Final
M/V *World Prodigy* Oil Spill
Restoration Plan and Environmental Assessment
Narragansett Bay, Rhode Island

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March 1996

Final Environmental Assessment and Restoration Plan

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EXECUTIVE SUMMARY

In June, 1989 the Greek tanker *World Prodigy* ran aground in Narragansett Bay, Rhode Island releasing approximately 290,000 gallons of number 2 fuel oil. Numerous species of marine organisms were adversely affected by the spill. The National Oceanic and Atmospheric Administration (NOAA) assesses and claims damages (compensation) from responsible parties for injuries to natural resources from discharges of oil, and is required to use those funds to restore the injured resources. In 1991, NOAA received $567,299 as a result of a legal settlement between the Federal government and the responsible party. NOAA will use these funds to restore the natural resources injured by the spill.

The Clean Water Act, as amended by the Comprehensive Environmental Response, Cleanup, and Liability Act (CERCLA), requires Federal and State natural resource trustees to restore, rehabilitate, replace, or acquire the equivalent of the natural resources injured by an oil spill. This restoration plan describes the proposed use of the settlement funds received by NOAA. The proposed plan presents a summary of the incident and injuries caused by the spill, identifies categories of restoration that were considered (resource and habitat enhancement, acquisition of equivalent resources, and no action), identifies criteria for project selection, and discusses the proposed alternatives.

NOAA's goal is to restore the resources injured by the *World Prodigy* oil spill and compensate the public for the lost use of those resources by enhancing habitat value for numerous marine resources, with specific emphasis on lobsters, quahogs (hard clams), and estuarine finfish. To meet this goal, NOAA proposes several actions: (1) enhance lobster habitat by establishing several lobster reefs; (2) transplant quahogs and establish quahog "spawner sanctuaries" to help restock formerly productive areas of the bay and to make more of the resource available to shellfishermen; (3) establish eelgrass beds in multiple sites throughout Narragansett Bay to enhance fisheries habitat; and (4) restore a saltmarsh system on Sachuest Point in Middletown, RI to enhance habitat for estuarine dependent fish and shellfish.

The National Environmental Policy Act (NEPA) requires an assessment of the effects of any Federal action that may impact the environment. This document also serves as an environmental assessment and will comparatively evaluate alternative methods for restoring or replacing the injured resources.

TABLE OF CONTENTS

I. INTRODUCTION: Purpose and Need for Action

The *World Prodigy* Oil Spill and its Impact on Narragansett Bay's Resources

On June 23, 1989, the Greek-registered oil tanker *World Prodigy*, owned by Ballard Shipping Company, en route from Bulgaria to Providence, Rhode Island, grounded on Brenton Reef in Narragansett Bay off Newport, Rhode Island (Figure 1). The impact of the grounding ruptured nine of the vessel's 23 cargo tanks causing the discharge of approximately 290,000 gallons of number 2 fuel oil into the bay. The oil eventually spread over a 123 square mile area of the bay and Rhode Island Sound. A portion of the oil was stranded on intertidal areas of lower Narragansett Bay. The spill adversely affected numerous species of marine organisms including large numbers of adult crustaceans, fish, shellfish and crustacean eggs and larvae, and a variety of benthic organisms in certain heavily oiled locations (Pilson 1989). Additionally, various human uses were adversely affected. The entirety of Narragansett Bay was closed to shellfishing as a precautionary measure for one week leading to a loss of access to shellfishing grounds for commercial and recreational clammers. Many of the state's beaches also were closed for up to two months, in some cases, though most were closed for several days.

Data collected by NOAA's National Marine Fisheries Service and other agencies suggested that the *World Prodigy* spill killed a significant number of planktonic life forms, larval and juvenile fish, and larval shellfish and crustaceans. Species that were adversely affected included significant numbers of early life stages of tautog, cunner, scup, sea robin, and larval lobsters (K. Sherman, National Marine Fisheries Service, pers. corr. 1989). The greatest proportion of NOAA trust resource losses were annually spawned pelagic juveniles. Their deaths represented the loss of a significant portion of the 1989 year class of those species within the impacted area (K. Sherman, NMFS, personal communications). Analysis of the data obtained by the State of Rhode Island, The University of Rhode Island, NOAA, the Food and Drug Administration, the U.S. Environmental Protection Agency and the U.S. Coast Guard demonstrated that the quahog or hard clam (*Mercenaria mercenaria*), American lobster (*Homarus americanus*) and a variety of finfish eggs and larvae were among the most seriously impacted of the NOAA trust resources in Narragansett Bay.

The shores of Conanicut Island were most affected. The Rhode Island Division of Fish and Wildlife conducted shoreline surveys at Mackerel and Hull Coves in Jamestown, RI and collected over 800 dead, small lobsters and crabs in those two locations. The total number may have been considerably greater since it is probable that not all carcasses were washed ashore and many could have been carried away by scavengers (gulls, foxes, skunks, and raccoons) (Pilson, 1989). Though the oil spread throughout a large area in Narragansett Bay and Rhode Island Sound, within days the oil had largely disappeared from the surface waters as a result of evaporation and mixing in the water column (Pilson, 1989). However, data collected for several years following the spill indicated that significant concentrations of oil remained in the beach sand in Hull Cove (Mulhare and Therrien, 1993). Extrapolation of that data suggests that degradation of the oil would slowly continue with significant concentrations remaining for at least five years after the spill (Mulhare and Therrien, 1993).

In addition to the scientific sampling performed by the various Federal and state agencies, and academic institutions, a computer model was run to simulate the effects of the spill on the bay's resources. The Natural Resource Damage Assessment Model for Coastal and Marine Environments ("Type A Model") was used to estimate damages caused by the spill. The model uses a variety of inputs including air and water temperature, current and wind data, type and amount of oil spilled, and resources present in the impact area, to calculate injuries to the affected resources. The modeling results were similar to the data collected, however, the model predicted large numbers of adult fish kills where sampling did not detect any (French, *et al.*, 1990).

Generally, refined petroleum products such as number 2 fuel oil (home heating oil) have greater concentrations of toxic components (i.e., aromatics) than crude oil. Consequently, spills of refined products are likely to have a greater ecological impact (Malins, 1977). The high content of toxic aromatics was one reason for the severity of effects of the 1969 spill from the barge *Florida* in West Falmouth, Massachusetts (Mielke, 1990). That spill released 4,500 barrels of number 2 fuel oil into Buzzards Bay. Number 2 fuel oil, as well as the other light oils, can have long-term impacts on intertidal resources. Although number 2 oil is considered to be moderately volatile, evaporation is not as complete as with a lighter fraction such as gasoline. Number 2 fuel can leave a residue, up to one-third of the spill amount. Porous sediments absorb this fuel oil rapidly; the petroleum moves downward as far as the water table allows. Refractory portions of the oil spilled at West Falmouth still remain in the sediments (Boesch, *et al.*, 1974; Mielke, 1990; Teal *et al.*, 1992).

The impact that no. 2 fuel oil has on an organism depends on environmental and biological factors, as well as oil concentration. Cardwell (1973) found that toxicity of no. 2 fuel oil increases concomitantly with increasing temperature. Heavy oil contamination results in the death of marine and salt marsh animals, particularly benthic animals (Burns and Teal, 1979; Pilson, 1990). In general, sensitivity to oil varies with life stage and species, with eggs being the most sensitive, and adults being the least.

The ability of an organism to avoid a contaminant is a major determinant in its ability to survive an oil spill. Generally, finfish are less at risk due to their motility; they can leave the area of degradation (RPI, 1989). Crustaceans are generally more sensitive than bivalves; since the latter can close their shells for extended periods. The marketability of bivalves, however, can be severely impacted. Even if they survive an oil spill, they still may be unfit for human consumption. Bivalves surviving the initial toxic dosing can accumulate oil in their tissues in the course of normal feeding. Clark (1989) reported that tainting, or becoming oily tasting, can occur at very low levels of contamination (a few parts per million) and remain present even after four weeks of attempted depuration. During harvesting, even a small quantity of oil on harvesting gear or a few organisms can taint the whole catch and render it worthless. Handling and processing quickly spread the tainting substance throughout the catch.

Settlement

A $3.9 million settlement resolving all Federal claims for response, clean up and injuries to natural resources was reached with the responsible party by the U.S. Government in 1991. NOAA received $567,299 to be used for restoration to compensate for injuries to natural resources. The remaining balance went to the Coast Guard and other Federal agencies for reimbursement for response and clean-up costs. The Under Secretary for Oceans and Atmosphere (NOAA Administrator), on behalf of the Secretary of Commerce, acts as a Federal trustee for natural resources under the Comprehensive Environmental Response, Compensation and Liability Act of 1980, the Clean Water Act, the Marine Protection, Research and Sanctuaries Act, and the Oil Pollution Act of 1990. Under these laws, NOAA acts on behalf of the public to assess and claim damages (compensation) for injuries to natural resources from discharges of oil or releases of hazardous substances, and to use the recovered damages to restore, replace, or acquire the equivalent of the injured resources. This proposed restoration plan was drafted to fulfill NOAA's requirements under these authorities.

Proposed Actions

The goal of the proposed restoration efforts is to restore the resources injured by the *World Prodigy* oil spill by enhancing habitat value for numerous marine resources, with specific emphasis on lobsters, quahogs (hard clam), and estuarine finfish. Projects were developed to address these resources because they were the most significantly affected by the oil spill. In order to meet this goal NOAA proposes several actions: (1) enhance lobster habitat by establishing several lobster reefs; (2) transplant quahogs and establish quahog "spawner sanctuaries" to help restock formerly productive areas of the bay and to make more of the resource available to shellfishermen; (3) establish eelgrass beds in multiple sites throughout Narragansett Bay to enhance fisheries habitat; and (4) restore a saltmarsh system on Sachuest Point in Middletown, RI to enhance habitat for estuarine dependent fish and shellfish.

Lobster reefs. To restore the lobster resource injured by the oil spill, NOAA proposes to establish six artificial reefs measuring 10 meters by 20 meters made of various sizes of cobble and boulders in the lower west passage of Narragansett Bay (Figure 1). We propose to place all six reefs in 20-30 feet of water off the Bonnet Shores area. The specific locations within this general area will be chosen in consultation with local fishermen and based on a side-scan sonar survey and current data. A total of 450 m^3 of cobble and boulders will be used covering 1,200 m^2 of bay bottom.

Quahog transplant and spawner sanctuaries. To compensate for the lost use of clam beds and restore the quahog resource injured by the oil spill, NOAA proposes to transfer a portion of the settlement funds to the Rhode Island Department of Environmental Management to be used to fund the transplanting of quahogs from restricted waters to two "spawner sanctuaries" at the mouth of Greenwich Bay and near Gould Island in the Sakonnet River (Figures 2 and 3). Quahogs will be transplanted to these locations and will be off limits to harvesting for two years.

Eelgrass bed restoration. To restore estuarine finfish injured by the oil spill, NOAA proposes to establish eelgrass beds at approximately 10 different locations throughout Narragansett Bay. Sites will be identified following site surveys and consultation with local investigators. Selection will be based on water quality conditions, sediment particle size, historical evidence of presence of eelgrass, degree of exposure to waves and tidal currents, and existing uses.

Salt marsh restoration. To restore estuarine finfish injured by the oil spill, NOAA proposes to restore a salt marsh in the Sachuest Point National Wildlife Refuge in Middletown, RI (Figure 4). This marsh has been degraded by inadequate tidal flow caused by road construction and an inadequately sized culvert. Tidal flow will be restored by replacing the culvert with two larger culverts and clearing the tidal creeks of excess sedimentation. Restoration of tidal flow should restore the marsh's natural vegetation and increase fish access to the marsh thereby enhancing the production of estuarine fish.

II. AFFECTED ENVIRONMENT

This section describes the environment affected by the T/V *World Prodigy* oil spill (the *World Prodigy* site) including a general description of the physical, biological, and cultural environments. All descriptions are non-technical. Citations refer the reader to more detailed information.

In 1989 dollars, Narragansett Bay generated almost $2.5 billion in revenues for the State of Rhode Island based on direct exploitation of the bay's fisheries, tourism, marine-related industry, marine research and education, and U.S. Navy-related activities (NBP, 1992). The major contributing sectors to this annual revenue include fish and shellfish harvesting, marine transportation, national defense, education, scientific research, and recreational activities. Many of these and other economically important activities associated with the bay depend on the productivity and functions of coastal and marine habitats found along the Rhode Island shoreline.

Physical and Biological Environment

Rhode Island is located along the southern coast of the New England region of the United States. The climate of the state is influenced by oceanic processes and is characterized by moderately cold winters and mild summers. Rhode Island contains numerous coastal, estuarine, and oceanic natural resources distributed along its 419 miles of coastline (Seavey, 1975). The most prominent of these features is Narragansett Bay.

Narragansett Bay is considered the state's most valuable natural resource (NBP, 1992). The bay is a 147 square mile glacially carved, drowned river estuary that dominates the physical geography of Rhode Island. The watershed of the bay encompasses 1,657 square miles within Rhode Island and Massachusetts (NBP, 1992). Narragansett Bay is influenced by marine waters via Rhode Island Sound at its southern end, and by freshwater inputs from numerous rivers, streams, ponds, industrial plants, sewerage treatment facilities, precipitation and other sources throughout the watershed. It is estimated that the bay receives 2,400 million gallons of freshwater everyday (Pilson, 1985; Ries, 1989). The salinity of the waters of the bay are distributed across a north-south gradient from the fresher upper bay areas (15‰) to the saline lower reaches of the mouth (33‰) (Bricker, 1993). The average depth of the bay is 27 feet with some areas (East Passage) having an average depth of 50 feet (NBP, 1992). The northern portion of the bay is surrounded by the heavily urbanized area of Providence and contains sediments that reflect the years of human and industrial waste disposal in the bay. The lower portion of the bay is surrounded by less densely populated communities and is generally characterized by less contaminated habitats.

The shoreline and waters of Narragansett Bay contain approximately 4,800 acres of coastal wetlands (RIDOA, 1988). Coastal wetlands in Rhode Island include salt marshes, freshwater the settlement funds to the Rhode Island Department of Environmental Management to be used to fund the transplanting of quahogs from restricted waters to two "spawner sanctuaries" at the mouth of Greenwich Bay and near Gould Island in the Sakonnet River (Figures 2 and 3). Quahogs will be transplanted to these locations and will be off limits to harvesting for two years.

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Narragansett Bay provides important fishery habitat for anadromous species, estuarine and marine finfish, shellfish and numerous other non-commercial but important lower trophic-level species (NBP, 1992). Commercial fisheries harvests in the state had a dockside value of $76 million in 1993 (U.S. DOC, 1994). The quahog (*Mercenaria*) is the most important commercial fishery within the bay (NBP, 1992; Pratt *et al.*, 1992) and supports over 2,000 jobs. Other important commercial stocks harvested from the bay include winter flounder (*Pleuronectes americanus*), lobster (*Homarus americanus*), menhaden (*Brevortia tyrannus*), and butterfish (*Poronotus triacanthus*) (see Olsen and Stevenson, 1975). Recreational fishing is estimated to generate more than $18 million of annual economic activity in Rhode Island (McConnell, *et al.*, 1981). Both commercial and recreational fisheries in Narragansett Bay are imperiled by over-utilization, habitat loss, and various types of pollution (NBP, 1992). These valuable fisheries can be maintained only through efforts to effectively manage fishing pressure, protect critical estuarine habitats, reduce pollution inputs, and initiate watershed-based ecological restoration.

Endangered and Threatened Species

Numerous Federally endangered and threatened species are seasonal or occasional visitors to Narragansett Bay. Several species of sea turtles may be present from June through November as wanderers in the bay. These include the threatened Atlantic loggerhead (*Caretta)*, and the endangered Atlantic leatherback (*Dermochelys coriacea*), Atlantic Kemp's ridley (*Lepidochelys kempi*), and the green sea turtle (Chelonia mydas) (D. Beach, NMFS pers. comm; Gould and Gould, 1992). The loggerhead, Kemp's ridley and green sea turtles are mostly juvenile and subadult individuals foraging in nearshore coastal waters. The Kemp's ridley appears to prefer estuarine areas where green crabs and mussels are found. Loggerheads feed on benthic organisms found in large bay systems and leatherbacks forage in the open waters in search of jellyfish. Several whale species (humpbacks, finback, and right whales) may transit the mouth of Narragansett Bay and Rhode Island Sound but do not typically enter the bay. Threatened or endangered bird species inhabiting the bay include the endangered bald eagle (*Haliaeetus leucocephalus*), peregrine falcon (Falco peregrinus), roseate tern (*Sterna dougallii*), and the threatened piping plover (*Charadrius melodus*) (Gould and Gould, 1992). The bald eagle, which is a rare migrant and winter visitor is most commonly found in salt ponds. Peregrine falcons are uncommon migrants usually seen in nearshore and tidal flat areas. The roseate tern is an uncommon summer breeder which favors rocky shores and islands for breeding. The piping plover is an uncommon migrant and summer breeder preferring sandy beaches for breeding and feeding (Gould and Gould, 1992).

Historic and Cultural Resources

The earliest evidence of human habitation of the Rhode Island coast dates back to 6,500 B.C. (Hale, 1980). Narragansett Bay has been a centerpiece of activities associated with local native American populations, the development of colonial America, the birth of the industrial revolution, the defeat of the Axis forces in World War II, and the origin of scientifically based marshes, forested wetlands, emergent wetlands, scrub-shrub wetlands, seagrasses, and tidal flats (Tiner, 1989). These coastal habitats support populations of wildlife including birds, fish, insects, mammals, and reptiles. Extensive scientific investigations have been conducted within the salt marshes of the bay by scientists at the University of Rhode Island Graduate School of Oceanography (University of Rhode Island, 1972). Salt marshes cover about 2800 acres of land around Narragansett Bay and fringing marshes line some 80 km of the bay shoreline. These intertidal wetlands, located along the bay shore and tributaries, serve as habitat for many important commercial and recreational marine fish species and other organisms that form critical links in the food chain of the bay ecosystem (Nixon and Oviatt, 1973; Nixon, 1982). It is estimated that 15-30% of the fisheries landed in Rhode Island waters are dependent upon estuarine wetlands (Greg Miller, National Marine Fisheries Service, pers. comm.).

Intertidal flats are composed of mud and sand sediments that occur between the limits of low and high tide and encompass some 4400 acres around Narragansett Bay (NBP, 1992). The utilization of tidal flats by numerous species of fish is also determined by water temperature and other factors such as tide level and time of day. Tidal flats are dominated by benthic worms and epibenthic crustaceans (Whitlach, 1982). These areas are believed to have few vertebrate residents, but instead are seen as areas "for the conversion of plant production into animal biomass" and that are interconnected to other coastal habitats (Whitlach, 1982). Tidal flats are also utilized as feeding and resting areas for migrating shorebirds such as sandpipers, and as foraging areas by other birds including herons, gulls, and terns (Whitlach, 1982). Many species of birds and fish alternate feeding between tidal flats and salt marshes in response to the tidal cycle.

The bay also contains eelgrass (*Zostera marina*) beds that function as finfish and shellfish habitat, sediment traps, nitrogen fixers, and wave energy absorption areas (Thayer *et al.*, 1984; Adamowicz, 1994). Seagrass beds were once found throughout some shallow areas of the bay. The decline is believed to have been caused by wasting disease, elevated nutrient loadings, increased turbidity, navigation channel construction and other forms of anthropogenic habitat destruction (Thayer *et al.*, 1984).

Sandy beaches are extremely important to the Rhode Island economy which is heavily dependent upon summer tourism (University of Rhode Island, 1994). Most of the state's sandy beaches are located outside of the bay along the shores of Block Island Sound. However, there are several significant sandy shorelines within the lower reaches of the bay especially at Narragansett Pier, Scarborough Beach, and Newport (Olsen and Grant, 1973). These coastal barriers provide foraging grounds to shore birds and mammals, as well as intertidal habitat for marine crustaceans and molluscs. Barrier beaches provide storm surge protection for coastal development and serve to moderate oceanic influences upon back barrier habitats such as salt ponds and coves. These and other coastal natural areas serve as recreational areas for residents and tourists, and provide habitat for important biological resources.

III. PROPOSED ACTIONS AND ALTERNATIVES

This section describes the actions NOAA considered to restore the resources injured by the *World Prodigy* oil spill. As discussed above, The Clean Water Act, as amended by CERCLA, requires NOAA to use settlement funds recovered from responsible parties to "restore, replace, or acquire the equivalent of the injured natural resources." NOAA considered three categories of activities: habitat restoration/resource enhancement; habitat acquisition; and no action. The environmental consequences of each of the aforementioned categories and alternatives is presented and discussed in this chapter. Monitoring methodologies for each of the preferred alternatives is also discussed.

The goal of the proposed actions is to enhance habitat value for a variety of marine resources with specific emphasis on quahogs (hard clams), lobsters, and estuarine finfish. This goal was developed because the spill adversely affected large numbers of the eggs, larvae and adults of these resources and because the public was prohibited from harvesting some of these resources during a period after the spill. To meet this goal NOAA proposes several actions: (1) enhance lobster habitat by establishing several lobster reefs; (2) transplant quahogs and establish "spawner sanctuaries" to help restock formerly productive areas of the bay and to make more of the resource available to shellfishermen; (3) establish eelgrass beds in multiple sites throughout Narragansett Bay to enhance fisheries habitat; and (4) restore a saltmarsh system on Sachuest Point to enhance habitat for estuarine dependent fish and shellfish.

A monitoring program will be implemented for each effort to evaluate its effectiveness. A requisite to any restoration project is a well designed and cost-effective monitoring effort. Such an effort forms the foundation and is a prerequisite of restoration plans because it is the sole means of providing a measure of the viability, stability and persistence of the restoration and, therefore, an assessment of the effective use of the settlement funds. The monitoring plan will provide the necessary information to establish criteria for and evaluate the need for mid-course corrections, should they be necessary.

Each alternative discussed below was evaluated based on the following criteria: (1) the project must restore resources injured by the spill; (2) the project must be cost effective; and (3) the project should use a proven technique and have a relatively high probability of achieving the restoration goal. Those projects which could not satisfy all of those criteria were eliminated from consideration. Table II at the end of this chapter summarizes the results of the criteria evaluation for each alternative. While there are more projects that can meet the above criteria than there is available funding, NOAA has determined that the proposed actions will be the most effective means to restore the injured resources.

1. Habitat Restoration/Resource Enhancement

In this category, several projects are considered to restore or enhance the resources and services injured by the *World Prodigy* oil spill. Seven alternative projects are considered, four of which are proposed. The proposed projects (letters A-D) are discussed first followed by the rejected proposals (letters E-G). General costs are provided for the proposed actions. Detailed budget information is available from NOAA at the address and phone number listed on the front cover page.

A. Lobster Habitat Enhancement (Preferred Alternative)

Hundreds of adult lobsters and other crustacea and untold numbers of their larvae were killed by the *World Prodigy* oil spill. To address these injuries to the lobster population in Narragansett Bay, NOAA proposes to enhance habitat for lobsters and associated fauna by establishing several rocky reefs in the bay, tagging and seeding the reef with hatchery-reared lobsters, and monitoring the development of the lobster population in this new habitat. A limited number of hatchery-reared lobsters will be tagged and used to seed the reef to monitor their development and to test the efficacy of stocking hatchery reared-lobsters using coded micro-wire tags. NOAA will issue a contract for the purchase and construction of the lobster reef and will issue a grant to the University of Rhode Island to conduct the design and monitoring work.

The enhancement of marine resources, either to enhance harvests or to restore losses, has a long history. Methods to enhance fishery resources include regulating fishing effort to reduce pre-recruit mortality or increase survival of breeding stock, adding hatchery-reared animals, increasing useful habitat, and protecting breeding stock in sanctuaries (Conan, 1986; Addison and Bannister, 1994). When habitat has degraded due to natural or anthropogenic causes, restoration of the habitat is appropriate to allow populations to return to pre-disturbance levels, assuming the cause of the degradation has been removed or is below acceptable levels.

Lobster Life History and Biology

The American lobster, *Homarus americanus*, is one of the largest and most valuable crustaceans in the world. It is found from the intertidal zone to depths of 700 m along the northeast coast of North America from New Jersey to Labrador. Lobsters have been studied scientifically for over one hundred years. A commercial fishery developed in the United States and Canada during the mid- 1800s and currently supports a large and valuable industry in both countries (Fogarty, in press).

The life cycle of the American lobster is reasonably well understood. Females mature at sizes ranging from 60 to 105 mm carapace length (CL) and hatch their eggs into the water column where the larvae remain for between 11 and 54 days (MacKenzie, 1988). The developing larvae and postlarvae are transported considerable distances (e.g., Katz *et al.*, 1993). The postlarva swims at the surface for several days, then makes the transition from pelagic to benthic habitat, settling and remaining for several years in shallow, cobble substrata (Hudon, 1987; Wahle and Steneck, 1991). Early benthic phase lobsters are cryptic and quite restricted in habitat use (Wahle and Steneck, 1991); they probably do not emerge from their shelters until reaching a size of about 25 mm CL (Wahle, 1992; Cobb and Wahle, 1994). Larger, but still sexually immature adolescent phase lobsters are found on a variety of bottom types, usually characterized by an abundance of potential shelters. Inshore, they are found in greatest abundance in rock and boulder areas (Cooper and Uzmann, 1980). There are very few data on the density of lobster populations. Surveys by divers have provided estimates ranging from 70 to 32,500 lobsters per hectare in inshore rocky areas (Cobb and Wang, 1985). In Rhode Island and Connecticut, densities of approximately one lobster per 10 m^2 were reported by Cobb (1971) and Stewart (1970) in rocky habitat. Juvenile lobsters seldom move more than a few kilometers (Wilder, 1963). Once mature, animals may range over 30 km annually and some travel as far as 100 km or more on cross-shelf migrations (Cooper and Uzmann, 1971) or along the coast (Campbell and Stasko, 1985).

Habitat Enhancement Efforts

Previous attempts to increase lobster populations in local areas through habitat enhancement have been successful. A relatively systematic habitat enhancement effort was conducted in Rhode Island waters (Sheehy, 1976). Artificial shelters, made of pumice concrete, were placed on featureless sand substrate in the Point Judith Harbor of Refuge. Lobsters of all sizes, including newly settled lobsters, colonized the shelters quickly, as did other species of crabs and fish. Design of the shelter was important: the triple chamber design was used by a larger number of lobsters than was the single chamber design. Lobsters both used the chambers and burrowed underneath the solid portions of the concrete blocks. Orientation of the shelter was important for hydrodynamic reasons. Currents, particularly during storms would scour around the shelters or flip them over.

An artificial reef made of 8 heaps (1 x 4m) of blocks fabricated from pulverized fuel ash covered an area of 10 m x 30 m in Poole Bay, England. The reef was situated approximately 3 km from hard substrate inhabited by lobsters. Within three weeks after deployment of the reef, lobsters (*H. gammarus*) were found on the reef by divers. Population estimates of lobsters on the reef are in the range of 20-30 animals per 100 m^2. Most of the movement of tagged lobsters seen was between units of the reef, and residence times on the reef were high. Several tagged individuals were resampled several times over a period of more than a year (Jensen *et al.*, 1994.)

A large rock reef (2740 m^2) was built in eastern Canada and the development of the lobster population followed for 7 years. During the first two years, the reef was colonized by lobsters larger than the average size of individuals in nearby natural areas, and the biomass was lower. However, after 5 years, the size distribution of lobsters on the reef was similar to natural ground, and the biomass was higher than neighboring areas (Scarratt, 1968, 1973).

The characteristics of a good artificial reef for lobsters were described by Spanier (1994). These include being a good recruitment substrate for postlarvae and juveniles, and being a refuge from predation for all stages. Adequate shelter and food resources also are important to the maintenance of a population on an artificial reef. Placement of the reef in a location where lobsters of all sizes will recruit to it also is important.

Project Description

Overview

NOAA proposes to establish six artificial reefs made of various sizes of cobble and boulders in the west passage of Narragansett Bay. All six reefs will be placed on sandy bottom in approximately 20-30 feet of water off the Bonnet Shores area (Figure 1), where both lobstering activity and earlier sampling have demonstrated a naturally occurring population. The specific locations within this general area will be chosen in consultation with local fishermen. Areas where quahogging is common, or where draggers frequently work will be avoided.

The proposed reef location in the lower West Passage, off Bonnet Point in Narragansett is reported in the Narragansett Bay Project Habitat Inventory to be "marine sand." Pratt (University of Rhode Island, personal communication) subclassifies the area as "bay mouth wave-washed sand." McMaster (1960) classified the area as "sand" and noted that the clay content was less than 10%. Little sampling for benthic fauna has been done in this area. The surf clam, *Spisula*, is found and occasionally harvested in the vicinity. A few specialized forms of benthic fauna adapted for mobile sands would be expected to inhabit this area. At the mouth of the Sakonnet River, where similar substrate is found, the benthos includes the capitellid *Amastigos caperatus*, two species of the polychaete *Arcia*, the predatory polychaete *Nephtys picta*, Haustoriid amphipods, and beds of the sand dollar *Echinarachnius parma* (S. Pratt, personal communication).

The reefs should become populated by newly settled lobsters and lobsters that migrate in from nearby, natural areas. The development of the population on the reefs will be followed over time. In addition, hatchery-reared lobsters will be released onto the reefs. This may augment the natural population and test the question of whether hatchery releases have an impact on lobster density. The impact of the reefs on the density of lobsters in the area where the reefs are placed will be evaluated using a Before/After-Control/Impact (BACI) design which addresses the needs for replicated sampling in time and in space and the comparisons of control (unaltered) areas to the affected area (Underwood, 1992).

Reefs

A total of six small reefs are proposed. Each of the artificial reefs will be composed of an area of cobble (small rocks 3-10 cm diameter, see Wahle and Steneck, 1991; Wahle, 1992) and an area of larger rocks and boulders (20-40 cm diameter). This range of substrate sizes will provide refuge for the whole span of lobster size (Wahle, personal observation). As a lobster grows, it outgrows the habitat it first selects and must move to new habitat where larger crevices are available (Wahle, 1992; Caddy and Stamotopoulos, 1990.) Each reef will be 10m x 20m. Vertical relief will be on the order of 1/4m in the cobble section and 1/2m in the rock/boulder section. A total of 450 cubic meters of cobble and boulders will be used, covering a total area of 1,200 square meters. The reefs will be established with a barge and crane operation with the rocks being placed on the bay bottom by the crane.

In order to locate the reefs in a suitable area where they will not be covered by moving sand, or be placed on top of existing lobster habitat, a survey using side-scan sonar will be conducted. The results of the survey will be interpreted using information about current speed in the area (available from earlier work by M. Spaulding, URI)

Release of hatchery-reared lobsters

Approximately 600-1000 juvenile (fifth-stage), hatchery-reared lobsters will be released onto each reef each of the first three years in the early summer to determine the effects of stocking on lobster population size on the reefs. Each individual will be tagged with a coded microwire tag. The tags are retained through molting and thus can be used to identify individuals seeded onto the reef and distinguish them from individuals that settled naturally.

The early benthic stage lobsters seeded on the reefs will be the progeny of females captured in Narragansett Bay. Egg bearing females will be brought into a laboratory at the University of Rhode Island's Graduate School of Oceanography and allowed to hatch their eggs on a normal schedule. The larvae will be reared, using standard techniques, in kriesels designed to keep the larvae moving and apart from one another. Animals will be maintained in the kriesels until the fifth stage is reached. At that point, they will be tagged, held for two or three days in individual compartments to ensure that tag-related mortality is low, and then released by divers on the reefs.

Monitoring

Monitoring will be conducted over a period of five years to quantify the impact of the deployment of the artificial reefs on the local lobster population. Divers using standard visual and air-lift census techniques will assess the number and size of lobsters on the reef at defined intervals for five years. Nearby natural lobster grounds also will be monitored. The population density, size and sex composition of natural and artificial lobster habitat will be compared. To monitor the development of the lobster population on the reefs, divers will census each reef on a regular basis. At least one (if possible, more) census will be made during the month before the reefs are installed. Monitoring is also proposed for the presence and relative abundance of species of larger invertebrates, fishes, and macroalgae (% cover) on the reefs. All small lobsters captured on the reef and in nearby natural areas will be screened for the presence of a microwire tag. This will allow us to determine the effect of stocking, and, depending upon emigration, provide estimates of mortality and carrying capacity. To provide an estimate of the longer-term effectiveness of the larval stocking effort, commercial and scientific fishing on the artificial reefs will be performed on a weekly basis in the final year of the project. All captured lobsters will be scanned using a magnetic scanner to determine the presence of the coded micro-wire tags. Monitoring activities will address the following:

- To quantify the impact of the reefs on the density of lobsters, the number of lobsters in nearby sandy habitat will be compared to those at the reef site.
- Do specific population parameters (density, size distribution, sex ratio) of lobsters on the artificial reef differ from those of lobsters in natural rock and cobble areas nearby?
- Do the measured population parameters (above) change over time as the reef ages?
- Does the size of the cobble affect the recruitment of lobsters to the reef?
- Does the seeding of early benthic phase lobsters affect population density on the reef when compared to unseeded reefs?
- Does the rate of loss of seeded lobsters vary with cobble size?
- Is there movement of marked lobsters from areas of small cobble to areas of larger rocks as the lobsters grow larger?

Costs

1. Six 10m x 20m artificial reefs, as described above will cost approximately $50,000 for purchasing and hauling the cobble and boulders and labor for operating the barge, crane, and tug.

2. Personnel, supplies and boat time for tagging, seeding, and monitoring for five years is estimated at $220,000.

Environmental Consequences

Establishing six cobble/boulder reefs appropriate for a wide size range of lobsters should attract and retain newly settling lobsters as well as "walk-ins." This should allow the reef to develop a population of lobsters similar in size and structure to those found in natural substrate areas. The reefs will displace the existing sandy substrate and its associated fauna. A total of 1,200 square meters of bottom will be covered by the reefs. In its place the reefs should attract fauna associated with rocky subtidal environments typical of those in Narragansett Bay. This type of community consists of such species as tautaog, cunner, sculpin, sponges, sea anemones, crabs, lobsters, encrusting algal species, sea stars, barnacles, bryozoans, gastropod molluscs, mussels, and others.

Criteria Evaluation

This project addresses injuries to lobsters caused by the *World Prodigy* oil spill. Artificial reefs for lobsters have been successfully implemented in a variety of locations and settings (Scarrat, 1968, 1973; Sheehy, 1976; Jensen, *et al.*, 1994). In addition, lobster habitat has been studied extensively in Narragansett Bay and elsewhere (Incze and Wahle, 1991; Wahle and Steneck, 1991;1992; Wahle, 1993;). This project will attempt to create lobster habitat which mimics their habitat found in nature. Based on previous studies, it is expected that the reef will be colonized rapidly by lobsters and other organisms. The cost of creating the habitat is relatively inexpensive given the potential benefit to injured fishery resources. An additional amount of the project budget is devoted to monitoring to ensure the success of the project, to make any necessary mid-course corrections, and to develop new information on the relative effectiveness of artificial reefs.

B. Quahog Spawner Sanctuary in Narragansett Bay (Preferred Alternative)

During the *World Prodigy* oil spill the entirety of Narragansett Bay was closed to all shellfish harvesting as a precautionary measure to protect public health. Though no documented injuries occurred to adult quahogs, commercial and recreational clammers lost access to the quahog resource for the closed period and shellfish larvae were killed by the spill. To address these injuries, NOAA proposes to transfer a portion of the settlement funds to the Rhode Island Department of Environmental Management (RIDEM) quahog spawner sanctuary program to expand their efforts. The RIDEM has a long history of transplanting quahogs from restricted areas to areas of the bay open to harvesting to allow shellfishermen access to the resource. The spawner sanctuary program attempts to reestablish clam beds in selected parts of Narragansett Bay. The objective of this project is to increase the number of harvestable quahogs to compensate recreational and commercial shellfishermen for the lost use of the bay during the oil spill. An additional objective of the project is to re-establish quahog populations in areas which previously, but no longer contain significant quantities of the resource.

Spawner sanctuaries have been used as a fishery management tool for decades. Such areas are closed to harvesting of living resources for a defined period of time to protect local populations of the resource so they can increase in abundance. A quahog spawner sanctuary established by the State of Rhode Island in Quonochontaug Pond has resulted in increased density throughout the pond over a four-year period (Ganz, 1988). The Rhode Island Marine Fisheries Council has recently established two quahog spawner sanctuaries in Narragansett Bay. The State of Rhode Island also has funded annual quahog transplants from areas that are closed to harvesting (due to fecal coliform contamination) to management areas to allow for spawning, depuration, and subsequent harvesting. Both the transplant and sanctuary programs rely on members of the industry to collect and move shellfish to the selected sites.

Methodology

Two areas of Narragansett Bay have been designated as spawner sanctuaries through regulations promulgated by the Rhode Island Marine Fisheries Council (Figures 2 and 3). One site is located at the mouth of Greenwich Bay (Figure 2). The site is irregularly shaped and encompasses the waters south of a line between the flagpole at the Warwick Country Club and the seaward end of Sandy Point; north of a line between the Warwick lighthouse and the seaward end of Pojac Point including all the waters of the Potowomut River. The second location is in the upper Sakonnet River in the vicinity of Gould Island (Figure 3). This rectangular shaped site includes most of the waters of the upper Sakonnet River to the north of

Gould Island. These sites were selected because they were once productive areas which are currently depleted.

Shellfish densities and presence of predators in the sanctuaries will be determined prior to transplant operations. If predators such as starfish, crabs, and whelks are determined to be a potential problem, they will be removed from the sanctuary sites by dredging or mopping to protect newly settled quahogs from predation while the bed is being established. Once the bed is established newly settled clams will no longer need the added protection that mopping provides.

Shellfish will be transplanted to each site in two successive years. Quahogs will be harvested and transplanted in the spring by commercial shellfishermen or a dredge boat from uncertified waters and used as the brood stock in the established spawner sanctuaries. Transplanting in the early spring will enable the quahogs to undergo a normal spawning cycle during the summer months. The quahogs will be transported by vessel to the sanctuary sites and planted. It is expected that approximately 200,000 pounds of quahogs will be transplanted to the sanctuary sites in each of the two years of the project. Harvesting from the sanctuaries will be prohibited for two spawning seasons. Increasing the spawning population density within these areas is expected to improve fertilization and larval distribution within the sanctuaries and adjacent waters. The presence of potential predators will be monitored by direct observation using divers, test tows, and mopping on a seasonal basis and controlled during the course of the two years. A population survey will be conducted prior to reopening the areas to harvesting.

Costs

Costs for RIDEM enforcement staff, monitoring, equipment, and contracts with local shellfishermen or a dredge boat to harvest and transplant quahogs will be approximately $75,000.

Environmental Consequences

Transplanting quahogs from one area of the bay to another will have minimal impact on the environment. Commercial shellfishermen will harvest quahogs from closed areas using bullrakes; a method that is normally used to harvest these resources in the bay. Rhode Island DEM enforcement staff and the Department of Health will ensure that quahogs harvested from the closed areas are transported to the sanctuary site and that harvesting from the sanctuaries is prohibited until after the quahogs have safely depurated.

Criteria Evaluation

Transplanting quahogs from closed areas to areas that are open to harvesting is a proven method of increasing fishermen's access to an otherwise unharvestable resource. Spawner sanctuaries have been used for a variety of species of fish and shellfish and have proven successful for enhancing local populations of these species. This project will compensate the public for the lost use of quahog beds during the oil spill. The cost of moving the shellfish is relatively inexpensive. Shellfishermen are paid a fee (usually $.10/lb) to harvest the shellfish to be transplanted. This resource in turn is then made available to the public for harvesting.

C. Eelgrass bed restoration (Preferred Alternative)

Personnel from the National Marine Fisheries Service's (NMFS) Beaufort, North Carolina laboratory will transplant eelgrass, *Zostera marina*, to approximately 10 different locations in Narragansett Bay to enhance fishery habitat as a compensatory measure for lost resources. Sites will be identified following site surveys and consultation with local investigators, and selection will be based on water quality conditions, sediment particle size, historical evidence of presence of eelgrass, and degree of exposure to waves and tidal currents.

Eelgrass is an important component of the marine ecosystem. Eelgrass meadows serve several important functions including stabilizing sediment, providing nursery areas for fish and shellfish, filtering suspended particles and nutrients from the water column, and providing an important source of organic matter to the ecosystem (Thayer, *et al.*, 1984). Eelgrass meadows serve as important habitats for forage fish and numerous commercially and recreationally important marine fish and shellfish including bay scallops (*Argopecten irradians*), quahogs, tautog (*Tautoga onitis*), winter flounder (*Pleuronectes americanus*), and sticklebacks. (Thayer *et al.*, 1984, Heck *et al.* 1989, and Peterson *et al.*, 1984).

Eelgrass beds were drastically reduced throughout their range in North America and Europe, including Narragansett Bay during the 1930s but have generally recovered since that time (Thayer *et al.*, 1984). However, in some areas, such as Narragansett Bay, recovery has been limited (Kopp *et al.*, 1995). The cause for the catastrophe, termed "wasting disease," has been determined to be the protozoan *Labyrinthula zosterae* (Muehlstein *et al.*, 1991). More recently water quality degradation has inhibited and caused the decline of seagrass in many locations (Short *et al.*, 1993). The loss of eelgrass has caused several severe adverse impacts to the coastal ecosystem including coastal erosion, changes in the sedimentary environment with concomitant changes in the benthos, and a near complete disappearance of the bay scallop in some locations including Narragansett Bay (Thayer *et al.*, 1984).

While a complete recovery of eelgrass has not occurred in Narragansett Bay, remnant beds still persist in numerous locations. Several reasons may have conspired to prevent greater recolonization of eelgrass in the bay. When seagrass losses occurred during the wasting disease of the 1930s substantial erosion of shorelines apparently occurred (Dexter, 1944). Concomitant with this erosion, one would expect substantially higher turbidity, a factor that reduces light availability and thus, potential eelgrass habitat. Over several decades, it is likely that erosion and sediment resuspension would have abated as an equilibrium between available, erodible substrate and water motion developed. However, at this time, widespread coastal development was on the rise which would have exacerbated turbidity, nutrient loading, and epiphytization, all factors which have been shown to severely limit the growth and survival of seagrass beds. Thus, dispersal from surviving stocks may not have found suitable areas to colonize or were so chronically disturbed that they could not form critical patch sizes to survive (Olesen and Sand-Jensen, 1994).

Other factors, such as increased shellfish harvesting which disturbs the bottom, anchor damage, propeller scarring, all could work together to create localized impediments to recolonization. Moreover, seagrass restoration research has demonstrated that shortly after transplanting seagrass, when the plants are at a low density (much like early stage colonization), significant losses can be effected by bioturbation (Fonseca pers. com., 1994). One vector of this disturbance in New England is the European green crab. The advent of this introduced species may also have limited the recolonization of the bay.

Given the importance of eelgrass to commercially and recreationally important marine resources and the marine ecosystem as a whole, restoring this seagrass has been attempted in numerous locations and transplanting techniques have been fairly well developed (Fonseca *et al.*, 1982, 1994; Fonseca, 1990, 1994). The historical existence and persistence of eelgrass beds in Narragansett Bay provides the strongest evidence that restoration of this seagrass in the bay is possible. In addition, with continued and planned improvements in sewage treatment in the bay, water quality is expected to continue to improve, thus enhancing conditions for the survivability of eelgrass.

Personnel from the NMFS Beaufort lab will implement the proposed eelgrass restoration project jointly with the University of Rhode Island's Graduate School of Oceanography and the Rhode Island Department of Environmental Management's Narragansett Bay Project. With funding provided by the *World Prodigy* settlement, the Rhode Island Aqua Fund and the NOAA National Estuarine Research Reserve Program each institution will contribute funds and expertise to accomplish the restoration of eelgrass in the bay.

Methodology:

NOAA will select up to 10 locations throughout Narragansett Bay to transplant eelgrass. These sites will be selected based on sediment type, water quality and clarity, wave energy, and human activity. At each of the 10 planting sites six planting plots will be established in a single block. Each plot will measure 5m x 5m. Each plot will be caged to protect the plants from bioturbation. Each plot will consist of two rows of five planting units (1-5 shoots per planting unit) each. One pair in each plot will receive fertilizer at the time of planting. Total planting would entail 1,000 to 3,000 plants spread over 540 square meters of seafloor. Eelgrass plants will be harvested from existing beds in Ninigret Pond or other suitable locations.

Monitoring:

The objective of the monitoring efforts will be to determine the degree of success of establishing the eelgrass beds. Specifically, monitoring to determine percent survival, areal coverage, number of shoots per planting unit, and benthic colonization will be undertaken on a regular basis for three to five years. Significant cost savings will be realized by the joint monitoring efforts of NMFS, URI, and R.I. DEM.

Cost:

The costs for personnel, equipment, transplanting, travel, and monitoring is approximately $100,000.

Environmental Consequences

This alternative will alter the topography of the bottom. The added vegetation will alter the flow regime and function to stabilize sediments. This will also increase the accumulation of organic and inorganic materials and will reduce erosion as a result of sediments binding with the roots (Fonseca, 1992; Kirkman, 1992). The added vegetation will have a positive increase in the amount of detrital nutrients contributing to the food web and will increase nursery areas for fish and shellfish (Fonseca, 1992; Kirkman, 1992). The eelgrass plants to be used for transplanting will be harvested in small patches from a healthy source bed in Ninigret Pond. It is expected that the harvested areas will be rapidly recolonized.

Criteria Evaluation

The objective of this project is to establish a number of eelgrass beds throughout Narragansett Bay to provide habitat for a variety of resources which were injured by the oil spill. While eelgrass beds were not directly affected by the spill, resources that use this habitat during their lifecycle were injured and will benefit from its restoration. The literature documents successful techniques to establish seagrass beds and provides information on the relative value of created or restored beds versus natural beds. Costs to establish beds are relatively inexpensive, though transplanting is labor-intensive. In addition, our URI partners in this project will be examining other lower-cost techniques (seeding) to establish eelgrass beds.

<u>D. Sachuest Point Salt Marsh Restoration</u> (Preferred Alternative)

Salt marsh ecosystems are among the most productive natural systems on earth and serve as spawning, feeding and nursery areas for numerous species of fish and shellfish and as a valuable habitat for shorebirds and waterfowl (Teal, 1986). Salt marshes also maintain water quality by trapping sediment and pollution, provide flood and storm damage protection, and recreation to the public. Salt marshes have also been subject to a wide variety of development activities which have severely altered their diversity and productivity. Along the New

England coastline railroads, roads, and other forms of development have often restricted the natural tidal flow into marsh systems. As the natural hydrology of the salt marsh system changes and the salinity is reduced the natural salt marsh vegetation (*Spartina spp.*) begins to change (Roman *et al.*, 1984; Roman *et al.*, 1995). Often common reed (*Phragmites australis*), an invasive brackish water plant, will colonize such areas. *Phragmites* is thought to be of limited value to fish and wildlife. Tidal restrictions also reduce the area of marsh available to estuarine dependent fish and reduce the outflow of detrital material from the marsh system.

The objective of this proposed alternative is to enhance estuarine fish habitat by restoring the natural salt marsh vegetation and associated organisms to a portion of the Sachuest Point salt marsh in Middletown, RI (Figure 4) as a compensatory action for lost resources. As described earlier, numerous species of estuarine finfish larvae were injured by the *World Prodigy* oil spill and this project is designed to restore the losses of finfish and their associated habitat injured by the spill. The marsh restoration will be accomplished by restoring tidal flushing to a portion of the marsh where flow has been restricted.

The salt marsh within the Sachuest Point National Wildlife Refuge has been adversely affected by road construction and an inadequately sized culvert that has severely reduced tidal flow into this marsh. Tidal flow is the key factor for the health of a salt marsh. As a result of the decrease in tidal flow, salinity has decreased and *Phragmites* has colonized large areas of the marsh and reduced its value for fish and wildlife. Other significant disturbances over time have adversely affected the salt marsh system in the refuge, including two freshwater reservoirs which supply drinking water to the City of Newport and a now closed and capped municipal landfill. Both the reservoirs and landfill have eliminated large areas of former salt marsh.

A number of recent studies of restoration projects suggest that reintroduction of tidal flow into hydrologically-restricted marshes can restore a number of functions and values of those marshes (Roman *et al.*, 1984; Sinicrope *et al.*, 1990; Barrett and Niering, 1993; Peck *et al.*, 1994). The reintroduction of tidal flow into *Phragmites*-dominated marshes is based on the premise that an increase in salinity and flooding will decrease and kill *Phragmites* and allow natural recolonization of the marsh by *Spartina* spp. and other salt marsh plants. Hellings and Gallagher (1992) found that *P. australis* density, growth, and total above ground biomass decreased significantly with an increase in salinity and flooding. In a project undertaken in Connecticut, Bongiorno *et al.* (1984, cited in Marks *et al.*, 1994) found that with the restoration of tidal flow into a *Phragmites* dominated marsh, a 1- to 3-foot reduction in stem height resulted over each of three years. In addition, plant density declined dramatically from 11.3 plants/m^2 in 1980 to 3.3 plants/m^2 the following year. In following years, *P. australis* continued to decline, although less dramatically. In addition to the decreased height and density of the *Phragmites*, typical marsh flora including *Salicornia* (saltwort), *Distichlis spicata* (spikegrass), *S. alterniflora* (saltwater cordgrass), and *S. patens* (salt meadow grass) returned (Marks *et al.*, 1994).

In a well studied case of salt marsh restoration in Connecticut, a number of studies have concluded that restoration of tidal flow has had a dramatic impact on both the flora and fauna of the tidally-restricted portion of the marsh (Sinicrope *et al.* 1990; Barrett and Niering, 1993; Allen *et al.*, 1994; Peck *et al.*, 1994). A central creek flowing south through the marsh was impounded by a dike in the mid 1940s to create waterfowl habitat. The impoundment converted the former salt marsh to a cattail (*Typha angustifolia*) dominated brackish marsh. Tidal flushing was restored to the area in 1978 and in 1982. Sinicrope *et al.* (1990) found that *Typha*, which covered 74% of the transects in 1976, covered only 16% in 1988, with most stunted. However, they found that *Phragmites* cover increased from 6% to 17%, though 9% of the transect lengths had standing dead *Phragmites*. The authors noted that this species was also relatively depauperate. *S. alterniflora* showed a dramatic increase, from less than 1% in 1976 to 45% in 1988. A variety of other salt marsh species which were not seen in 1976 covered an additional 20% in 1988. In addition, the authors measured peat salinity which showed that *Typha* remained relatively healthy at 10‰ or less, became stunted as the salinity increased and died at about 20‰. *Phragmites* grew best at 20‰ or less and by 30‰, stands of this species were extremely depauperate (0.3-1.0 m tall), and typical salt marsh species tended to dominate.

The authors suggested that there may have been two reasons for an increase in *Phragmites* coverage. Herbicides were used in the early to mid 1970s to control *Phragmites* and may have skewed the baseline data. Secondly, *Typha* may have limited the spread of *Phragmites* in 1976. Once tidal flow was restored, however, *Typha* declined rapidly and allowed for the expansion of the more salt-tolerant *Phragmites*. Average *Phragmites* height in 1976, however, was 2-3 m and was 0.3 to 1.5 m in 1988. Additionally, since the time of the study, it appears that *Phragmites* has continuously decreased in coverage (Scott Warren, Connecticut College, pers. comm.).

Fell *et al.* (1991) and Peck *et al.* (1994) studied the impact of the restoration of tidal flow in this same system on invertebrate populations. Fell *et al.* (1991) compared distribution and abundance of the high marsh snail (*Melampus bidentatus*) above and below the impoundment dike. Peck *et al.* (1994) compared this same species and the ribbed mussel (*Geukensia demissa*) above and below the impoundment and also with a nearby reference marsh. These studies found that populations of *M. bidentatus*, *Geukensia* and other tidal marsh invertebrates were re-established on the restored portion of the marsh system and no significant differences in the numbers of the snail were found.

Site Description

The Sachuest Point salt marsh is located in the Sachuest Point National Wildlife Refuge in Middletown, Rhode Island and is bordered by Third Beach and the Sakonnet River to the west, Second Beach and Sachuest Bay to the east, Gardiner Pond (drinking water reservoir) to the north, and the upland Sachuest Point to the south (Figures 4 and 5). The property is owned by the U.S. Fish and Wildlife Service. The salt marsh is fed by a tidal creek which flows from the Sakonnet River through about 400 feet of beach to a 5.5 foot diameter culvert under Third Beach Road. The tidal creek flows through a relatively healthy salt marsh consisting of *Spartina alterniflora*, *S. patens*, *Distichlis spicata*, and *Juncus gerardi* (Area A on Figure 6). Just after the tidal creek passes through the culvert, a smaller tidal channel branches off in a southerly direction through the marsh. After some distance, this channel is crossed by a road which connects Third Beach and Sachuest Point roads ("connector road"). The channel, which has a maximum width of eight feet, carries tidal flow through a 20-inch culvert underneath the connector road to another pocket of wetlands totaling 12.8 acres (Area B on Figure 6). The channel is silted in and has been colonized by *S. alterniflora* some 250 feet before the channel reaches the culvert. The culvert also appears to be clogged. Immediately south of the connector road an area of salt marsh is present measuring about 1.8 acres in area. The majority of the remainder of Area B (about 11 acres) contains common reed and shrub wetland.

Fish and wildlife use at the site varies throughout the year. Bird nesting species found there include Willow Flycatcher, common yellowthroat, Eastern phoebe, swamp and song sparrows, yellow warbler and others (Table 1). Breeding bird surveys conducted since 1993 indicate that flycatchers, yellowthroats, phoebes, and both swamp and song sparrows are the most abundant nesting species using the site (Table 1).

Table 1. Average number/survey of the ten most abundant songbirds at the proposed wetland restoration site (Point Count site 2) and a nearby saltmarsh (Point Count site 1) at Sachuest Point National Wildlife Refuge.

Species	Average #s Site 1	Species	Average #s Site 2
Song Sparrow	2	Willow Flycatcher	3.9
Common Yellowthroat	1.9	Barn Swallow	3.0
Red-winged Blackbird	1.6	Common Yellowthroat	2.5
Yellow Warbler	1.4	Eastern Phoebe	1.3
Sharp-tailed Sparrow	0.7	Swamp Sparrow	1.1
Willow Flycatcher	0.6	Song Sparrow	1.1
Gray Catbird	0.5	American Robin	0.9
American Goldfinch	0.5	Brown-headed Cowbird	0.5
Mourning Dove	0.4	Yellow Warbler	0.4
Northern Cardinal	0.3	Red-winged Blackbird	0.3

Information on wintering species of birds at the site is sketchy but probably includes black ducks, yellow-rumped warblers, and white-throated sparrow. Wading birds such as rails and bitterns might use the site infrequently but have not been observed. No data regarding small mammals or reptiles exist for this area but probably include meadow vole, short-tailed shrew, and Eastern garter snake as some of the more common species. Fish species found in the tidal creeks include American eel (*Anguilla rostrata*), striped killifish (*Fundulus majalis*), mummichog (*Fundulus heteroclitus*), and Atlantic silversides (*Menidia menidia*) (J. Catena, pers. obs.). The Rhode Island Division of Fish and Wildlife has a permanent juvenile finfish sampling station just off Third Beach. The most frequently sampled fish from 1987-1993 at this station include winter flounder (*Pleuronectes americanus*), windowpane (*Scophthalmus aquosus*), Atlantic silverside, mummichog, tautog (*Tautoga onitis*) and bluefish (*Pomatomus saltatrix*) (RIDEM, unpublished data).

No state or federally threatened or endangered species are known to inhabit the immediate area. Sachuest Point is a state historical site for Sea Beach Amaranth (*Amaranthus pumilus*) a federally listed species. The federally endangered peregrine falcon sometimes uses the Refuge for roosting or foraging during migration but none have been observed at the site. Several "State Interest" species occur in the area including great blue heron, snowy egret, great egret, and glossy ibis. All species use the site for foraging and not nesting. Northern harriers (state endangered) can also be found in the area during the winter and might use the site for foraging only, but are listed only in terms of their nesting status. No state-listed plants are known to occur at the site.

Proposed project description

Under the auspices of the Coastal America Partnership,[1] the U.S. Army Corps of Engineers' New England Division (COE) provided technical assistance to NOAA to develop recommendations for restoring tidal flushing to the restricted marsh (U.S. Army Corps of Engineers, 1994). The COE conducted a hydraulic analysis of the marsh system using data from a limited elevation survey and tidal information gathered from NOAA's nearby Newport, RI tidal gage. Based on this analysis, the COE recommended that twin-30 inch culverts replace the existing 20-inch culvert beneath the road to adequately restore tidal flushing to the marsh south of the connector road. In addition, the channel feeding the culvert will be cleared of vegetation and deepened approximately two feet. Without channel modification, hydraulic scouring may occur through normal tidal flushing. However, the natural process is expected to be significantly slower because of the amount of root mass and silty material which must be removed. A channel south of the connecter road will also be deepened and lengthened to extend the influence of the tidal flow into the *Phragmites* dominated area of the marsh.

The combination of channel modification and placement of twin 30-inch culverts should increase tidal range within Area B by 1.0 to 2.0 feet, providing slightly greater high tide elevations (a few tenths of a foot) and significantly lower low tide elevations (approximately

[1]The Coastal America Partnership is comprised of Federal agencies with coastal resource management responsibilities (e.g. NOAA, COE, EPA, F&WS, etc.) that have agreed to collaborate and cooperate on identified problems to produce demonstrable environmental results.

one foot). The larger culvert will inherently provide better drainage during low tide conditions. After flow is restored to Area B with larger sized culverts, maintenance of the channel may not be required.

A baseline assessment of the marsh system will be conducted prior to culvert replacement to gather more detailed data on vegetation, fish use, hydrology, and topography. The hydrologic and topographic information will be used to verify the COE's recommendations and to develop an accurate estimate of acreage expected to be influenced by the increased tidal flow. Post-construction monitoring will be conducted every 3 years over a 10 year period to determine the success of estuarine fish habitat enhancement. Specific monitoring elements will consist of rate of colonization by *S. alterniflora* and other marsh plants, plant species composition, plant cover and height, hydrology, soil salinity, and fish use of tidal creeks.

Costs

The costs for personnel, equipment, construction, baseline assessment, and monitoring is approximately $80,000.

Environmental Consequences

Marsh enhancement will have positive effects on floral and faunal species composition. It will create valuable nursery grounds, allow for the reoccupation of salt marsh vegetation, and increase fish use of the tidal creeks.

Based on the literature and past experiences in Connecticut and elsewhere, the restoration of tidal flow into area B should convert the *Phragmites*-dominated marsh into a *Spartina*-dominated system. Salinity and tidal range should increase and slowly allow for the reoccupation by *Spartina* and other of salt marsh vegetation as the less salt-tolerant *P. australis* dies out. Restoration of tidal flow should also enhance the marsh as a habitat for fish and invertebrates that are dependent upon salt marsh ecosystems by making more habitat available for them to exploit. Bird communities should change to those more typical of the nearby saltmarsh (area A). Sharp-tailed sparrows, marsh wrens, and red-winged blackbirds which are typical of the marsh to the north of the connector road (Table 1) should increase on the south side of the road as well when more typical high marsh vegetation is established. Black duck use will probably increase as *Phragmites* retreats from open water areas and wading bird use will probably increase also.

It is quite likely that if no restoration activity occurs at this site, *Phragmites* would continue to colonize the marsh. Available subtidal and intertidal habitat for fish and invertebrates would continue to decline since access to the marsh by these organisms would continue to be cut off. *Phragmites* coverage would likely would reduce numbers of swamp sparrows, common yellowthroats and other wetland associated species.

This alternative will have no effect on the cultural environment.

Criteria Evaluation

The objective of this project is to enhance estuarine fish habitat by restoring the natural salt marsh vegetation and associated organisms to a portion of the Sachuest Point salt marsh in Middletown, RI. While this particular salt marsh was not injured by the spill, resources that use salt marsh habitats during their lifecycle were injured and will benefit from its restoration. Marsh restoration of this type is fairly well documented (Roman *et al.*, 1984; Sinicrope *et al.*, 1990; Fell *et al.*, 1991; Barrett and Niering, 1993; Roman *et al.*, 1995). The cost of restoring tidal flow into the Sachuest Point marsh system is relatively inexpensive given the resource benefits that will accrue. Furthermore, cost-savings will be realized since the property is owned by the U.S. Fish and Wildlife Service and equipment and personnel from that agency will be used in carrying out certain aspects of the restoration project.

E. Construct and operate a hatchery (Not proposed)

The construction and operation of a shellfish and lobster hatchery is a potential method of replacing the biota impacted by the spill as well as their lost progeny. The oil spill resulted in closure of shellfish beds and mortality to larval quahogs and larval and adult lobsters which the hatchery would attempt to replace. Enhancing natural population size by the release of larvae or juveniles reared in hatcheries is a time tested method for some freshwater and a few marine fish species. Hatchery stocking of lobsters and quahogs has been used extensively. However, there has been minimal evaluation of the impact of these stocking activities on the natural populations of these species. For reasons discussed below the construction and operation of a hatchery is not proposed.

Attempting to enhance natural quahog populations with hatchery-reared quahog seeds is a method that has been used extensively. However, there effectiveness has never been adequately evaluated (Malouf, 1985). Hatchery-reared quahog larvae dispersed into the bay are likely to suffer high predation losses and their impact on local populations is likely to be minimal. Research has shown that survival of quahog seed is greatly affected by its size when introduced into the environment. The larger the seed size the greater the likelihood of survival. However, because the space and nutrient requirements increase geometrically with size, hatcheries typically sell the seeds in the 2-4 mm size range. Using such a seed size increases risk of predation, and reduces the probability of success. The probability of survival increases when quahog seed is adequately protected by nets, screens, or other protective measures (Kraeuter and Castagna, 1985; Castagna, 1984). Even with protection and large seed sizes, however, predators can still cause significant mortality (Flagg and Malouf, 1983). In addition, there is no evidence that these introduced juveniles result in long-term enhancement of the population (Malouf, 1985). An on-site hatchery program would provide the necessary seed but would have to be maintained and operated indefinitely. In addition, protected nursery and grow-out areas would be required to give the hatchery-reared seed a chance to survive predation.

Early in this century, lobster hatcheries were very common in Canada and New England as well as France, Norway and England and these hatcheries produced and released between 200,000 and one million larvae each year (Addison and Bannister, 1994). However, the impact of these releases never was evaluated adequately. Lobster hatcheries are rare now, because the costs of larval rearing and release could not demonstrate benefits to the fishery. Recently, a new technique to evaluate effectiveness of hatcheries has been used. This technique involves rearing the lobsters to a larger size (approximately three months old, 15mm carapace length) and tagging them with coded, microwire tags before setting them out in appropriate natural habitat (Addison and Bannister, 1994). The harvested lobsters are then scanned for the presence of the coded tags. Rearing to this size is considerably more expensive than rearing and releasing them at the traditional three to four week stage (stage IV -- as is practiced at the Massachusetts State Lobster Hatchery). The increased expense is due to the need to separate and rear each juvenile lobster in individual containers after stage IV because of their cannibalistic behavior.

Recent studies conducted in England indicate that hatchery-reared lobsters can recruit to the fishery. (Bannister *et al.*, 1994, Addison and Bannister, 1994). Nearly 50,000 three-month old hatchery-reared lobsters were tagged with coded microwires and released into an area that supports a substantial fishery (Bannister *et al.*, 1994). Of these, 621 were recaptured up to eight years later. The recapture rate of tagged lobsters was about 1% of those released. However, when the data were viewed as catch rate per size class, tagged lobsters made up a much higher proportion (10-35%) of all lobsters of that size. Sampling outside the area of seeding gave no evidence of dispersion any distance from the general release area. Bannister *et al.* (1994) estimated that the survival rate from the time of seeding to entry into the fishery (4-8 years depending on growth rate) may have averaged 50%. Despite this, the tagged lobsters were a very small proportion of the fishery catch, suggesting that seeding 50,000 three-month old juveniles over a five year period did not make a substantial difference in catch rates. An additional question remains as to whether the hatchery-reared lobsters added to the natural stock or merely displaced it (Addison and Banister, 1994.) The question of the economic benefit of re-stocking remains open.

Although studies focusing on the introduction of stage X to XII hatchery-reared juveniles show there is initial biological success, long-term enhancement of the fishery has not been shown. With a low experimental recapture rate, it is difficult to determine if the hatchery-reared lobsters that survived are beneficial to the natural population or if they survived at the expense of the naturally existing lobster recruits. It is uncertain if these stocks result in long-term population benefits. One possibility is that hatchery-reared lobsters would need to be released in large numbers to be able to impact a local fishery (Bannister *et al.*, 1994). Future studies will determine if hatchery-reared stocks enhance a natural community or if they increase competition for shelter and displace the natural population. If the introduced lobsters displace the natural population, then what has resulted is not really an enhancement but a restocking. More research is needed to determine effects on the genetic diversity of hatchery-reared lobsters.

Cost

The construction and continuous operation of a hatchery requires funding beyond what is available from the oil spill settlement and natural resources trustees are prohibited from selecting a restoration project that would require funding beyond what is available (43 CFR 11.93(b)). Although the construction of a hatchery is a one-time expense, operational expenses would exceed the available budget since the hatchery would need to be operated in perpetuity to maintain the quahog and lobster populations needed to sustain a fishery. Funding to operate a hatchery would last less than five years with no guarantee that a self-sustaining natural population would result. While the facility could be transferred to other entities (state government or non-profit organization) NOAA has received no commitments for such a transfer. Without such a commitment it would be impractical to build and operate a hatchery for only a few years.

Environmental Consequences

Potential impacts of introducing hatchery-reared organisms into the environment include: introduction of disease organisms or exotic species; reduction of genetic variability in stocks, or masking of the total extinction of local natural stocks; and reduction in growth and survival of natural and planted clams if the local environmental carrying capacity is exceeded (Malouf, 1985). It is not known if hatchery-reared lobsters enhance a natural population or if they increase competition for shelter and displace a natural population. Long-term monitoring studies are needed to determine the effects of introduced juveniles on wild stocks. Although there may be initial biological success with introduced lobsters, it is not known if this success is sustainable without continued human intervention. Hatchery-reared juvenile lobsters artificially elevate the natural population and more information is needed to determine the density dependent factors controlling the balance in the ecosystem (Addison and Bannister, 1994, Bannister *et al.*, 1994).

There should be no effect on the cultural or historical environment of the Narragansett Bay area.

Criteria Evaluation

Lobster and shellfish hatcheries, while having been used quite extensively over the years, remain an unproven technique to enhance populations of these species. New evaluation techniques have been developed for lobsters. However, to employ these on a large scale would be cost-prohibitive. Cost-effectiveness is quite low given the relatively high cost of construction, operation, and maintenance of a hatchery and the lack of proven success. In addition, available funding is insufficient to continue operation of a hatchery beyond a very limited time period. Due to these factors, hatchery construction and operation is not selected as a proposed alternative.

F. Purchasing and seeding juvenile clams and lobsters (Not proposed)

A slight variation on the above alternative is to purchase larval clams and lobsters from existing hatcheries and release them into the Narragansett Bay environment. Larval lobsters and clams would be purchased from hatcheries currently operating in the area. The juveniles would be transported to pre-selected sites and released. Sites would be selected based upon habitat types, water quality, and circulation patterns. While the expense of constructing and operating a hatchery would be saved, this alternative has not been proven to enhance the populations of these species. See the above hatchery alternative for further discussion. For these reasons, this alternative is not proposed.

Cost

This alternative faces operating challenges similar to the hatchery because this program would need to be operated indefinitely. With the funds available for restoration, operating this program in perpetuity is not feasible.

Environmental Consequences

Effects under this alternative are similar to those described under the hatchery alternative since lobsters and quahogs would be placed in the environment in the same manner as described above. Please refer to the discussion of the effects on the biological environment under the hatchery alternative. There would be no effect on the cultural environment under this alternative.

Criteria Evaluation

Purchasing and seeding larval quahogs and lobsters on a scale adequate to enhance the population of Narragansett Bay is not likely to be successful given the level of funding available (see McHugh, 1981). Methods to evaluate effectiveness of seeding have remained elusive until relatively recently. However, the cost for implementing these evaluation techniques described above would reduce the cost-effectiveness of the project relative to the other available alternatives. Given the uncertainty of the relative success of enhancing lobster and quahog populations using the seeding technique, this alternative is not proposed.

G. Quahog habitat enhancement by shelling (Not proposed)

Another potential option to enhance quahog populations in the bay is to select one or more sites for "shelling" the bottom ("cultching") by broadcasting bivalve shell over the bottom.

This option is based on studies which indicate that quahogs are more abundant in areas with a naturally high percentage of shell on the bottom (Pratt, 1953; Wells, 1957; Saila, *et al.*, 1967; Craig and Bright, 1986; Kassner *et al.* 1991). This method, however, was rejected because, while shelling can enhance the bottom for a variety of organisms, it is still largely experimental for quahogs with unproven, though potentially promising, results (Kraeuter *et al.* 1994, Kassner, 1995).

Like many forms of marine life, quahogs spend the earliest portion of their life cycle as free-floating planktonic larvae and then make the transition to bottom-dwelling life up to two weeks after fertilization. It is during these early stages that quahogs are most heavily preyed upon. Rice (1992) indicates that the period of larval settlement and metamorphosis is one of the most critical in the quahog's life cycle and large numbers of larvae do not survive the transition. Preferred settlement locations appear to be important for minimizing subsequent post-settlement predation losses. One potential approach to enhancing quahog populations is to improve the survival rate of juveniles through the provision of shelter from predators by shelling the bay bottom.

Cultching has been used to expand shellfish resources, in particular oysters, in the United States and in other countries. Several states encourage habitat enhancement with cultch. Connecticut has an active program to enhance oyster beds that has resulted in the placement of more than four million bushels of cultch on public shellfish beds (Volk, 1992). The State's effort has resulted in both a sustained growth in the number of active oyster harvesters and increased stocks of harvestable resources on the public beds (Volk, personal communications). Within the borders of Rhode Island, cultching of oysters beds was once a traditional practice. The decline of the oyster industry as a result of overfishing, hurricanes, disease, increased predation and pollution in the 1960's and the associated reduction in shucking operations providing suitable cultch precluded its continuation.

The methodology would involve dispersal of clean shell over the bay bottom from the deck of a barge, using a high pressure water jet or other dispersive technique. Cultching would take place in 12 to 20 feet of water (Mean Low Water). A density of 2,000 bushels per acre (Tallmadge Brothers Company, personal communications) for creating shellfish setting habitat on stable, sandy to gravelly bottoms would be targeted. This amount would allow the shells to form a uniform, single layer. The shelled bottom should enhance setting of juvenile clams and protect them from predation by permitting the larvae access to the actual sediments while requiring predators to move the shells in order to feed on the quahogs.

Monitoring activities would involve gathering pre- and post-cultching data, relative to quahog abundance and growth, sediment characteristics, and topography. The data could include numbers of quahogs per square meter, mass, and the comparison of those values to pre-enhancement and adjacent site values. Control sites would be sufficiently removed from the area to ensure that they are not within the zone of influence of the cultching. The number of individuals settling into an area and their survival ratio would be determined by count.

Cost

Shell would have to be purchased and transported to selected sites by tug and barge. Additional equipment costs would include water-jet dispersal equipment to disperse shell over the bottom and divers to insure proper placement. Shell could be purchased, transported and dispersed for about \$.70/bushel to \$1.30/bushel or \$1,000 to \$3,000 per acre. Monitoring costs to evaluate effectiveness of the project would add additional costs.

Environmental Consequences

The alternative would slightly change the bottom topography of the area selected for cultching which in turn may slightly change the hydrographic conditions along the bottom. The shell will add three dimensional relief. Shelling could enhance other benthic dwelling organisms such as crepidula (*Crepidula fornicata*), crabs, drills, and other epifauna. No additional effects to the physical environment are expected. This alternative will have no effect on the cultural environment.

Criteria Evaluation

Although the use of shell placement to enhance oyster survival is a proven technique it has only been attempted on an experimental basis for the enhancement of quahogs (Kassner *et al.*, 1991; Kraeuter *et al.*, 1994; Kassner, 1995). Given the uncertainties about shelling's potential for success for enhancing quahog habitat this method was not selected to address the injuries to the quahog resources caused by the *World Prodigy* oil spill.

2. Habitat Acquisition (Not proposed)

One method to "restore, replace, or acquire the equivalent of the injured natural resources" is to purchase coastal habitats, thus protecting them from further development and degradation. While acquisition protects habitats from future development, it does not restore injured resources directly. Rather it would provide compensation for lost resources and services. Lands in the lower Narragansett Bay would be targeted for purchase and turned over to state and local agencies for ownership and management. For reasons discussed below habitat acquisition was not chosen as a preferred alternative.

Habitat acquisition is often used as an effective coastal resource protection mechanism. However, except for small, non-tidal wetlands, acquisition is generally seen as an unlikely solution for conserving most of the remaining unprotected coastal wetland areas in the Rhode Island area watersheds. There are several reasons for this. First, the federal government already owns most of the remaining large, undeveloped coastal wetlands in the state, and administers these areas as wildlife refuges. Secondly, other entities, including governments and private conservation groups, own and protect many other small to medium sized wetland areas throughout the Rhode Island coastal zone. Thirdly, the State's public trust and regulatory authority over all tidally influenced areas provides protection from most potential non-natural threats to coastal wetlands. Finally, acquisition is by far the costliest protection measure available. Land prices in the area are prohibitively expensive because of their natural beauty and recreational uses. In 1991, the price of coastal land was approximately $500,000 per acre. The limited funds available to NOAA from the *World Prodigy* settlement prevent the acquisition of coastal real estate large enough to provide sufficient ecological services to mitigate for the impacts of the incident.

Cost

The cost of acquiring land is prohibitively expensive (see above).

Environmental Consequences

This alternative will protect acquired coastal wetlands from further on-site anthropogenic degradation. Natural degradation or effects from off-site contamination will not be avoided. The act of acquiring land will have no significant impact on the physical environment. However, land acquisition will prevent future development activities on the parcel in question and will have a beneficial impact on the physical environment. Acquisition of land is not expected to have any negative impact on the cultural environment. On the contrary, it is possible that parcels of land may be selected to protect important historical or cultural resources.

Criteria Evaluation

Land acquisition in the Narragansett Bay area is not a cost-effective method to restore the injured resources given the high per-acre cost of waterfront or wetland property. While acquisition is an acceptable method to "acquire the equivalent of the injured resources" it is NOAA's least preferred alternative if other direct restoration alternatives are available. Furthermore, land acquisition would not meet the goal of enhancing habitat value for a variety of marine resources with specific emphasis on quahogs (hard clams), lobsters, and estuarine finfish. Due to these factors, land acquisition is not selected as a proposed alternative.

3. No Action (Not proposed)

The no action alternative (i.e., natural recovery) allows biological impacts to be naturally mitigated. In order for natural recovery to be selected as a preferred alternative, in addition to the criteria mentioned above, all of the conditions listed below must be met: (1) the natural process must be more effective in restoring the environment than available or potential restoration options and alternatives; (2) the time to recovery must not be significantly different from that resulting from human intervention; (3) the affected area will not suffer from additional adverse ecological effects before the site returns to a natural state; (4) no negative threats to the health and safety of the general public will be caused by the time lag of natural recovery; (5) funds are not available for restoration.

Cost

While immediate costs under the no action alternative may appear insignificant, the costs of the public's lost use of the injured resources and their progeny must be considered. Planning, permitting and construction costs would be avoided, but costs for monitoring would be required to demonstrate that recovery has occurred.

Environmental Consequences/Criteria Evaluation

The no action alternative will not be effective in compensating the public for the injured and lost resources and services. The resources that were killed or injured by the spill have been lost and can no longer contribute to the productivity of the bay system. The no action alternative will not replace those lost resources and services. There is some evidence that even after 20 years residue from oil spills may remain buried in sediments, and the sub-lethal toxic effects of the component parts remain (Teal *et al.*, 1992). At this time, it is likely that most of the oil from the *World Prodigy* spill has been dispersed or buried and there are no longer continuing effects from the oil. However, it is likely that oil remained in beach sediments of the most heavily oiled locations for as many as five years after the spill (Mulhare and Therrien 1993). In any case, the losses sustained by the spill will not be recovered under this action.

4. Summary

Table II below summarizes the results of the criteria evaluation for each alternative. Each alternative was evaluated based on the following criteria: (1) the project must restore resources injured by the spill; (2) the project must be cost effective; and (3) the project should use a proven technique and have a relatively high probability of achieving the restoration goal. Those projects which could not satisfy all of those criteria were eliminated from consideration. Based on the criteria evaluation and the information provided in the above sections, NOAA has determined that the following proposed actions will be the most effective means to restore the injured resources: (1) enhance lobster habitat by establishing several lobster reefs; (2) transplant quahogs and establish "spawner sanctuaries" to help restock formerly productive areas of the bay and to make more of the resource available to shellfishermen; (3) establish eelgrass beds in multiple sites throughout Narragansett Bay to enhance fisheries habitat; and (4) restore a saltmarsh system on Sachuest Point to enhance habitat for estuarine dependent fish and shellfish.

Table II - Criteria Evaluation	Criteria		
Alternatives	Restore injured resources or services	Cost effective	Proven technique
*Lobster reef	+	+	+
*Quahog spawner sanctuary	+	+	+
*Eelgrass restoration	+	+	+
*Salt marsh restoration	+	+	+
Habitat acquisition	-	-	-
Lobster and shellfish hatchery	-/?	-	-
Purchase and seed clams and lobster larvae	-/?	-	-
Shelling	+/?	+/?	-
No action	-	-	N/A

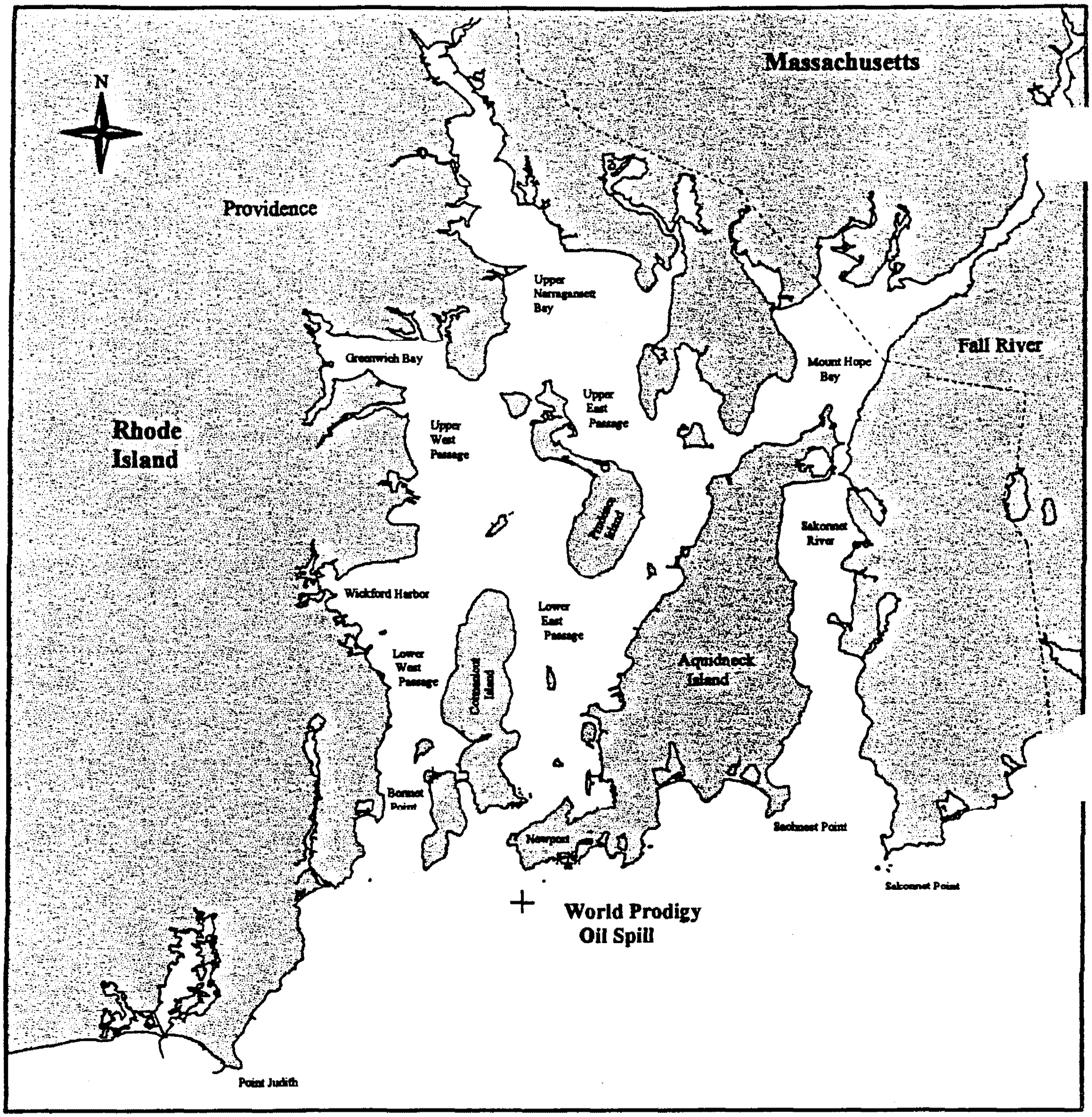
Key: + meets criterion, - does not meet criterion, ? uncertain, N/A not applicable, *Proposed actions

IV. BUDGET SUMMARY

Estimated costs for each of the proposed actions is provided below. Detailed information on the budgets of each project is available from NOAA from the contact person listed on the front cover page. "Project oversight, administration and contingency fund" costs include personnel time for developing the restoration plan, designing the restoration projects, issuing contracts and grants to entities carrying out the specific projects, securing permits, oversight of the implementation of each project, development of outreach and educational material on the results of the restoration projects, and additional funds for any unexpected future project-related expenses.

Lobster reef project:	$270,000
Eelgrass bed restoration	100,000
Sachuest Point salt marsh restoration	80,000
Quahog transplant and spawner sanctuary	75,000
Project oversight, administration and contingency fund	42,299
Total	$567,299

V. FIGURES



2.5 0 2.5 5 Miles

Produced by the GIS, Northeast Regional Office
National Marine Fisheries Service
National Oceanic & Atmospheric Administration
U.S. Department of Commerce

Figure 1 – Narragansett Bay

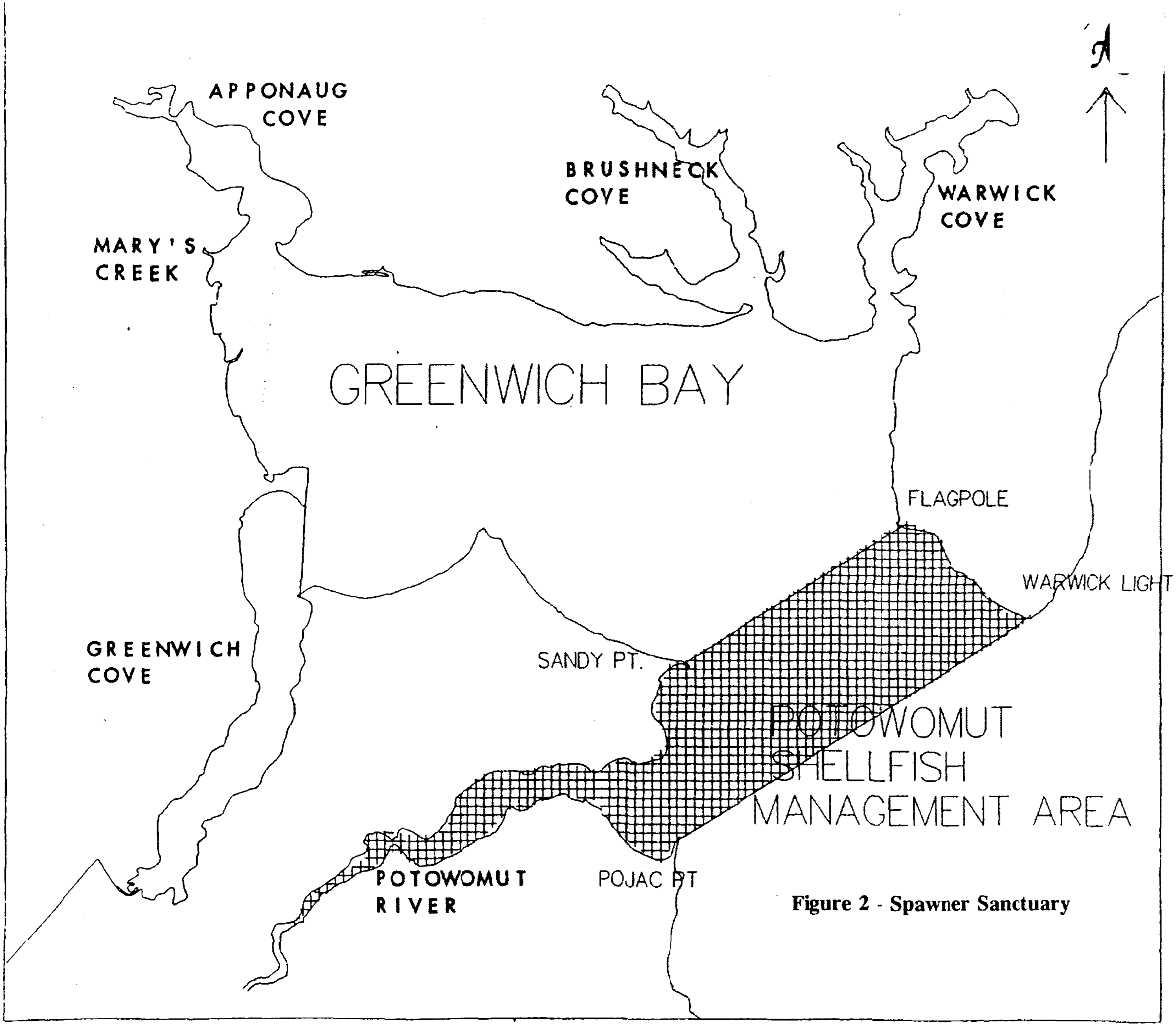


Figure 2 - Spawner Sanctuary

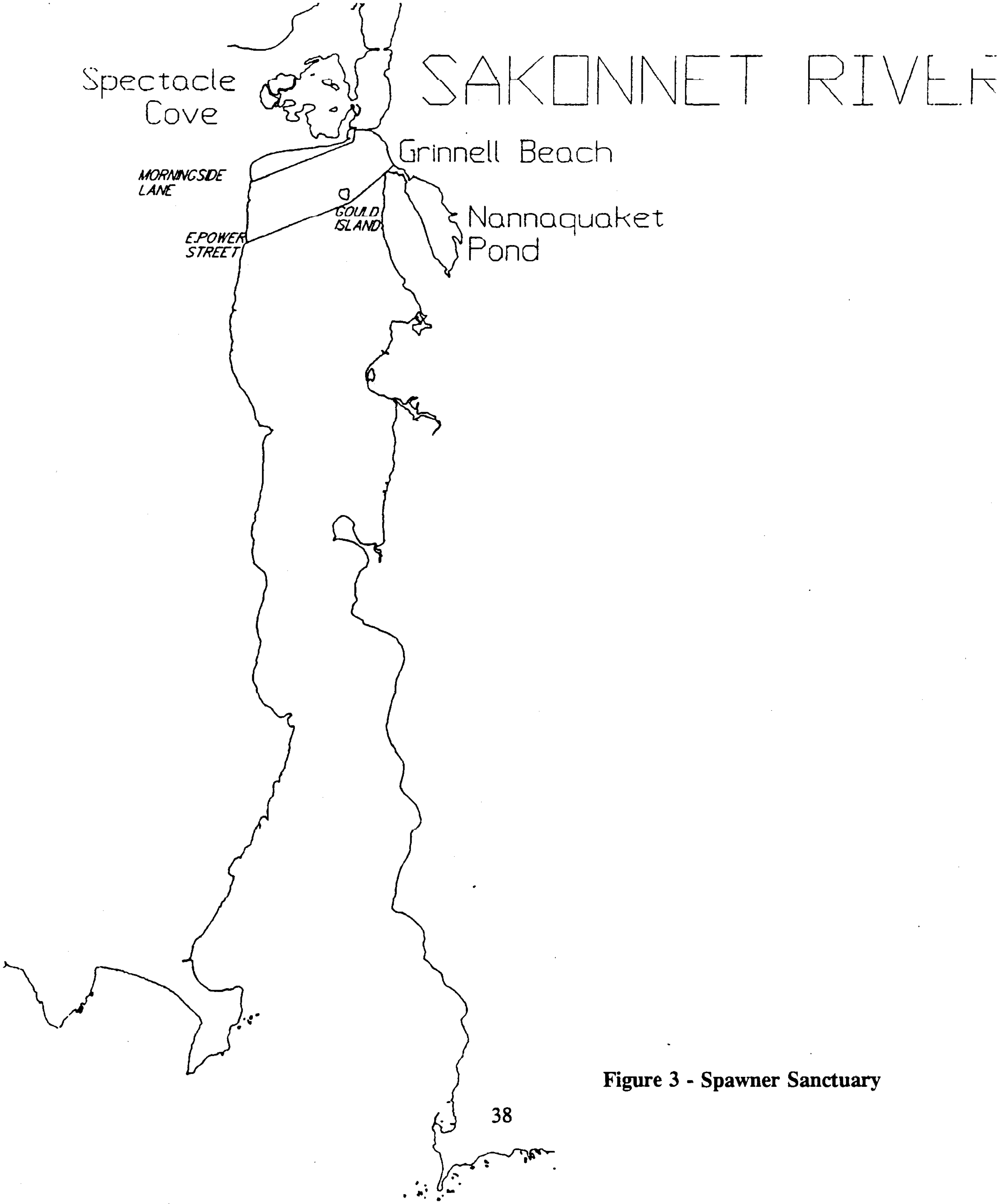


Figure 3 - Spawner Sanctuary

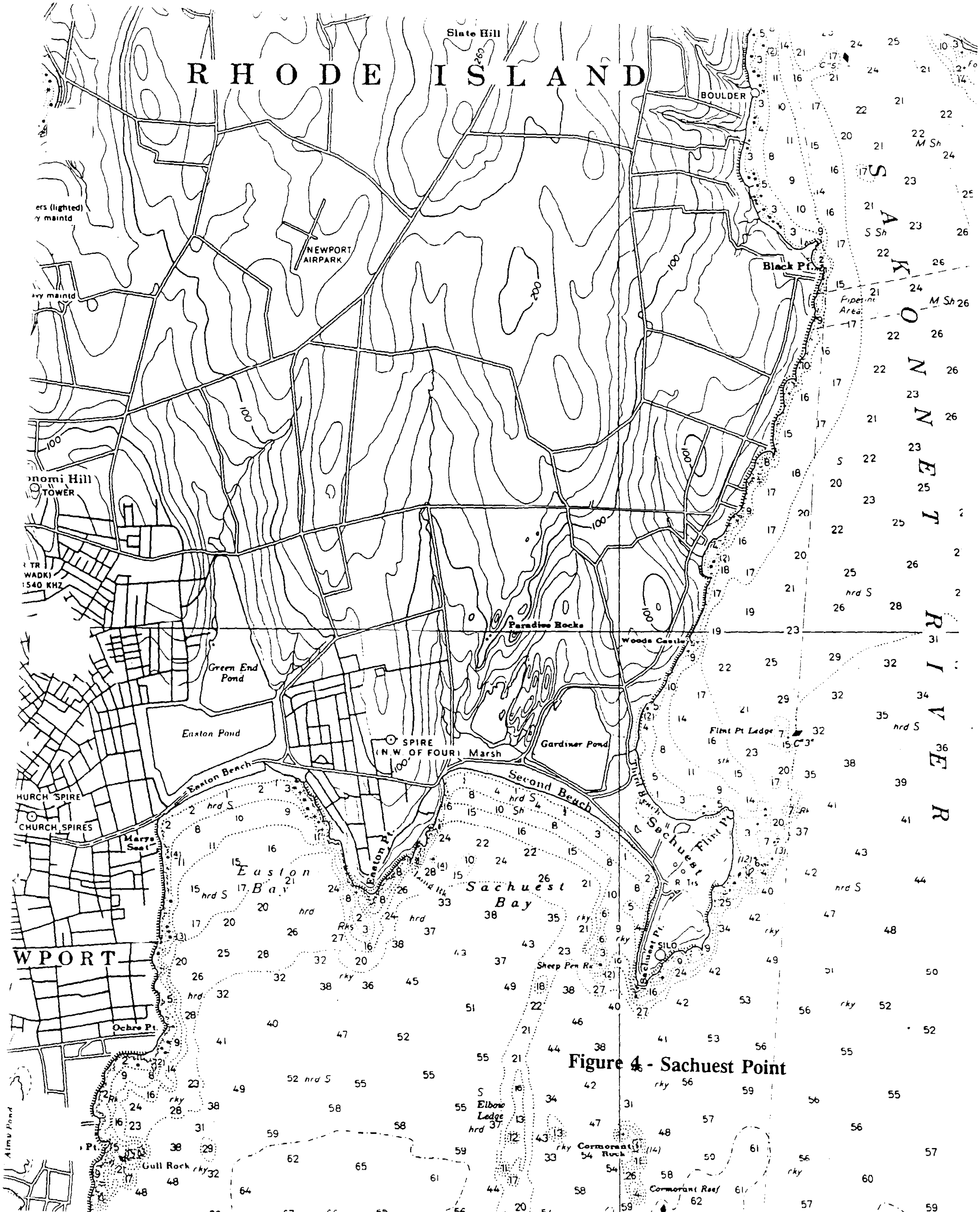
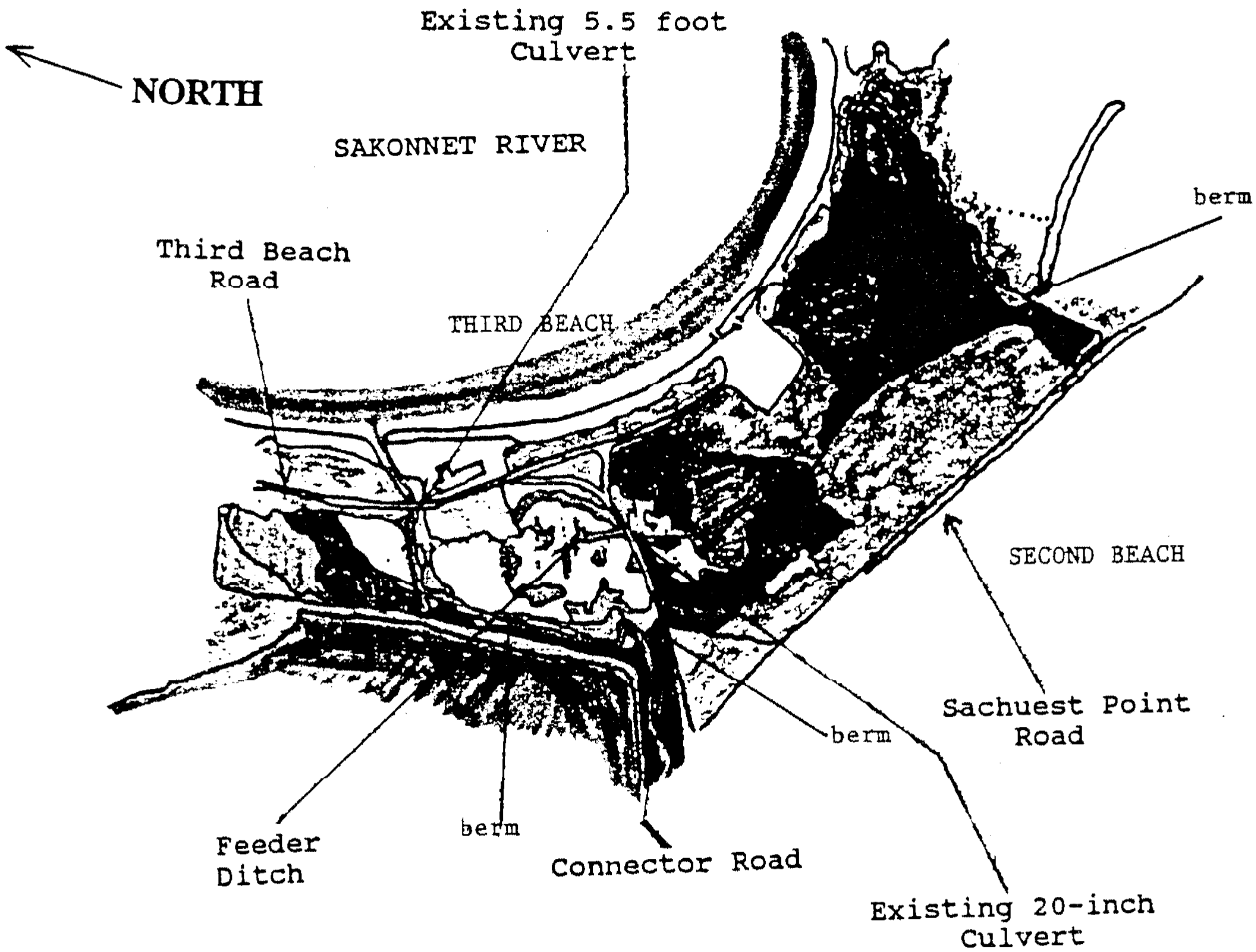


Figure 4 - Sachuest Point

SACHUEST POINT WETLAND



Salt marsh

Emergent wetland

High tide bush

Dune or coastal shrub

Cattail

Open water

Common reed

Upland

Panne

Wetland shrub

Approx. Scale 1"=800'

FIGURE 5

SACHUEST POINT WETLAND AREAS

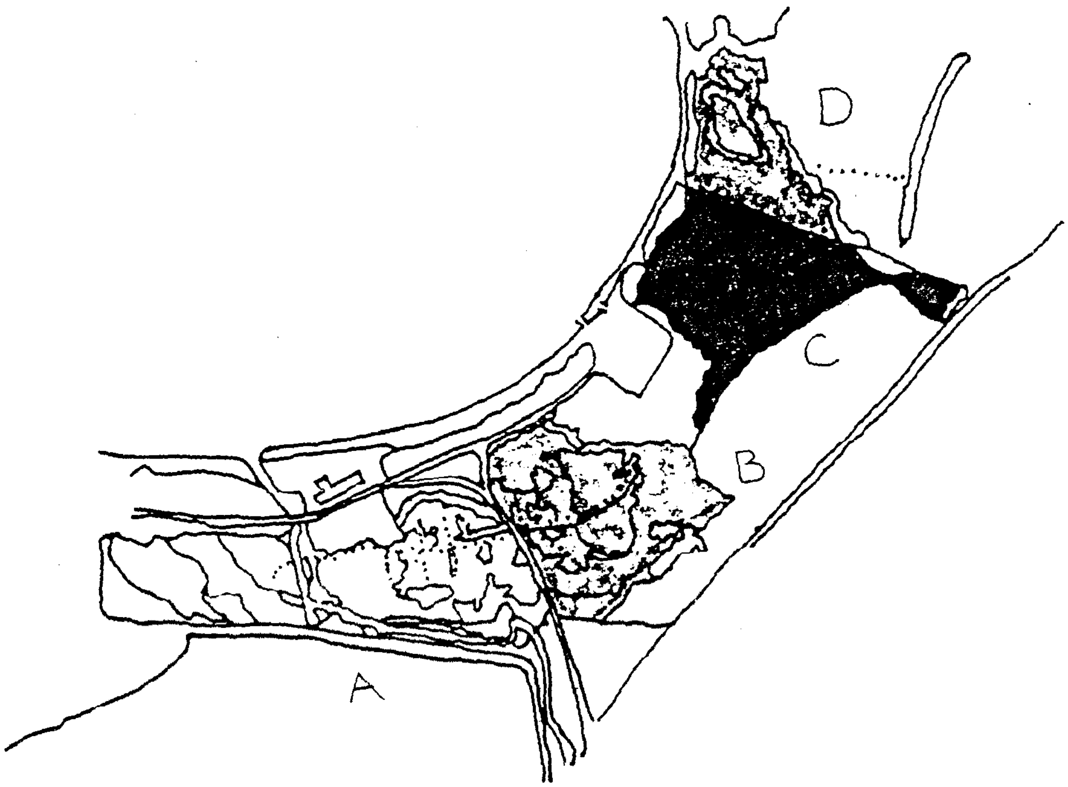


FIGURE 6

VI. FINDING OF NO SIGNIFICANT IMPACT

Finding of No Significant Impact

Having reviewed the attached environmental assessment and the available information relative to the proposed action in Narragansett Bay, Rhode Island, I have determined that there will be no significant environmental impacts from the proposed actions. Accordingly, preparation of an environmental impact statement on these issues is not required by Section 102 (2)(c) of the National Environmental Policy Act or its implementing regulations.

Rolland A. Schmitten
Assistant Administrator for Fisheries
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U.S. Department of Commerce

Date 4/15/96

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We would also like to acknowledge the contributions and assistance provided by Mark Fonseca and Gordon Thayer, National Marine Fisheries Service, Beaufort, NC, James Thomas, National Marine Fisheries Service, Silver Spring, MD, Stanley Cobb and Kathy Castro, University of Rhode Island, Rick Wahle, Bigelow Laboratory for Ocean Sciences, Larry Oliver and Bill Hubbard U.S. Army Corps of Engineers, and Charles Roman, National Biological Service.

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UNITED STATES DEPARTMENT OF COMMERCE
Office of the Under Secretary for
Oceans and Atmosphere
Washington, D.C. 20230

APR 19 1996

TO ALL INTERESTED GOVERNMENT AGENCIES AND PUBLIC GROUPS:

Under the National Environmental Policy Act, an environmental review has been performed on the following action:

TITLE: M/V *World Prodigy* Oil Spill Restoration Plan and Environmental Assessment

LOCATION: Narragansett Bay, Rhode Island

SUMMARY: In June 1989, the Greek tanker *World Prodigy* ran aground in Narragansett Bay, Rhode Island, releasing approximately 290,000 gallons of number 2 fuel oil. Numerous species of marine organisms were adversely affected by the spill. The National Oceanic and Atmospheric Administration (NOAA) assesses and claims damages (compensation) from responsible parties for injuries to natural resources from discharges of oil, and is required to use such funds to restore the injured resources. In 1991, NOAA received $567,299 as a result of a legal settlement between the Federal Government and the responsible party. NOAA will use these funds to restore the natural resources injured by the spill.

The Clean Water Act, as amended by the Comprehensive Environmental Response, Cleanup, and Liability Act, requires Federal and state natural resource trustees to restore, rehabilitate, replace, or acquire the equivalent of the natural resources injured by an oil spill. To fulfill NOAA's responsibilities under the National Environmental Policy Act as well as under these statutes, NOAA has developed the M/V *World Prodigy* Oil Spill Restoration Plan and Environmental Assessment (EA/RP). The EA/RP describes the proposed use of the settlement funds received by NOAA. It presents a summary of the incident and injuries caused by the spill, identifies categories of restoration that were considered (resource and habitat enhancement, acquisition of equivalent resources, and no action), identifies criteria for project selection, and discusses proposed alternatives.

NOAA's goal is to restore the resources injured by the *World Prodigy* oil spill and to compensate the public for the lost use of those resources by enhancing habitat value for living marine resources, with specific emphasis on lobsters, quahogs (hard clams), and estuarine finfish. To meet this goal, NOAA proposes several actions: (1) enhance lobster habitat by establishing several lobster reefs; (2) transplant quahogs and establish quahog "spawner sanctuaries," to help restock formerly productive areas of the bay, and to make more of the resource available to shellfishermen; (3) establish eelgrass beds in multiple sites throughout Narragansett Bay to enhance fisheries habitat; and (4) restore a saltmarsh system on Sachuest Point in Middletown, Rhode Island, to enhance habitat for estuarine-dependent fish and shellfish.

The public was informed of the availability of the RP/EA for comment through publication in the *Providence Journal* on January 22, 1996. Environmental and commercial groups in the Narragansett Bay area, and state and local governments were contacted as well. The RP/EA was made available for public comment from January 22 to March 1, 1996. Several comments were received; however, none suggested there would be significant impacts on the environment if this restoration plan were undertaken.

RESPONSIBLE OFFICIAL:

Rolland A. Schmitten
Assistant Administrator for Fisheries
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
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301/713-2239

The environmental review process has led us to conclude that the proposed restoration actions will not have a significant effect on the human environment. Therefore, an environmental impact statement will not be prepared. A copy of the Finding of No Significant Impact, including the environmental assessment and Restoration Plan are enclosed for your information.

Sincerely,

Donna Wieting

Donna S. Wieting
Director, NOAA Ecology and Conservation Office

Enclosure