES permit.

Offshore vertical shafts will connect the deep bedrock tunnels to the intake structures and discharge diffuser. These shafts may be constructed from a floating vessel commonly referred to as a jack-up barge. The jack-up barge will be positioned over the location of the shaft, and a steel casing then driven through the overburden deposits. Once the casing is firmly seated on bedrock, the overburden within the casing will be removed, and a large rock roller bit drill will be used to drill downward through the bedrock. A cylindrical steel shaft with a concrete lining will then be installed in the casing and anchored to the bedrock with concrete grout. The steel shaft will contain diaphragm covers and valves to ensure that the ocean water does not enter the shaft or tunnels until the appropriate time in the construction sequence. The completed steel shafts will support the three intake structures and also provide a transition between the discharge tunnel and the pipe discharge diffuser. Material excavated from within the casings, estimated not to exceed 3000 cubic yards, will be deposited on the sea bed adjacent to the excavation.

A typical intake structure is shown on Sheet 5. The intakes will be constructed of reinforced, precast concrete or metal and barged or towed offshore for installation, or constructed in the dry utilizing steel cofferdams. Little, if any, environmental impact is associated with the operation.

Sheet 6 is a schematic view of the multiport discharge diffuser through which the cooling water will be discharged. The diffuser pipes will be buried under the ocean bottom as shown, and will be installed subaqueously in an open cut excavation.

Clamshell or bucket dredging will be used to remove the sediment from the diffuser pipe excavation. The total amount of sediment to be removed is approximately 122,000 cubic yards (includes 3000 cubic yards removed from the riser shafts), and will be placed alongside the trench. The diffuser pipes will be supported by approximately 14,000 cubic yards of clean bedding material. It is anticipated that the excavated material will be suitable for use as backfill and subsequently up to approximately 94,600 cubic yards will be placed back in the trench after the diffuser pipes are installed in the trench. The excess material will be naturally distributed over the affected area such that the final bottom contours will not change significantly from original conditions. The final decision on the suitability of the material for backfilling will be determined from test borings, for which a Corps of Engineers permit has been received (Permit No. RI-QUON-78-167). If the excavated material is not suitable for use as backfill, it will be disposed of at an approved location.

An alternate construction method will be considered should the boring program determine that geological conditions are suitable. The bedrock tunnels would be extended the entire 1200 foot length of the diffuser. The diffuser nozzles would be installed utilizing a drilled-in concept, whereby diffuser nozzles are directly connected to the bedrock tunnel via individual riser shafts of appropriate size.

6b. Barge Unloading Facility

A barge unloading facility is required for the delivery of heavy and/or large equipment. The proposed location is the Silver Spring Cove Marina in South Kingstown. After offloading, the equipment will ultimately be transported to the site, approximately 11 miles away, by road.

The existing marina will be upgraded to service barges approximately 45 feet in width, 175 to 200 feet in length and requiring drafts up to 5 feet. Improvements include the installation of a steel sheet piling bulkhead and wood piles according to the general arrangement shown in Sheet 10. Additionally, Applicant intends to dredge, and maintain while in use, the channel from the proposed bulkhead to buoy "C-25" as indicated in Sheet 9. Total material to be dredged is approximately 17,000 cubic yards. Sediment composition is described in the attachment. Sampling locations are depicted on Sheet 9. Sediments were collected from the top 6-12 inches with a gravity corer.

Applicant plans to hydraulically dredge the channel from the buoy C-25 in front of the Ram Point Marina to the beginning of the barge slip area. The hydraulic dredge will pump the slurry to a holding basin for dewatering. Applicant will construct this holding basin in the barge slip area by building a 1000 cubic yard earth dike (or sheet pile wall) out from the corner of the Silver Spring Cove Marina to the Route 1 roadway embankment. This dike will be constructed prior to beginning any dredge work. After the dredge material is pumped to this holding area, the spoil material will be allowed to drain naturally or be mechanically dewatered in the basin. Once the material has been dewatered, it will be loaded onto trucks for transportation to an upland disposal area.

The loading for transportation will be done by either a clam shell or front end loader since the holding basin would be dried out during the operation. This area would then be excavated down to the desired grade. If the existing bedding material in the barge slip area is not suitable for supporting the barge, then clean structural fill, not to exceed approximately 500 cu yds, would be placed in that area. The sheet pile bulkhead will be constructed during the excavation of the holding basin. Once the holding basin area has been completed, the earth dike would be removed and construction in the tidal zone will be complete. During the construction period, it is anticipated that the marina boat haul will be temporarily relocated as shown on sheet 10.

6c. Site Related Work

As part of the site erosion control program, a settling basin will be built to clarify site runoff. The settling basin will discharge into a percolation channel which leads to Ninigret Pond (Sheet 12). The channel will be formed by excavating a total of 4,400 cu yds and then lining the channel with 1,050 cu yds of 8 inch diameter riprap stone. Approximately 130 cu yds of the excavation and 100 cu yds of stone lining will lie below MHW. A riprap apron in Ninigret Pond will be laid to prevent scour. No excavation is proposed in the Pond below the normal high water mark. As shown in Sheet 13, no wetlands will be affected by this structure.

Item 14

6a. Offshore Structures in Block Island Sound (Additional Information)

Submarine Cables

A submarine cable area is approximately 2,000 yards west of the proposed offshore work area as shown in sheet 1 (reproduced from NOAA/NOS Chart 13215). A transatlantic cable comes ashore at Green Hill Point which is approximately 3 nautical miles to the east of the work area. Both of these cable areas are distant enough from the work area that there is no possibility of damage to the cables.

Ship Traffic

There are no designated shipping channels or lanes in Block Island Sound on NOAA/NOS Chart 13215. The chart does indicate seaward limits for commerical fish traps which extend approximately 1,500 yards from the coast. Within this area large fish nets or traps (1/2 mile x 1/2 mile area) may be placed and attended to, starting in late spring and continuing into the late fall. The proposed work site for the offshore structures is within this fishing area.

Block Island Sound is frequently used as a deep navigable waterway for ship traffic between Long Island Sound and Narragansett Bay and areas farther to the east, e.g., Buzzards Bay, Cape Cod, etc. These vessels do not pass close enough to the offshore construction site to constitute a hazard to the work platform or vessels servicing the work platform. The work platform will not be a hazard to commercial shipping, because shipping generally keeps about 4 miles off the East Beach coastline.

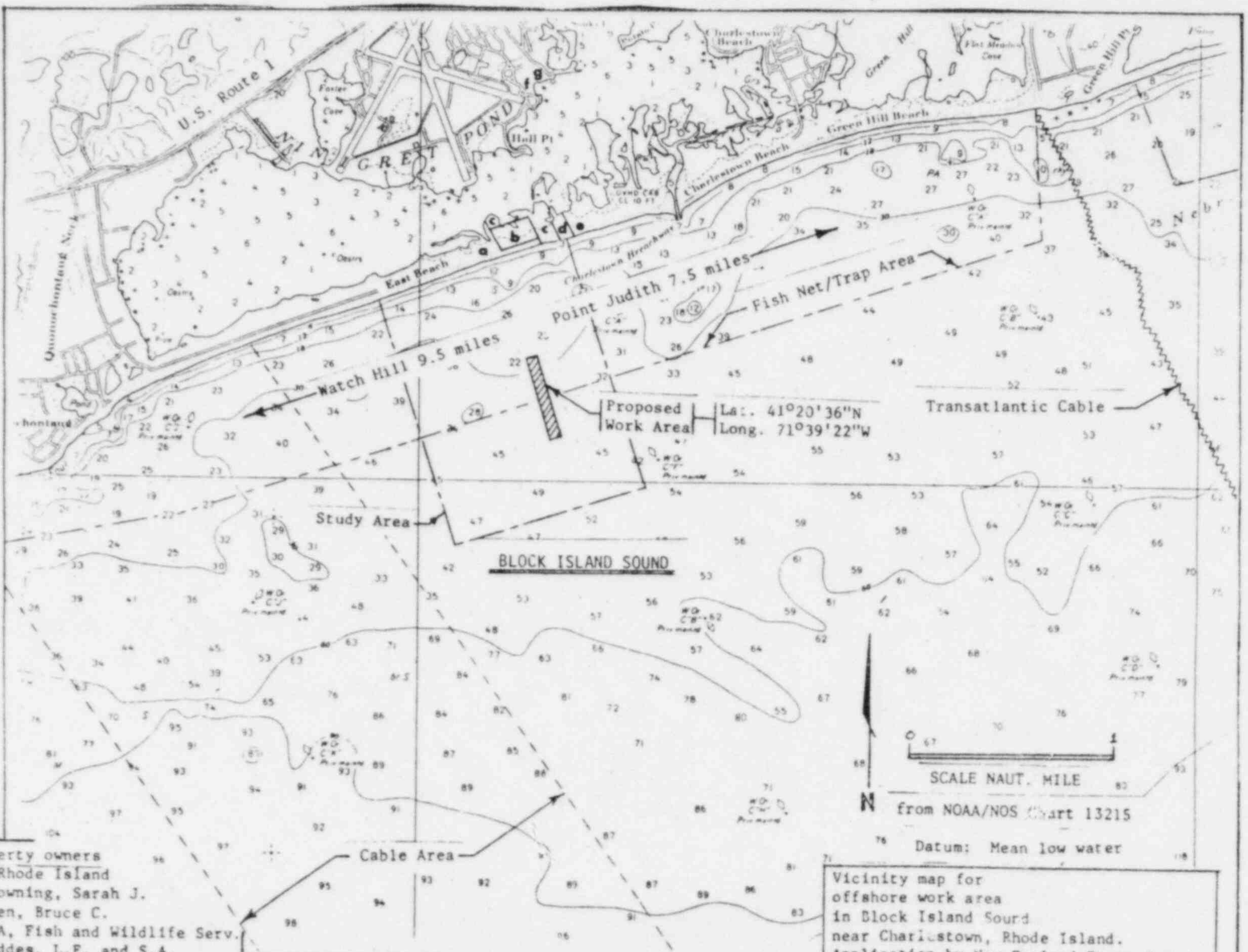
Small pleasure craft frequent the nearshore area but will be able to avoid the work area since they rely on visual navigation when close to the coast. Proper navigational aids and warning lights or bells will be installed and maintained at the work area as required by the U.S. Coast Guard.

Ferry boat traffic in Block Island Sound consists of ferry service from New London, Connecticut; Point Judith, Newport and Providence, Rhode Island; all to Block Island. The nearest of these ferry routes to the offshore work area is approximately six miles, and therefore neither is considered a hazard to the other.

Item 12

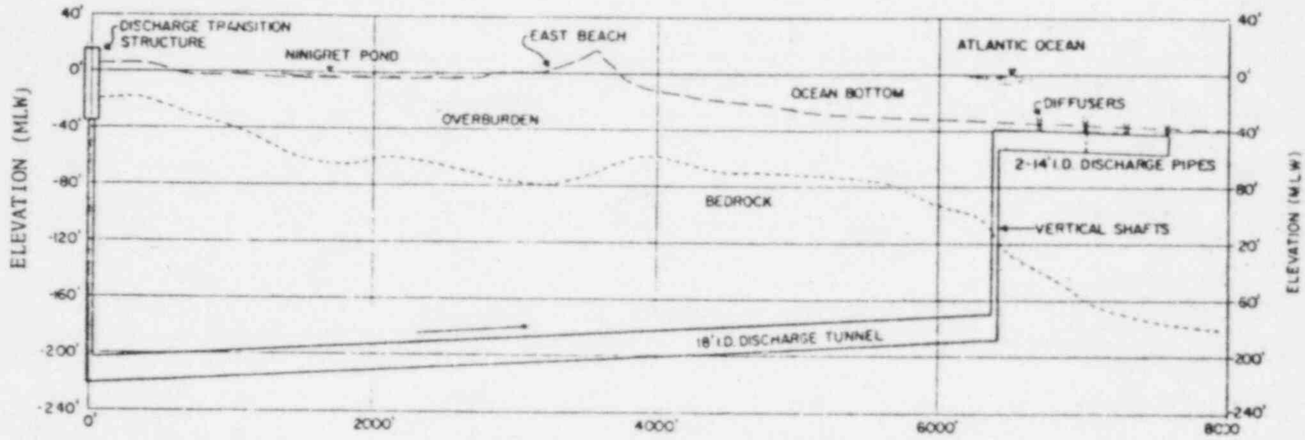
Issuing Agency	Type Approval	Identification No.	Date Of Application	Date of Approval
U.S. Nuclear Regulatory Commission	Class 103 (utilization facility) construction permit and operating license Public Law 91-190, 83 Stat. 852	Docket Nos. STN 50-568 and STN 50-569	Docketed 9/9/76	
Rhode Island Coastal Resources Management Council	R.I. General Laws Section 46-23-6 Permit and license for installation and maintenance of circulating water system. Approval of design, location and construction of plant. Permit for dredging.			
U.S. Environmental Protection Agency	Federal Water Pollution Control Act Amendments of 1972, Section 316 (a) and (b), Section 402. Alternate effluent limitation and NPDES discharge permits.	RI0020982	2/28/77	
Rhode Island Department of Environmental Management	Federal Water Pollution Control Act Amendments of 1972, Section 401(a), and R.I. General Laws Section 46-12-2(c), and 46-12-4. Circulating water discharge permit and certification to EPA and NRC.			

Issuing Agency	Type Approval	Identification No.	Date of Application	Date of Approval
Rhode Island Department of Transportation	Construction on state land. R.I. General Laws 24-8-4			
Rhode Island State Properties Committee	R.I. General Laws Section 37-7-8. Approval of grant of interest in State property.			

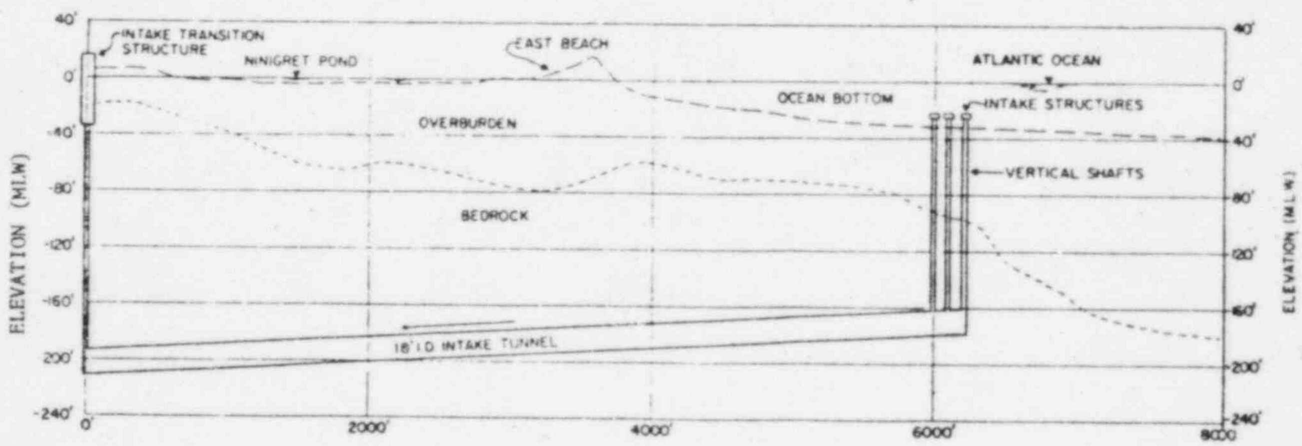


Property owners
a,d Rhode Island
b Browning, Sarah J.
c Glen, Bruce C.
e USA, Fish and Wildlife Serv.
f Gaddes, L.F. and S.A.
g Whittemore, L.

Vicinity map for
offshore work area
in Block Island Sound
near Charlestown, Rhode Island.
Application by New England Power Company
Sheet 1 of 13 Date: 4/17/79

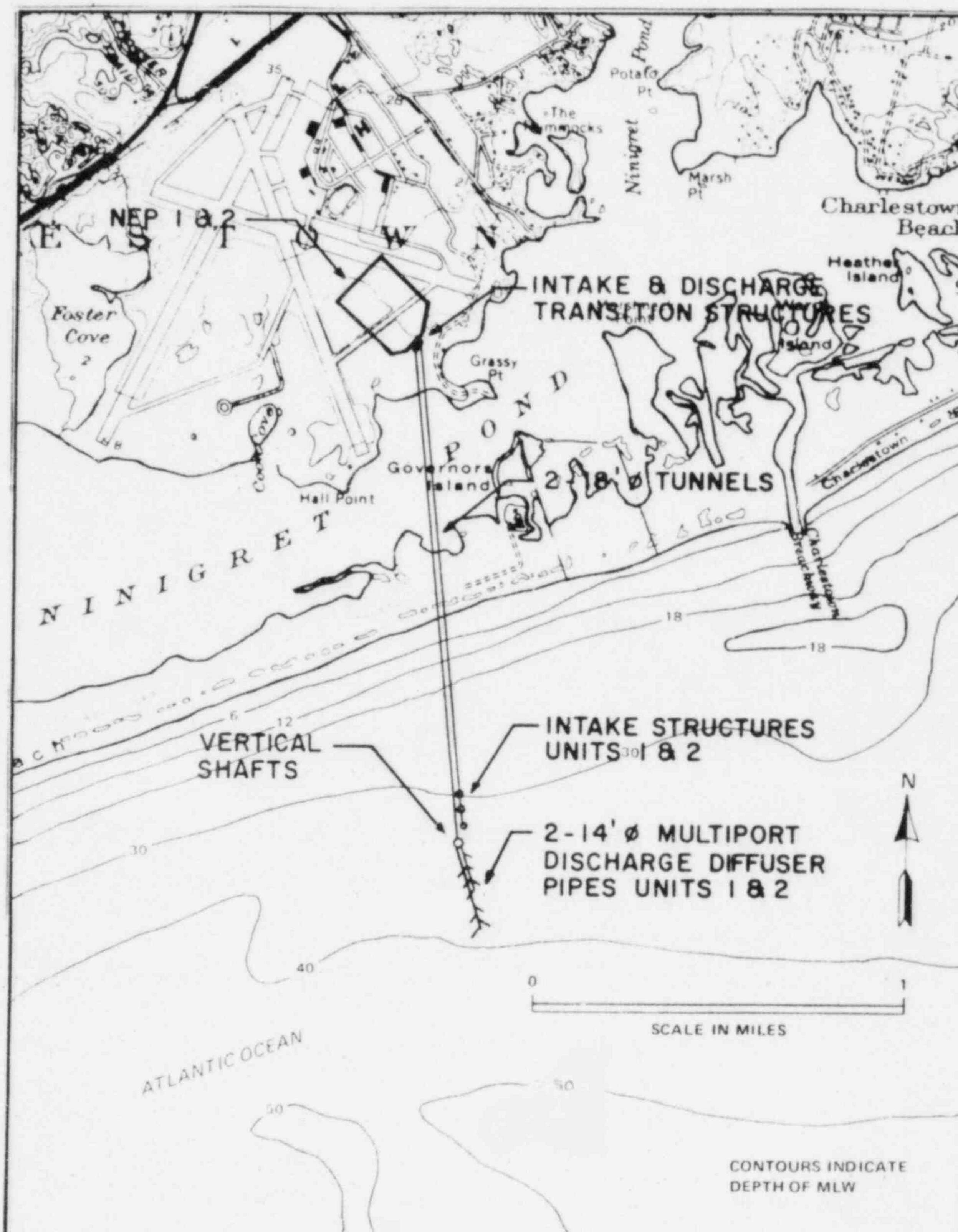


DISCHARGE TUNNEL PROFILE

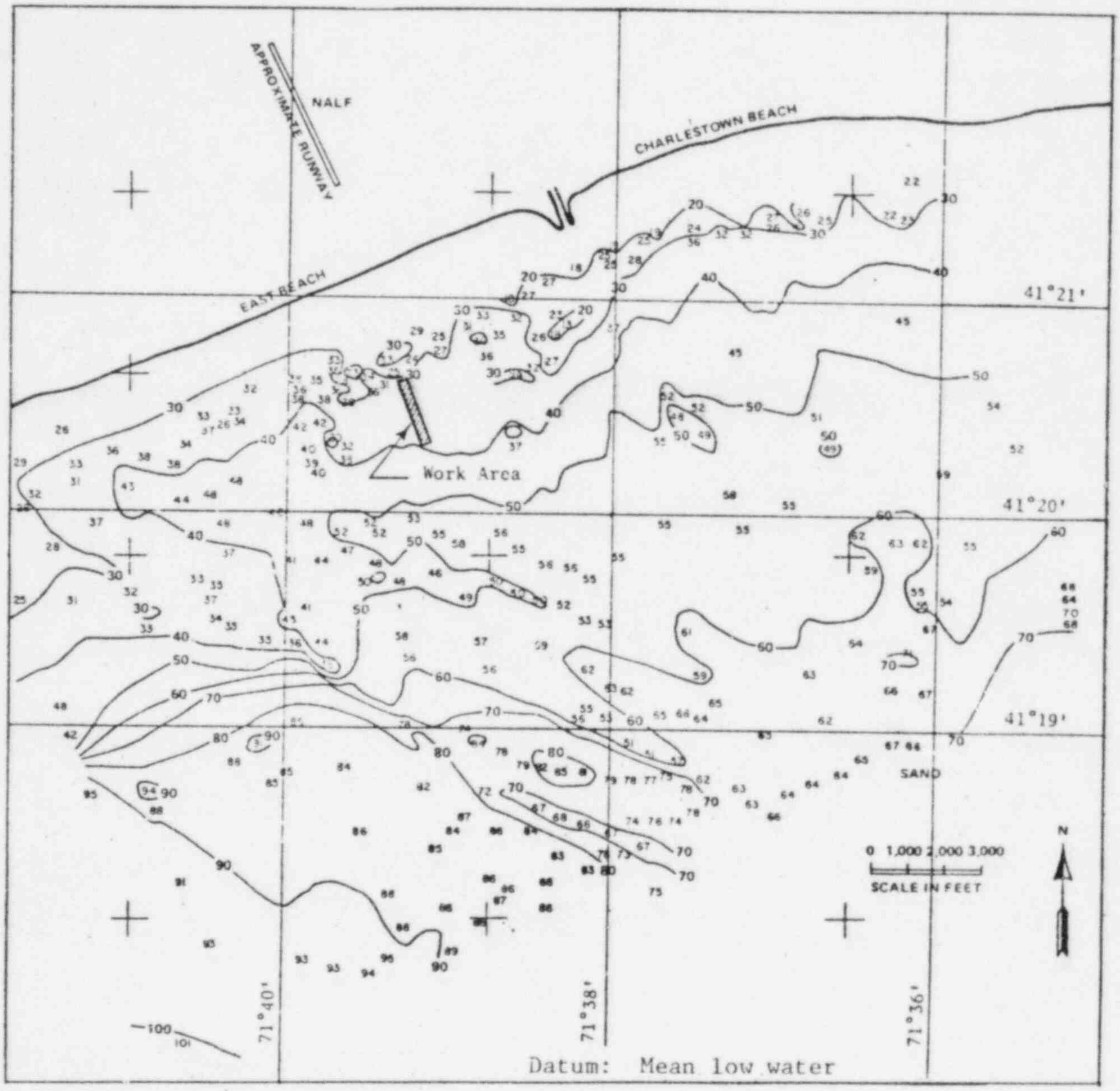


INTAKE TUNNEL PROFILE

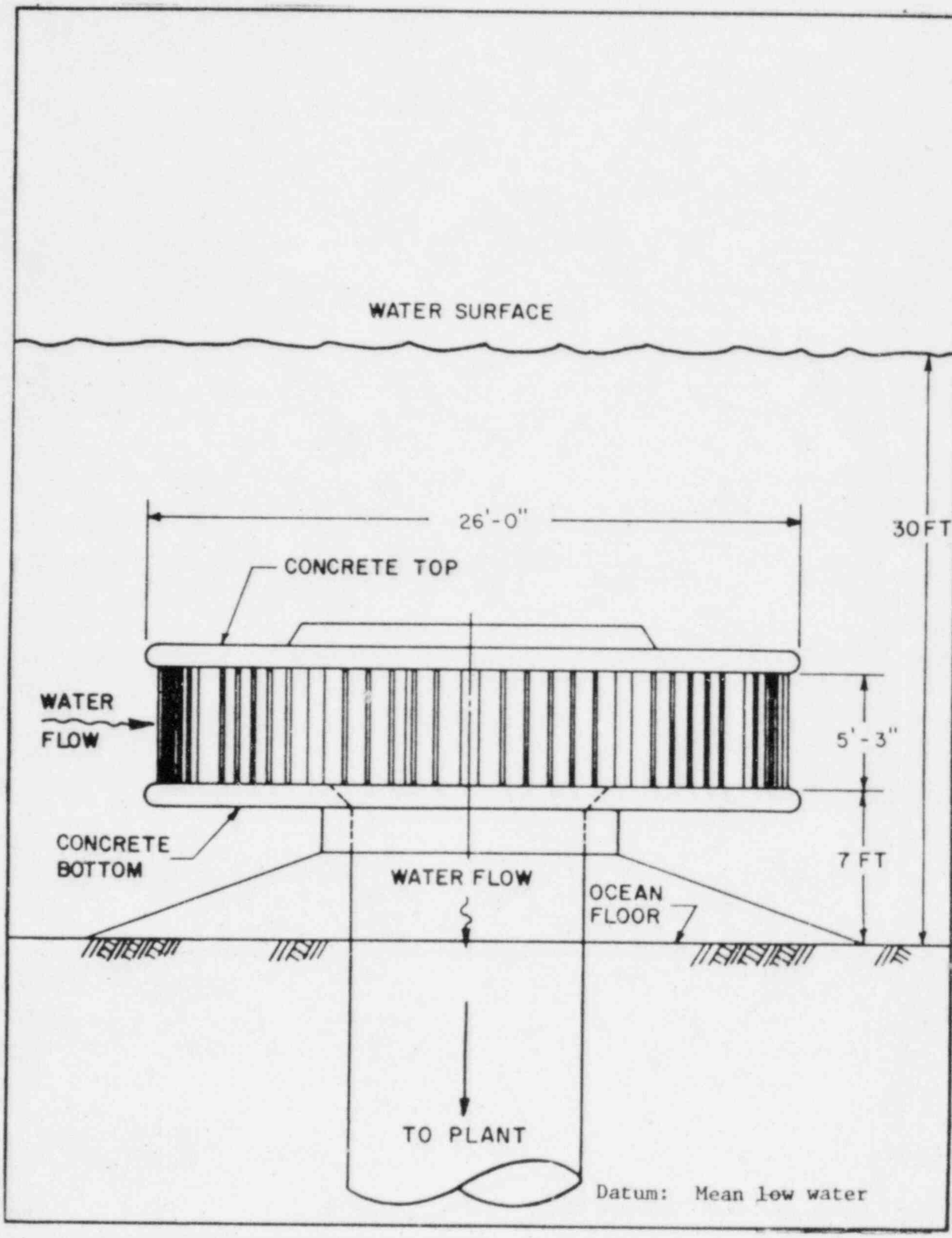
Intake and Discharge
Tunnel Profiles
in Block Island Sound
near Charlestown, Rhode Island.
Application by New England Power Company
Sheet 2 of 13 Date: 4/26/78



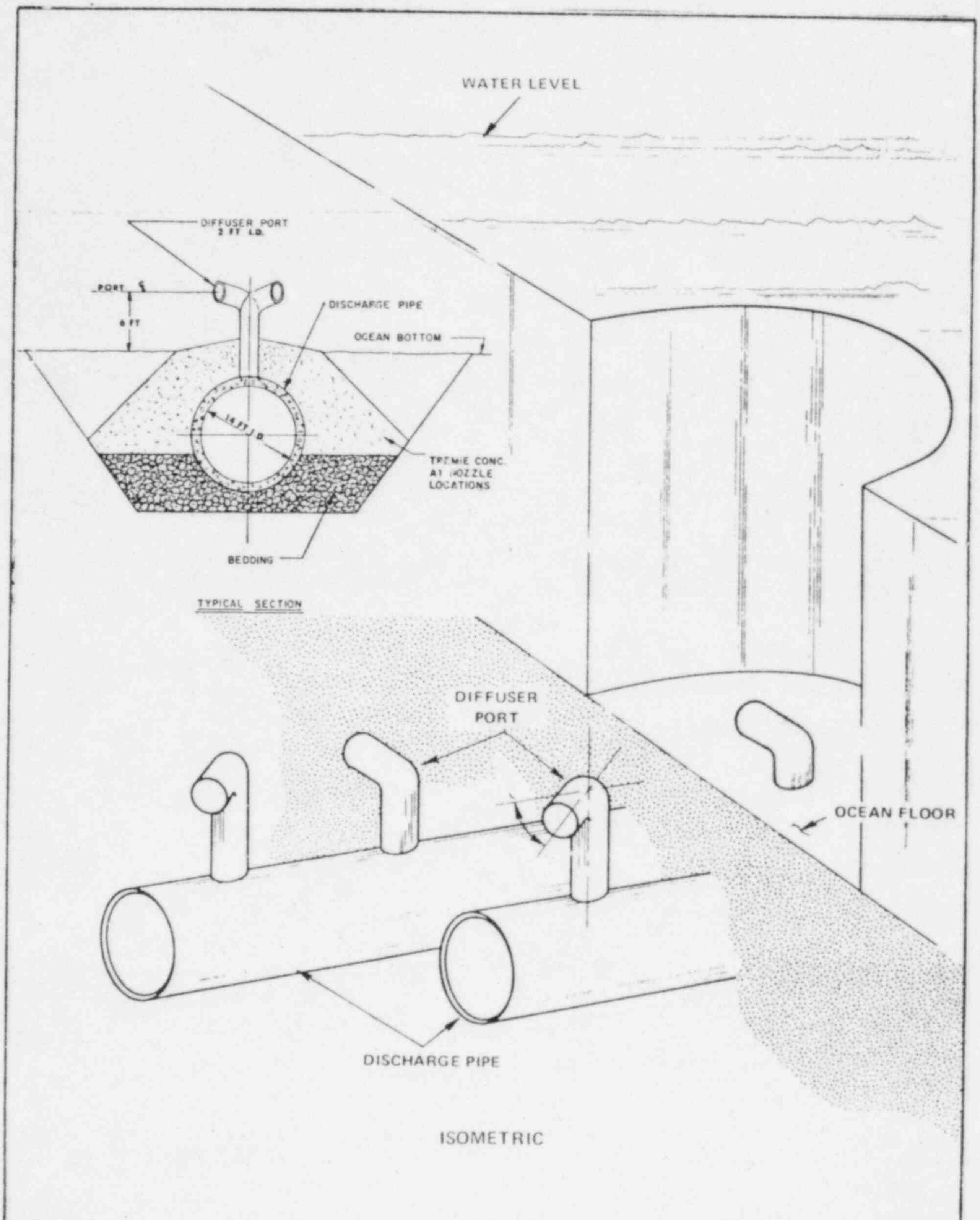
Proposed circulating water system
in Block Island Sound
near Charlestown, Rhode Island.
Application by New England Power Company
Sheet 3 of 13 Date: 4/17/79



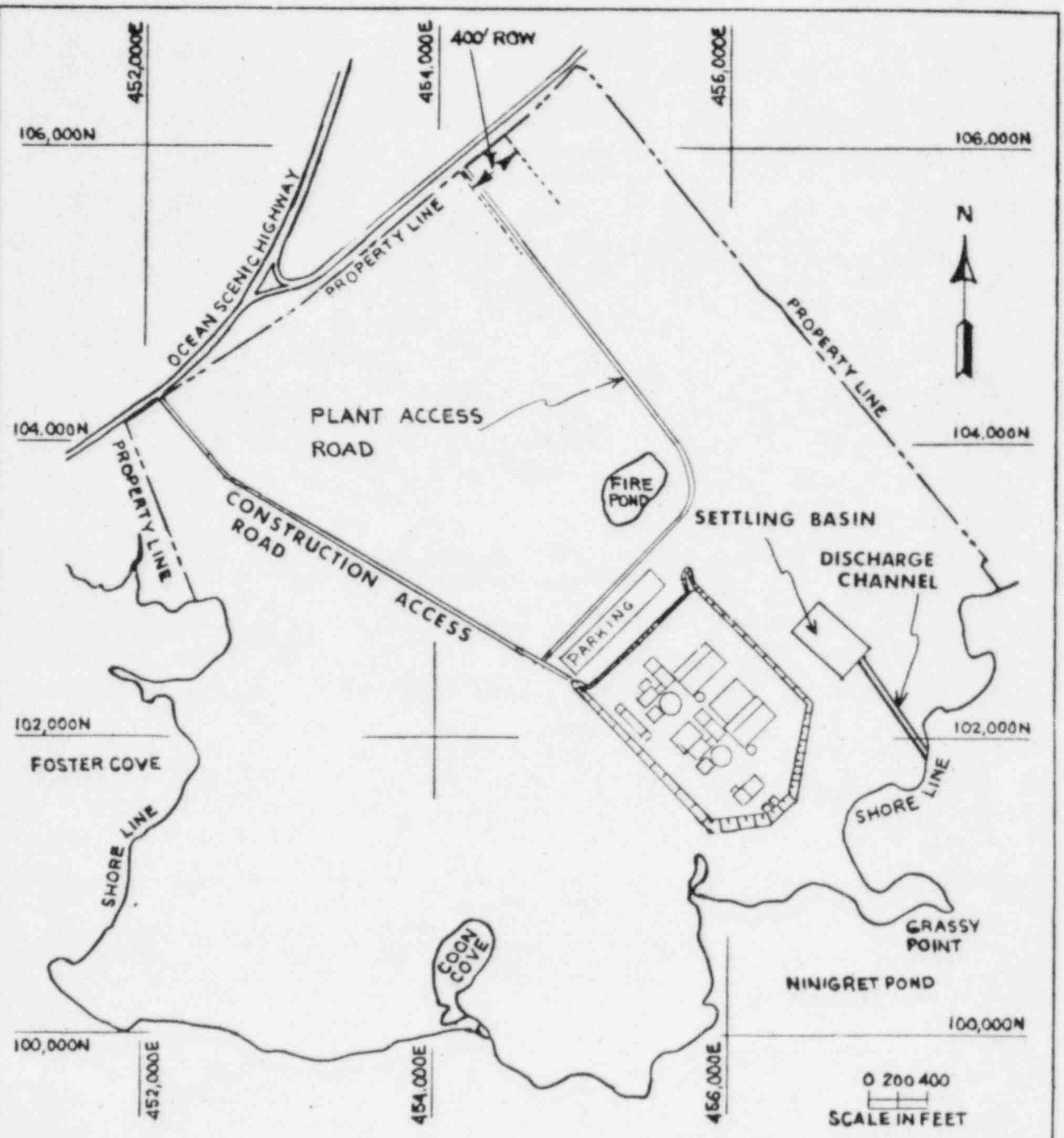
Bottom contours in work area
in Block Island Sound
near Charlestown, Rhode Island.
Application by New England Power Company
Sheet 4 of 13 Date: 4/26/78



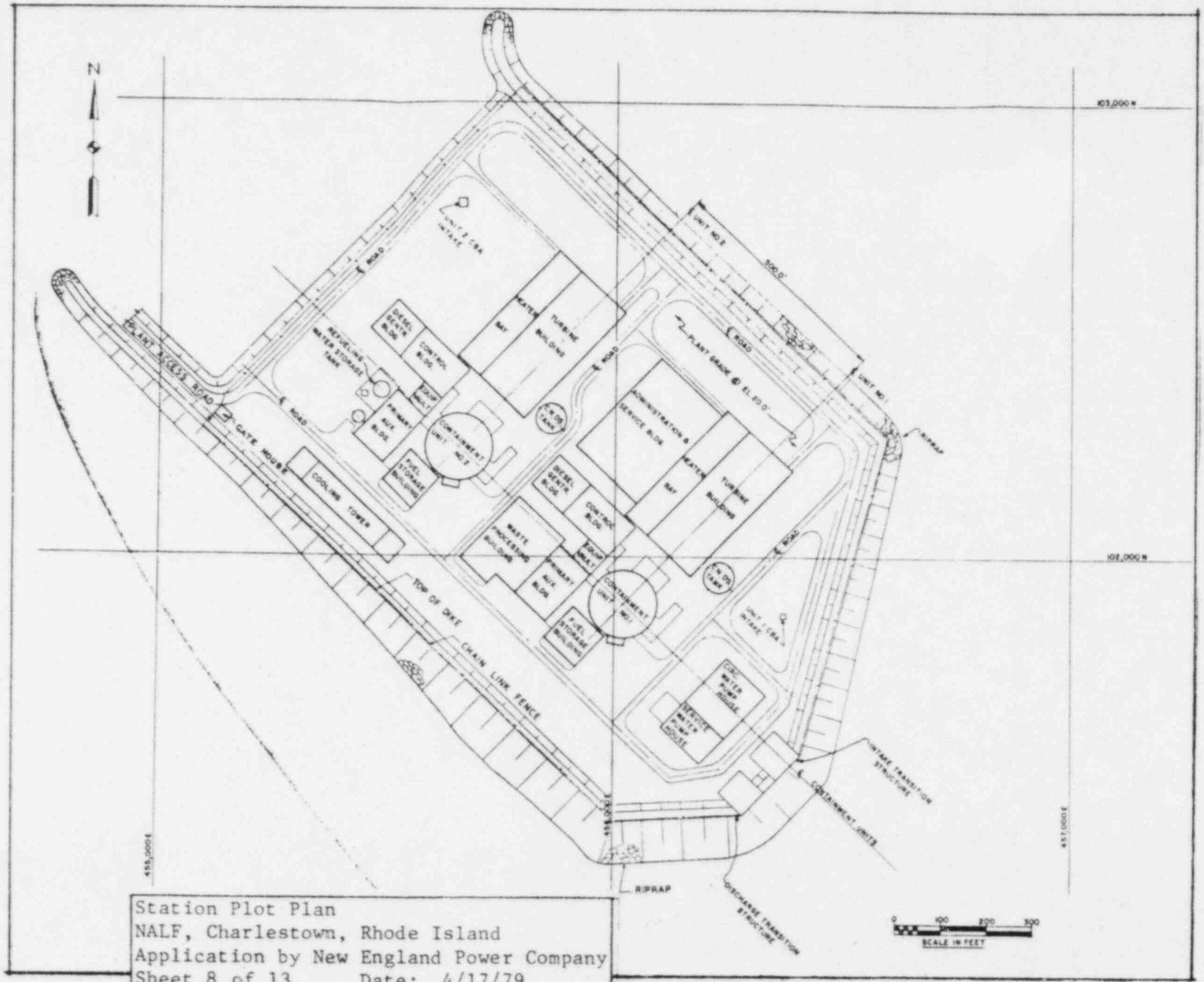
Proposed intake structures
in Block Island Sound
near Charlestown, Rhode Island.
Application by New England Power Company
Sheet 5 of 13 Date: 4/26/78



Proposed discharge structures
in Block Island Sound
near Charlestown, Rhode Island.
Application by New England Power Company
Sheet 6 of 13 Date: 5/15/78

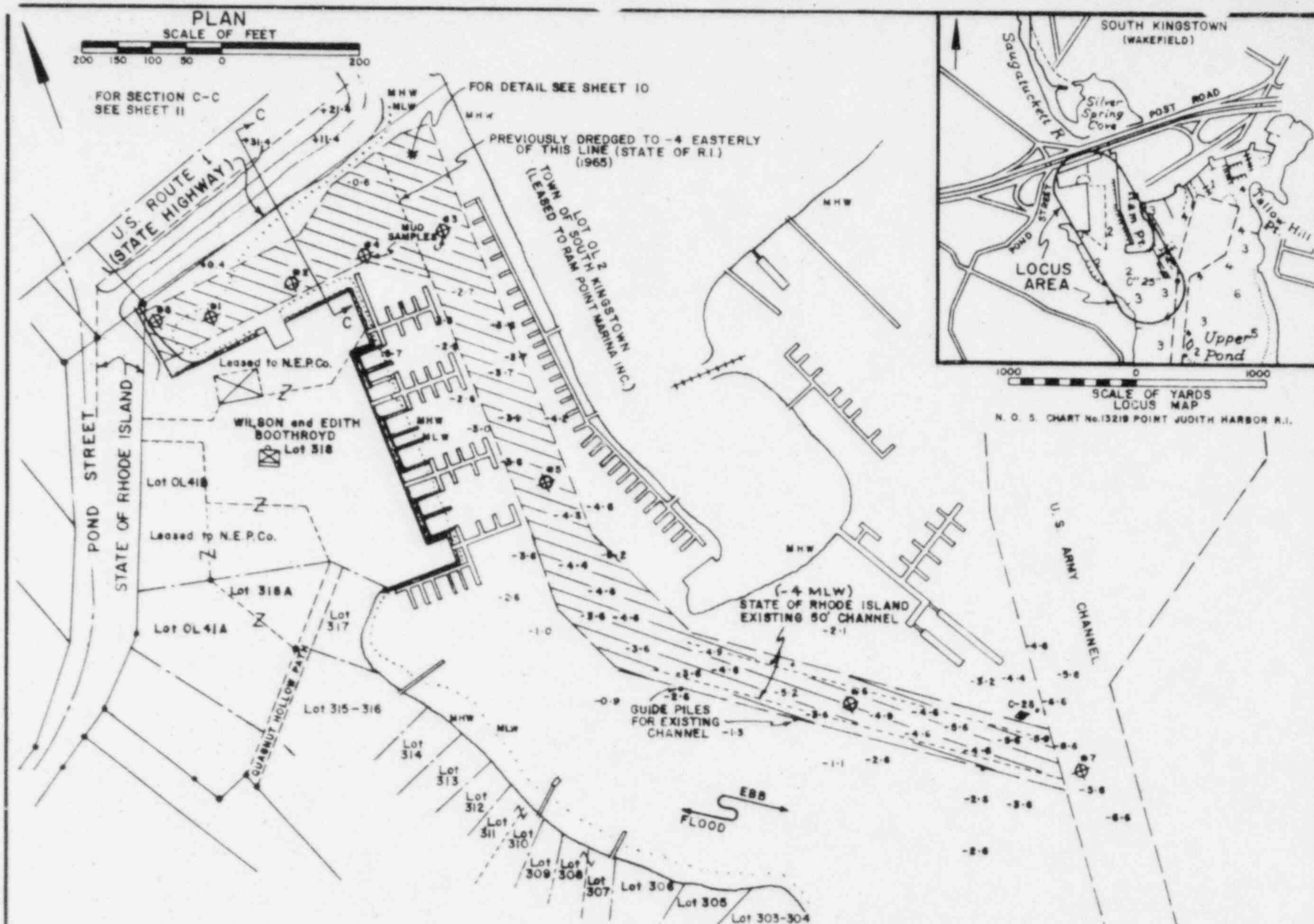


Site Plan
Application by New England Power Company
Sheet 7 of 13 Date: 4/17/79



Station Plot Plan
NALF, Charlestown, Rhode Island
Application by New England Power Company
Sheet 8 of 13 Date: 4/17/79

PLS 1342



NOTE:

APPROXIMATELY 17,000 Cu. Yds. OF DREDGE MATERIAL TO BE REMOVED

ELEVATION AND SOUNDINGS ARE IN FEET AND REFER TO MEAN LOW WATER

SOUNDINGS TAKEN MARCH 1978

DREDGE SIDE SLOPES TO BE 3H : 1V

SEE SHEET 11 FOR LISTING OF PROPERTY OWNERS

PROPOSED DREDGING AND BULKHEAD
AT SILVER SPRING COVE IN UPPER POINT JUDITH POND
TOWN OF SOUTH KINGSTOWN, WASHINGTON COUNTY, RHODE ISLAND

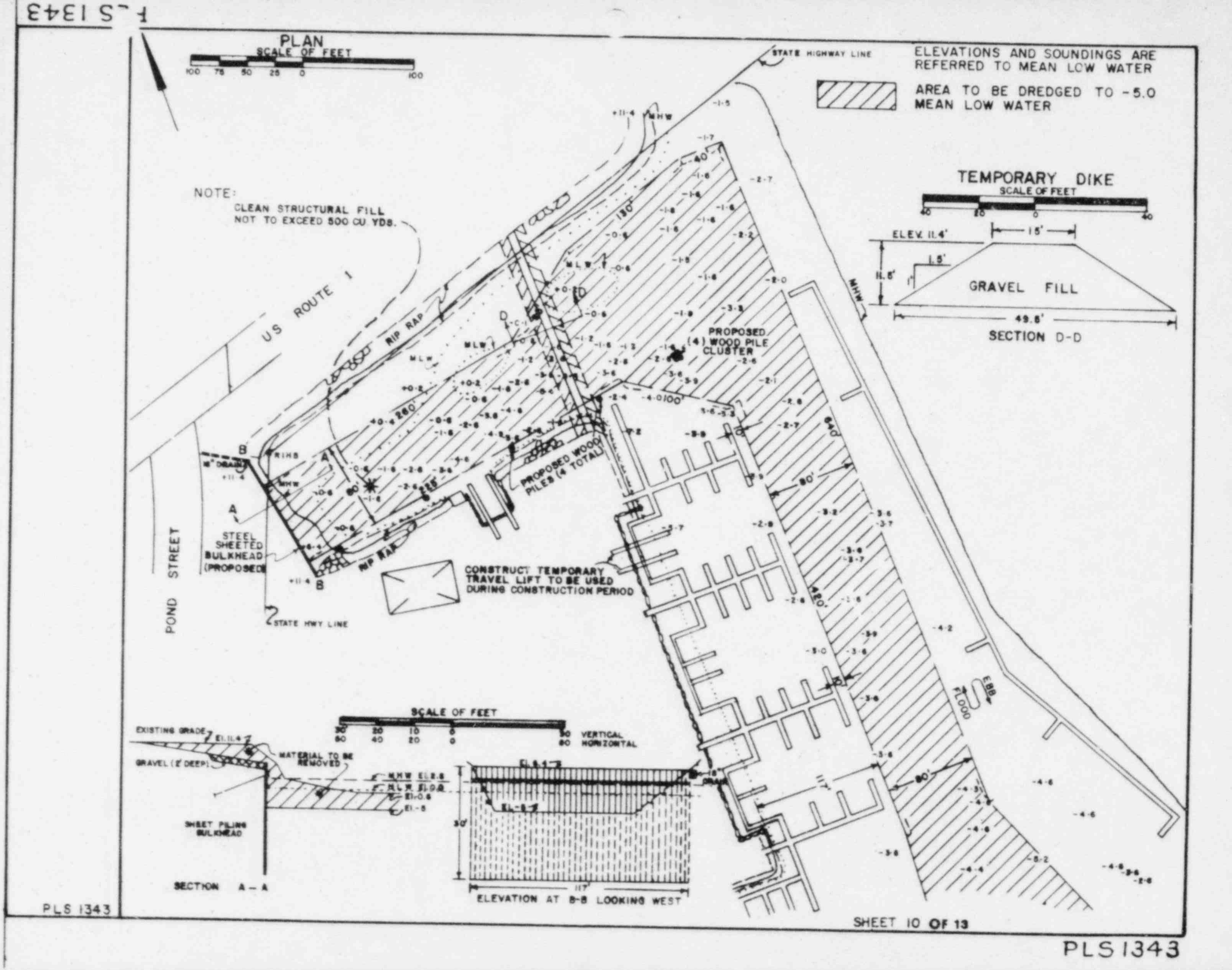
APPLICATION BY:

NEW ENGLAND POWER COMPANY

SHEET 9 OF 13 REV. APRIL 17, 1979

PLS 1342

PLS 1342

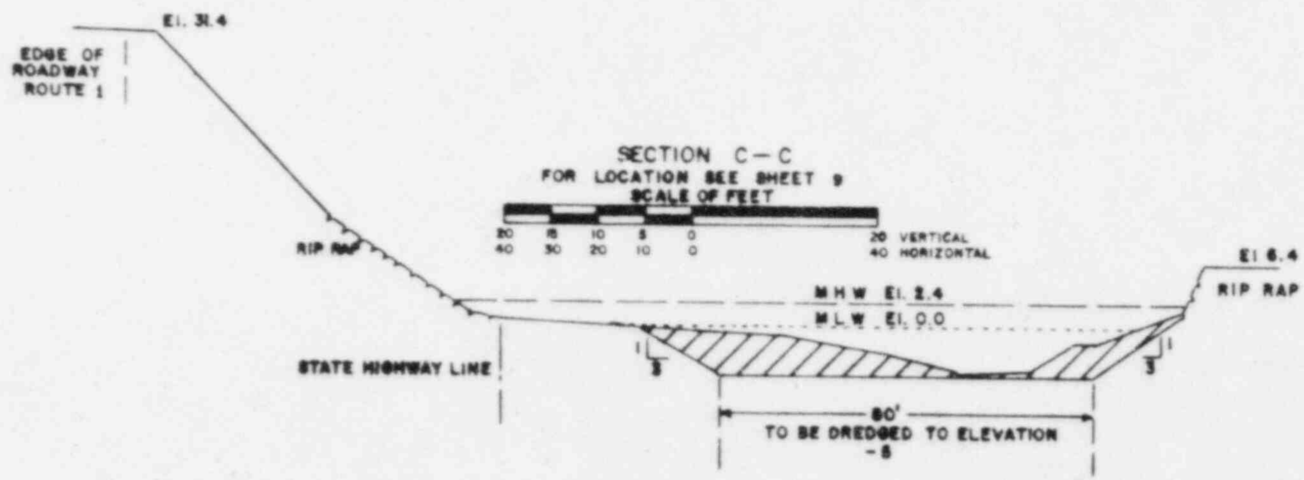

PLAN
SCALE OF FEET
100 75 50 25 0 100
ELEVATIONS AND SOUNDINGS ARE REFERRED TO MEAN LOW WATER
AREA TO BE DREDGED TO -5.0 MEAN LOW WATER
STATE HIGHWAY LINE
NOTE:
CLEAN STRUCTURAL FILL NOT TO EXCEED 500 CU. YDS.
TEMPORARY DIKE
SCALE OF FEET
ELEV. 11.4'
15'
1.5'
11.8'
GRAVEL FILL
49.8'
SECTION D-D
US ROUTE 1
RIP RAP
PROPOSED (4) WOOD PILE CLUSTER
PROPOSED WOOD PILES (4 TOTAL)
STEEL SHEETED BULKHEAD (PROPOSED)
POND STREET
CONSTRUCT TEMPORARY TRAVEL LIFT TO BE USED DURING CONSTRUCTION PERIOD
STATE HWY LINE
MHW
MLW
EBB
FLOOD
640'
420'
80'
117'
130'
260'
SCALE OF FEET
VERTICAL
HORIZONTAL
EXISTING GRADE
GRAVEL (2' DEEP)
MATERIAL TO BE REMOVED
SHEET PILING BULKHEAD
SECTION A - A
ELEVATION AT B-B LOOKING WEST
PLS 1343
SHEET 10 OF 13
PLS1343
F-S 1343

See Sheet 9 For Lot No. References

LOT NO.	OWNER
318 & OL41B	Wilson and Edith Boothroyd 17 Arbor Way, Wakefield, R.I. 02880 (Portions leased to N.E.P.Co.)
OL2	Town of South Kingstown Town Hall, 66 High St. Wakefield, R.I. 02879 (Leased to Ram Point Marina, Inc. c/o G. William Schmid, Jr. Salt Pond Road, Wakefield, R.I. 02879)
318A & OL41A	Burton L. Little 83 Diane Drive, Vernon, Conn. 06086
317	Sixty Six Acres Improvement Association c/o Mrs. William Nye, Winchester Drive Wakefield, R.I. 02879
315 - 316	Philip L. and Helen E. Carpenter 42 Upper College Road, Kingston, R.I. 02881
313 - 314	Charles E. and Irene C. Redman 2 Newland Avenue, Lincoln, R.I. 02865

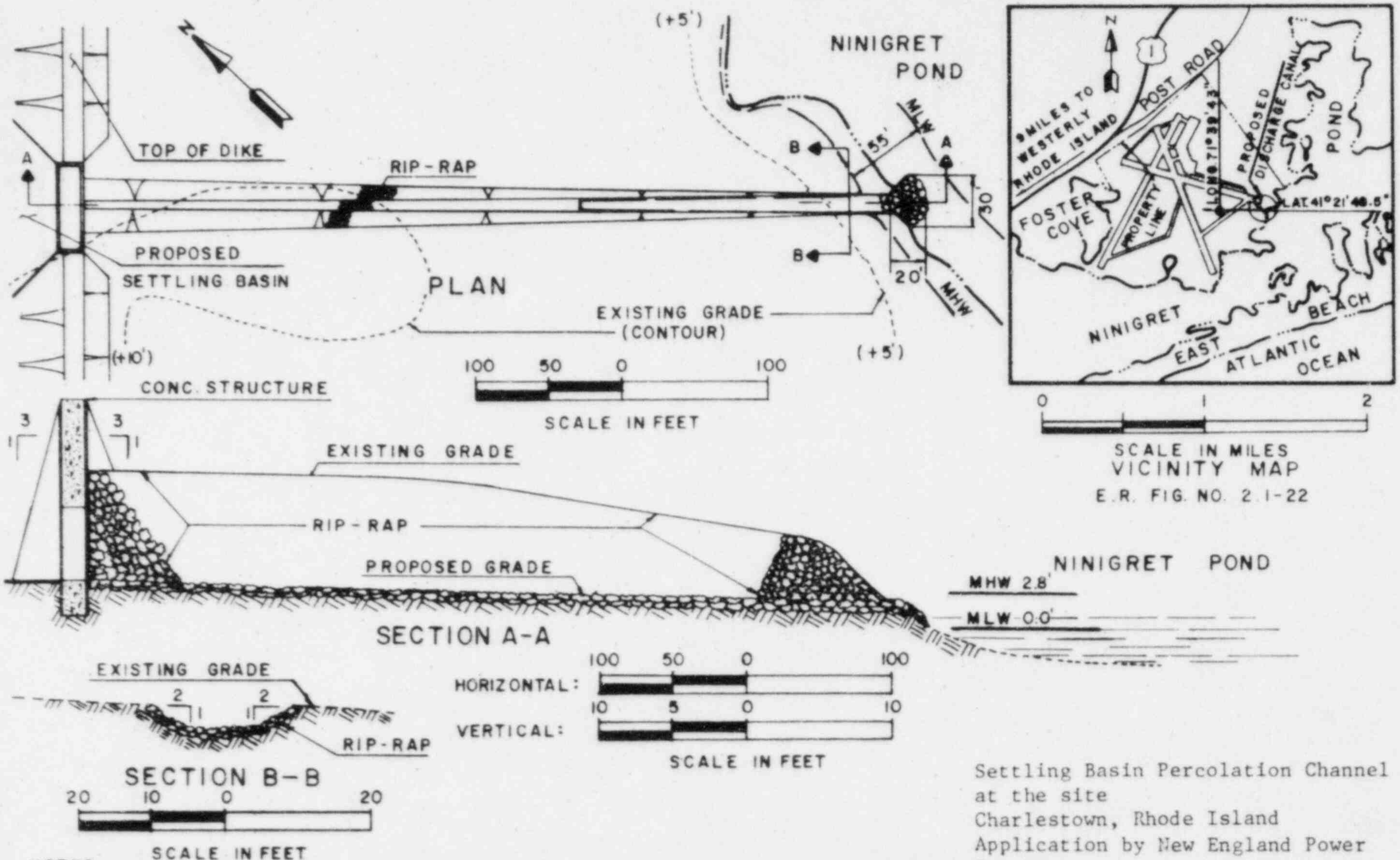
LOT NO.	OWNER
312	Sandra Fish Cross 17 Quagnut Drive, Wakefield, R.I. 02879
311 & 310	Christine D. Bailey 186 Fairview Avenue, Walcott, Conn.
309	Joseph G. and Gilda A Boragine 40 Quagnut Drive, Wakefield, R.I. 02879
308 & 307	Henry J. and Evelyn Provencher 48 Quagnut Drive, Wakefield, R.I. 02879
306 & 305	Rene M. and Minnie J. Bollengier 52 Quagnut Drive, Wakefield, R.I 02879
303 & 304	Girl Scouts of America, Inc. c/o Council Officer, 125 Charles Street, Providence, R.I.

State of Rhode Island
Department of Transportation
State Office Building
Providence, R.I. 02903
c/o Wendell Farley, Director



SECTION C – C
FOR LOCATION SEE SHEET 9
SCALE OF FEET

PLS 1344

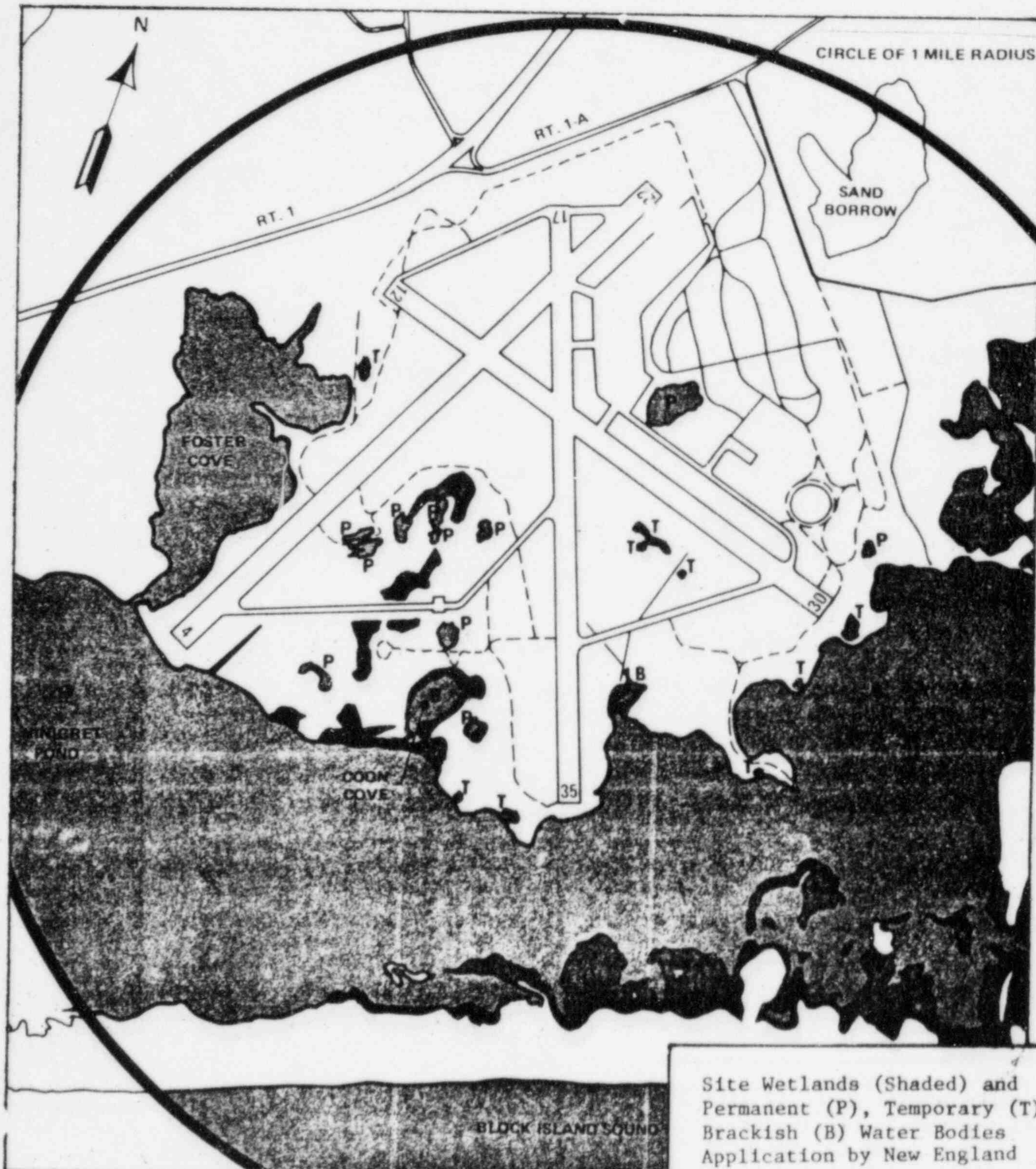


NOTES:

PURPOSE: DISCHARGE OF SETTLING BASIN EFFLUENT

DATUM: MEAN LOW WATER
MHW AND MLW MARKS ARE WITH RESPECT TO THE ATLANTIC OCEAN. TIDAL RANGE IN NINIGRET POND IS 4-8 INCHES.

Settling Basin Percolation Channel
at the site
Charlestown, Rhode Island
Application by New England Power Company
Sheet 12 of 13 Date: 4/17/79



Site Wetlands (Shaded) and Permanent (P), Temporary (T) and Brackish (B) Water Bodies
Application by New England Power Company
Sheet 13 of 13 Date: 4/17/79

ATTACHMENT

Barge Unloading Facility

Sediment Composition

Application No. 23-78-269

May 1979

Analysis Results from First Samples of Sediment Material

(All results expressed as mg/g sludge except Coliforms as #/g)

#	Coliforms[c] Total	Coliforms[c] Fecal	Kjeldahl N[a]	Odor Index	COD[b]	Oil & Grease[c]	Vol. Solids[b]	Metals[b] Pb	Cu	Zn	Cr	Ni	As	Hg	Cd	V
1	200	0	1.6	1.5	124	2.5	135	.22	.09	.37	.13	.04	.014	<.001	.002	.03
2	2000	10	0.6	1.0	49	0.2	52	.09	.05	.19	.06	.02	.004	<.001	.001	.02
3	10000	2000	4.0	3.1	57	0.7	89	.18	.05	.14	.06	.02	.003	<.001	<.001	.02
4	100	10	5.2	2.0	81	1.7	90	.19	.09	.29	.09	.03	.005	<.001	.001	.03
5	2300	100	14.4	3.1	65	0.8	85	.24	.10	.31	.11	.03	.012	<.001	.001	.03
6	100	10	2.8	3.1	125	0.3	134	.08	.03	.09	.07	.03	.002	<.001	<.001	.03
7	6000	600	7.0	4.9	114	<0.1	125	.31	.09	.27	.16	.05	.015	<.001	.001	.03
1A			2.5	1.5	110	2.8	166	.21	.06	.23	.09	.02	.014	<.001	.001	.02
2A			4.0	1.0	82	0.2	70	.21	.08	.18	.08	.03	.005	<.001	.001	.02
3A			3.5	3.0	71	0.7	85	.24	.08	.20	.06	.02	.002	<.001	.001	.02
4A			3.5	1.5	82	1.5	99	.24	.11	.27	.08	.02	.006	<.001	.001	.02
5A			2.0	3.1	80	0.7	109	.31	.16	.33	.14	.04	.011	<.001	.001	.04
6A			2.5	3.1	128	0.4	144	.05	.03	.07	.04	.02	.001	<.001	<.001	.03
7A			7.5	4.9	126	<0.1	133	.16	.09	.24	.13	.02	.011	<.001	.001	.03

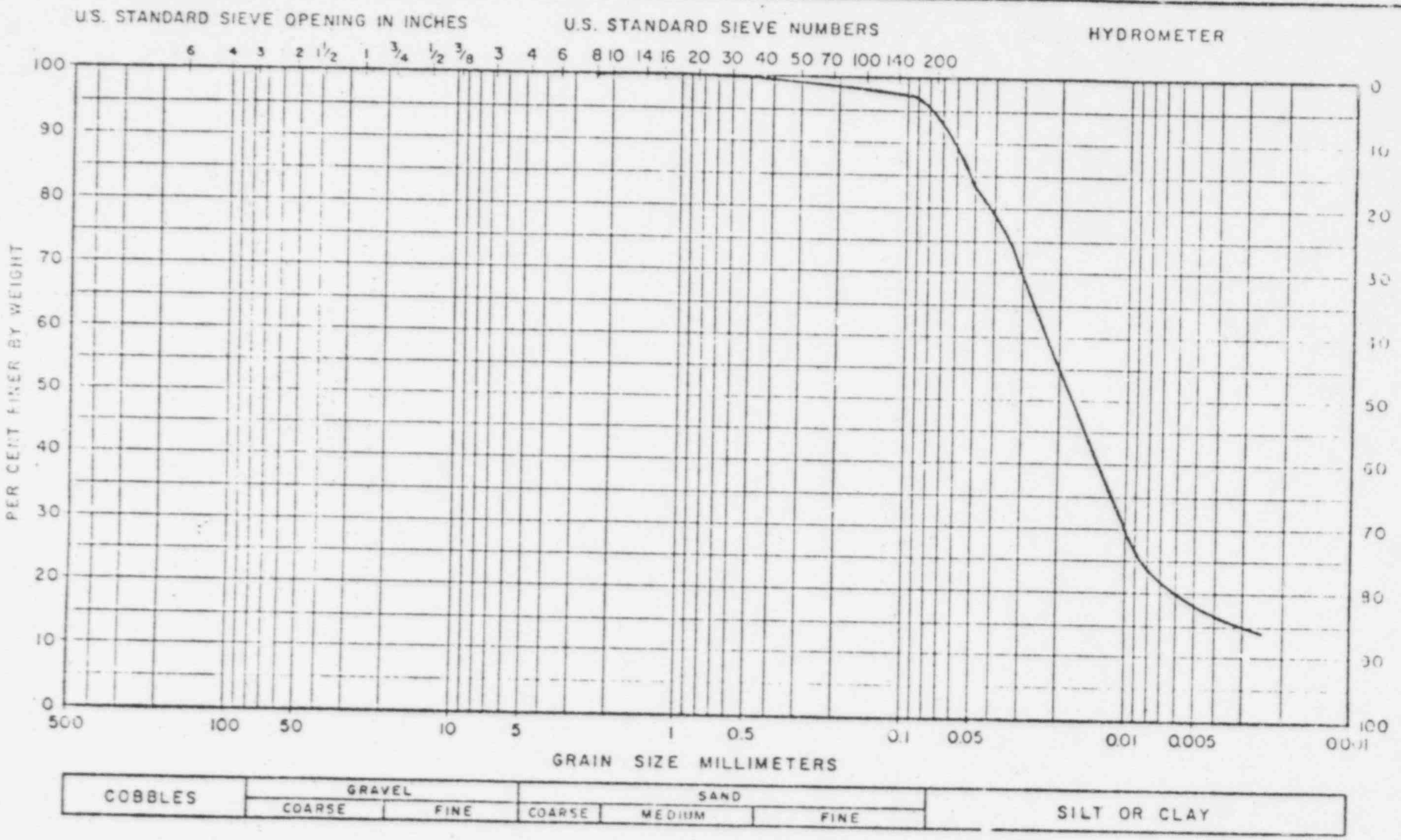
.B.: [a] results expressed as mg NH_4Cl/ g dry weight

[b] results expressed as mg/g dry weight

[c] results expressed as mg/g wet weight

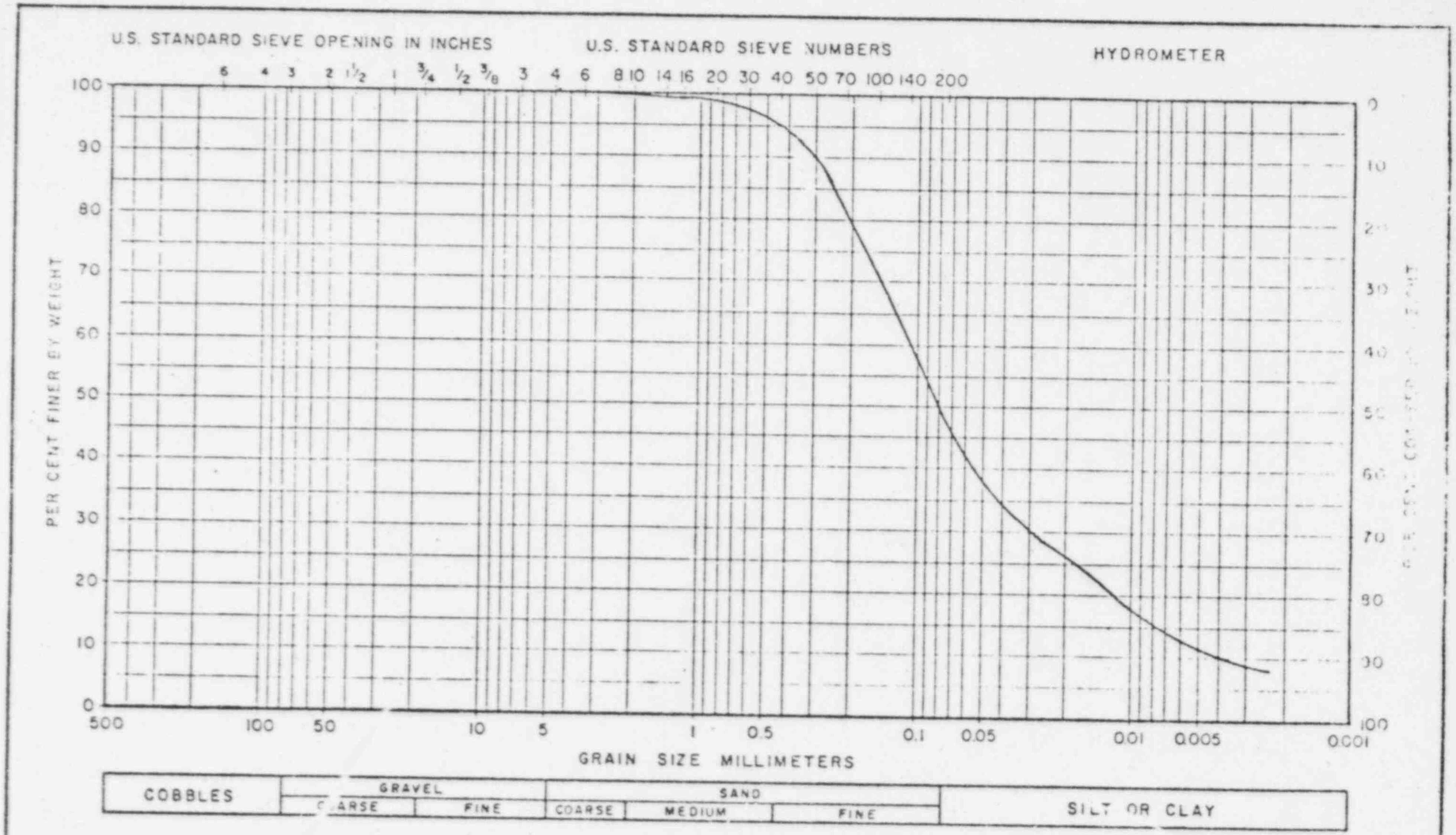
/14/78

Lab 4-3 rev. 0 28 May 74



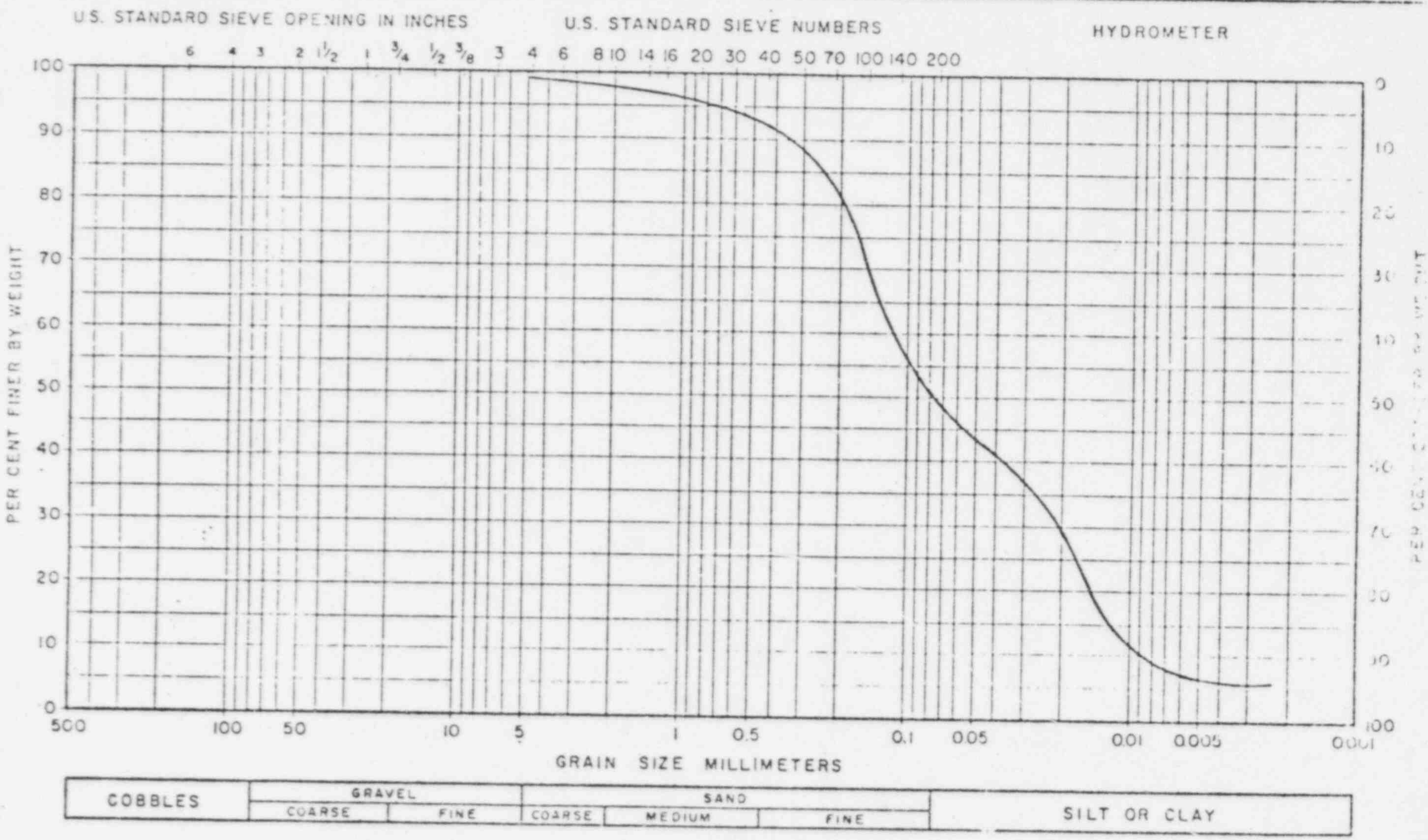
Yankee Atomic Electric Co. Westborough, Massachusetts	Barge Berth Silver Spring Cove Wakefield, RI	GRAIN-SIZE CURVE SAMPLE 1 B/C
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 78424	April 1978 Fig. 1

Lab. 4-3 rev. 0 28 May 74



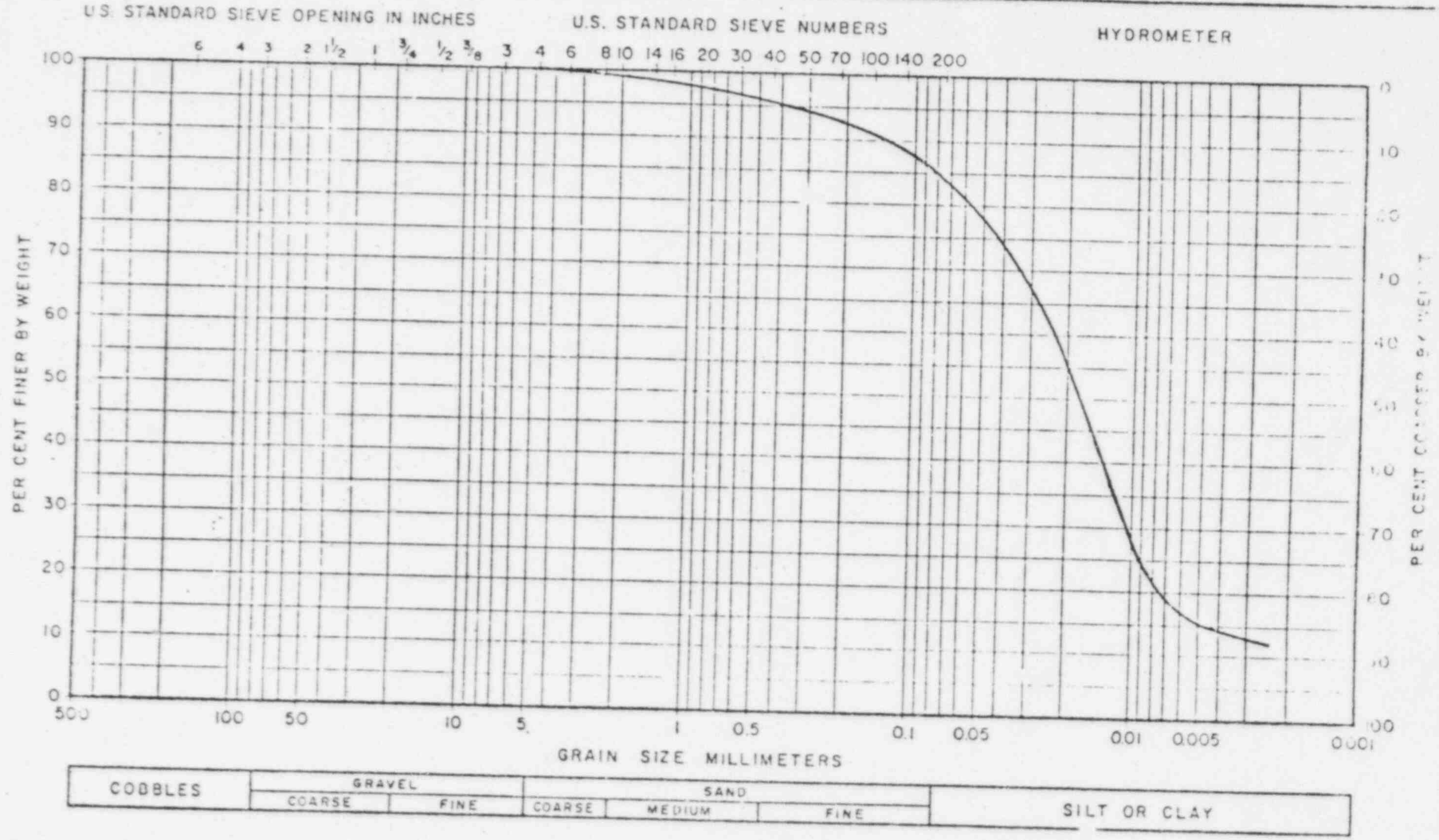
Yankee Atomic Electric Co. Westborough, Massachusetts	Barge Berth Silver Spring Cove Wakefield, RI	GRAIN-SIZE CURVE SAMPLE 2 A/B
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 78424	April 1978 Fig. 2

Lab 4-3 rev. 0 28 May 74



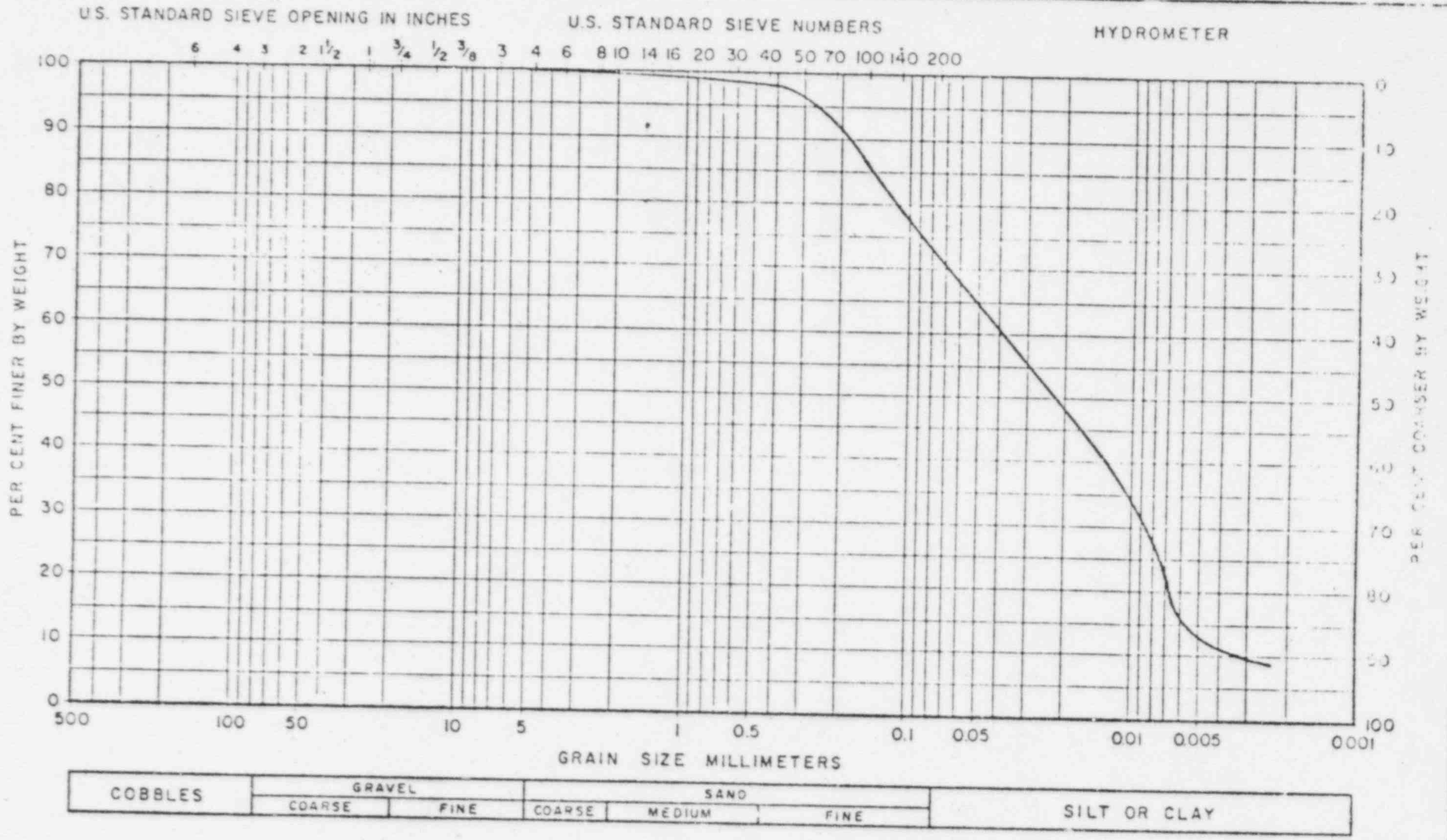
Yankee Atomic Electric Co. Westborough, Massachusetts	Barge Berth Silver Spring Cove Wakefield, RI	GRAIN-SIZE CURVE SAMPLE 3 A/C
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 78424	April 1978 Fig. 3

Lab 4-3 rev. 0 28 May 74



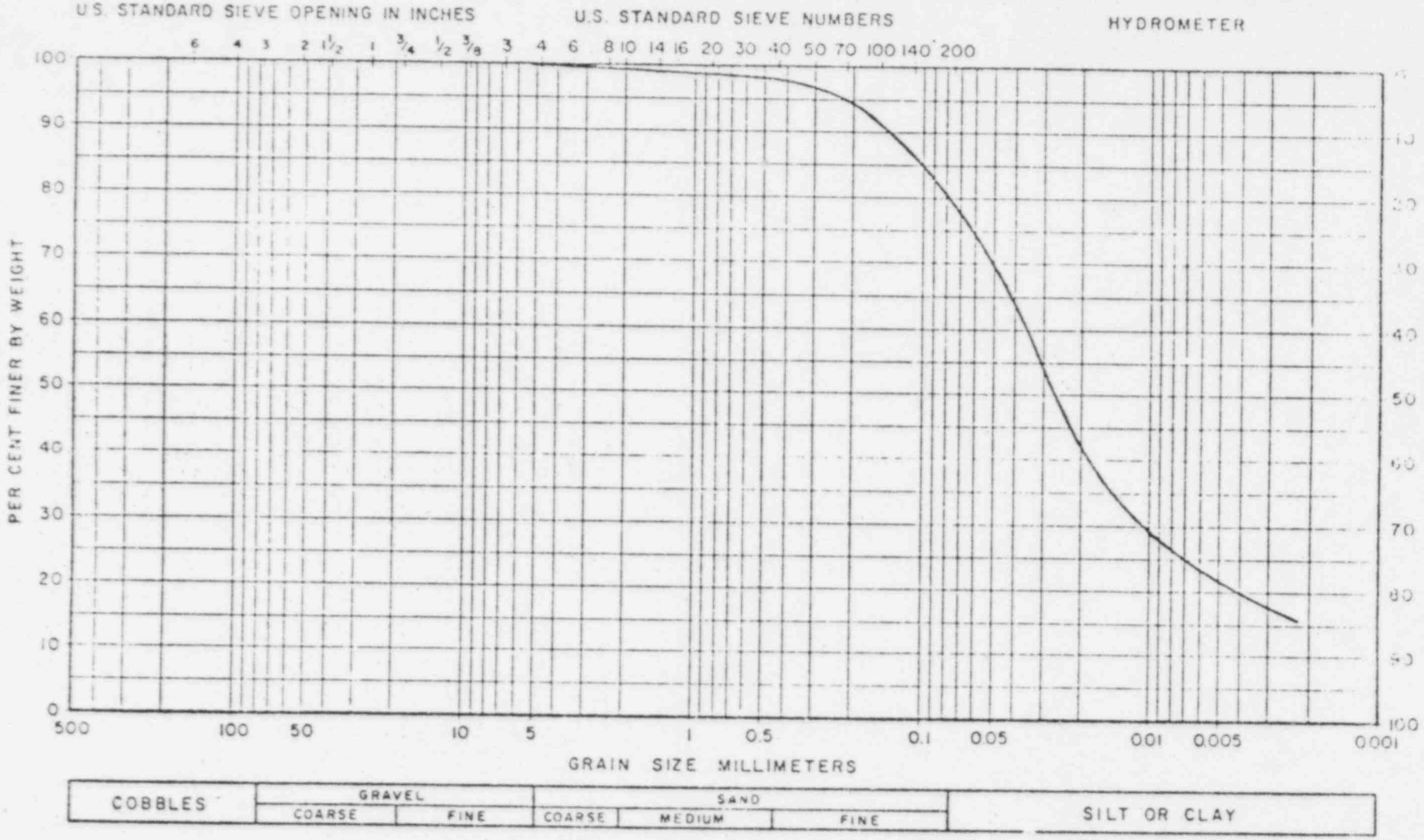
Yankee Atomic Electric Co. Westborough, Massachusetts	Barge Berth Silver Spring Cove Wakefield, RI	GRAIN-SIZE CURVE SAMPLE 4 A/B
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 78424	April 1978 Fig. 4

Lab 4-3 rev. 0 28 May 74



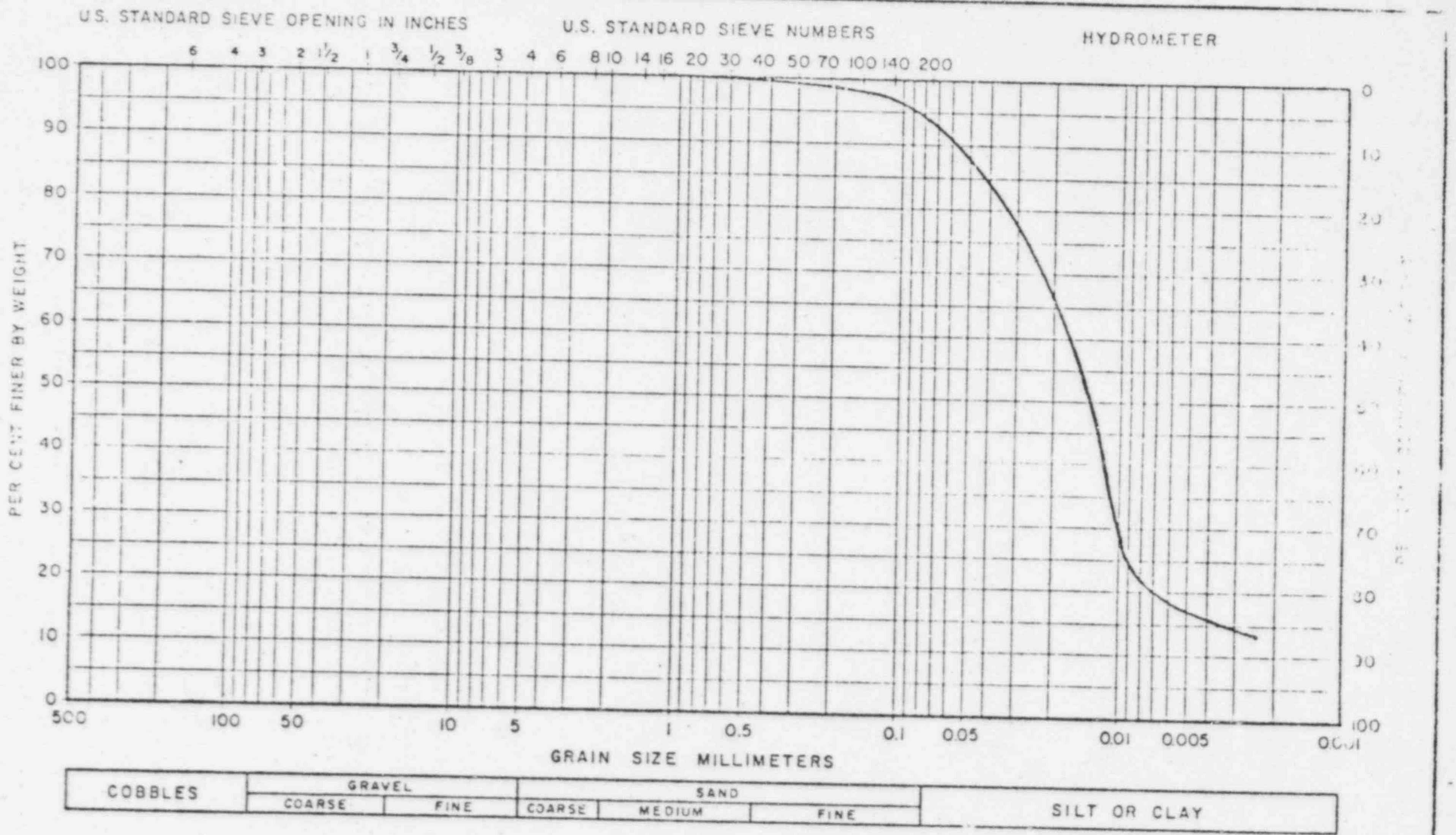
Yankee Atomic Electric Co. Westborough, Massachusetts	Barge Berth Silver Spring Cove Wakefield, RI	GRAIN-SIZE CURVE SAMPLE 5 I C
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 78424	April 1978 FIG. 5

Lab 4-3 rev. 0 28 May 74



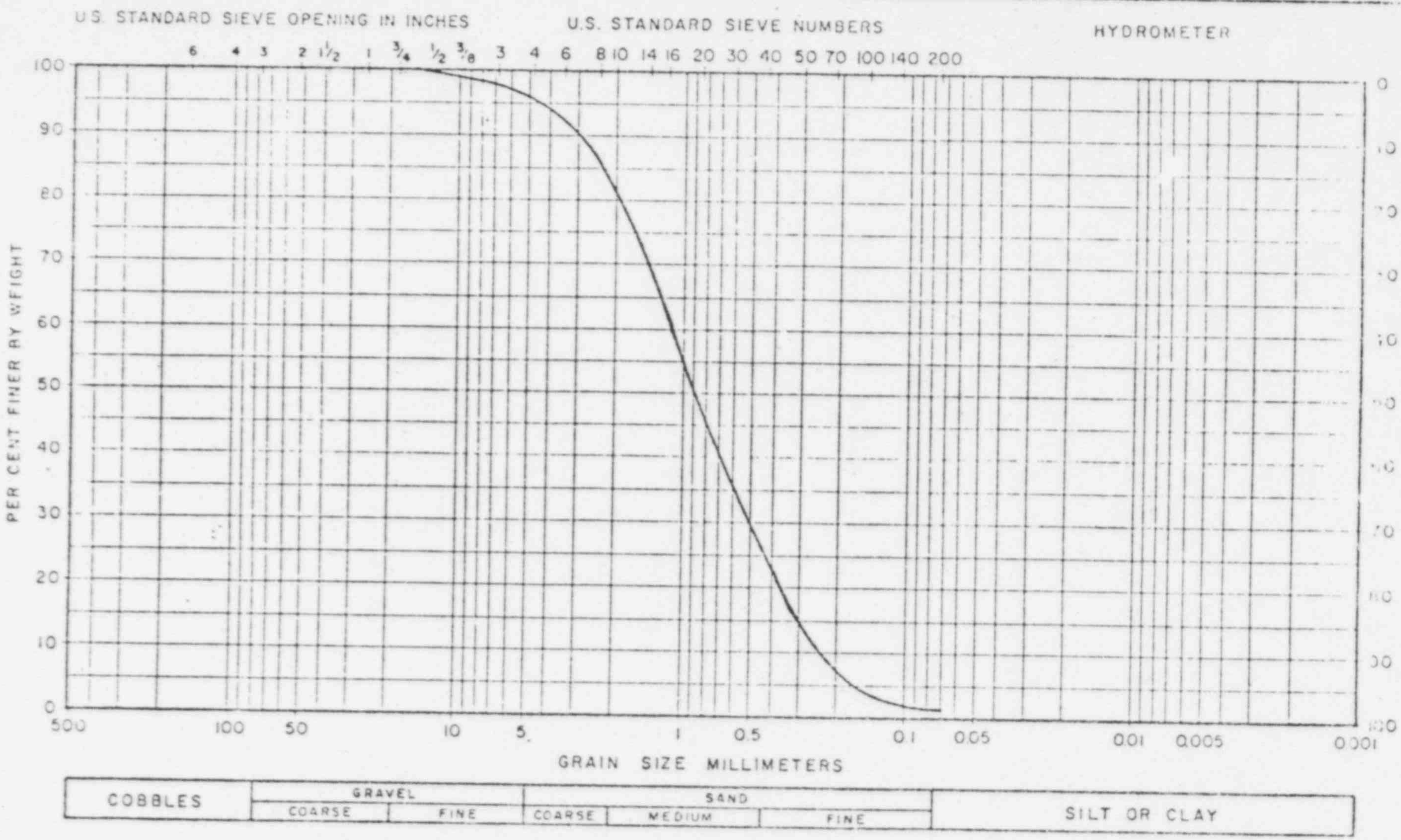
Yankee Atomic Electric Co. Westborough, Massachusetts	Barge Berth Silver Spring Cove Wakefield, RI	GRAIN-SIZE CURVE SAMPLE 6
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 78424	April 1978 Fig. 6

Lab. 4-3 rev. 0 28 May 74



Yankee Atomic Electric Co. Westborough, Massachusetts Geotechnical Engineers Inc. Winchester, Massachusetts	Barge Berth Silver Spring Cove Wakefield, RI Project 78424	GRAIN-SIZE CURVE SAMPLE 7 A/C April 1978 Fig. 7

Lab 4-3 rev. 0 28 May 74



Yankee Atomic Electric Co. Westborough, Massachusetts	Barge Berth Silver Spring Cove Wakefield, RI	GRAIN-SIZE CURVE SAMPLE 8
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 78424	April 1978 Fig. 8