INJURY DETERMINATION AND QUANTIFICATION CHAPTER 4

This chapter describes and quantifies the injuries caused by the *North Cape* oil spill. The chapter begins with an overview of data collected during the Preassessment Phase of the damage assessment process, followed by a description of the Trustees' assessment strategy, including the approaches used to identify, determine, and quantify potential injuries. The remainder of this chapter presents the results of Trustee injury assessments for the specific resources affected by the *North Cape* spill. Chapter 5 addresses the identification, selection, and scale of restoration options to restore injured resources and services.

4.1 OVERVIEW OF PREASSESSMENT ACTIVITIES AND FINDINGS

Three requirements identified in the Oil Pollution Act of 1990 (OPA) must be met before Restoration Planning can proceed:

> Injuries must have resulted, or be likely to result from, the incident;
>
> Response actions must not have adequately addressed, or not be expected to address, the injuries resulting from the incident; and
>
> Feasible primary and/or compensatory restoration actions must exist to address the potential injuries.

All of the information collected during the Preassessment Phase of the *North Cape* oil spill is contained in the Preassessment Data Report (RPI 1996a). Using this information, the Trustees found that this spill met all three criteria.

4.1.1 <u>Nearshore and Offshore Impacts</u>

The two blends of oil released in the *North Cape* spill were both home heating oils. These oils, which are essentially the same as No. 2 fuel oil, are particularly toxic to aquatic organisms under the conditions of release in the *North Cape* incident. Daily beach surveys taken by the Rhode Island Department of Environmental Management (RIDEM) during the two week period following the spill (January 20 to February 2) recorded substantial mortality of lobsters, surf clams and other benthic invertebrates, including starfish, blue mussels, and several species of crabs. Several species of dead fish also washed ashore; skates, grubby, rock gunnel, cunner and tautog were found in the greatest frequency. Because stranded organisms were too numerous to count, RIDEM personnel focused their assessment efforts on lobsters and surf clams. Surveyors systematically sampled the beaches to estimate total lobster strandings. Surf clam strandings also were recorded, but the level of effort involved with this sampling was smaller and less systematic. The results of these sampling efforts are not included in the Preassessment Data Report but are provided in separate injury quantification reports (Gibson *et al*. 1997, Gibson 1997).

4.1.2 Bird Impacts

United States Fish and Wildlife Service (USFWS) data indicate that 405 oiled birds were retrieved on Rhode Island and Block Island beaches during the 19 days immediately following the spill. While 114 of these birds were recovered alive, all but 13 died or were euthanized, resulting in a total observed mortality of 392 birds. The types of birds found most frequently include common loons (67), diving ducks (common eiders (59), goldeneyes (32) and red-breasted mergansers (34)), gulls (great black-backed (33) and herring (40)) and grebes (horned (21), red-necked (16) and unidentified grebe (1)). Overall, 41 different species of birds were recovered by spill response personnel. As a consequence of the bird mortality described above, bird productivity was also lost due to the spill.

4.1.3 Salt Ponds Exposure

Surface oil was observed in Point Judith, Potter, Cards, Trustom, Green Hill and Ninigret Ponds. Persistent oil sheens were observed during overflights and ground surveys undertaken the first week after the spill in Point Judith, Potter, and Cards Ponds. Trustom Pond was generally covered with ice for several weeks following the spill, but sheens were frequently observed in open water, even after the pond was breached by USFWS personnel on March 5. Sheens also were reported in Ninigret Pond from January 21 to 23. In Point Judith and Potter Ponds, the prevailing winds generally concentrated the surface sheen against the shoreline in a narrow band of silver sheen. In some areas, the sheen was much wider and rainbow in color. In addition to surface sheens, measurement of in-water and sediment oil concentrations indicate oil exposure of the salt pond water column, sediment and marsh substrate. Observers also noted shoreline oiling in Cards and Trustom Ponds.

4.1.4 Shoreline Exposure

An initial shoreline survey was conducted by joint Trustee and Responsible Party teams on January 22 and 23. The teams surveyed 75 percent of the 54.7 miles of ocean and salt pond shoreline between Charlestown Beach and Point Judith. Approximately 85 percent of the surveyed shoreline was oiled. The outer beach sediments, extending from inside the Harbor of

Refuge eastern breakwater to Charlestown Breachway, were described by response personnel as having an oily smell. Visible oil was observed in portions of the surf zone, and sheens were reported on the water table in three trenches.

4.1.5 Ocean Water and Sediment Impacts

Dispersed oil could readily be detected in nearshore waters, based on fifteen bottom water samples collected by University of Rhode Island (URI) scientists on January 21 from depths as great as 21 meters. Within 0.5 miles from shore, total petroleum hydrocarbons (TPH) levels were between 3.3 ppm and 6 ppm; at 1.0 mile from shore, 1.3 to 1.6 ppm; and at 2.0 miles from shore, 0.09 to 5.5 ppm. On January 25, these stations were resampled at both the water surface and 1meter off the bottom. Concentrations ranged from 0.02 to 4.24 ppm of TPH, of which 0.2-54 ppb (0.0002-0.054 ppm) were the polynuclear aromatic hydrocarbons (PAHs), the most toxic components of the spill oil. These observations indicate that the dispersed oil plume was retained near the grounding site for at least six days after the spill, and that it was mixed throughout the water column, reaching the bottom sediments.

Water samples collected January 23-26 in more remote offshore locations did not show significant concentrations of oil. The Connecticut Department of Environmental Protection collected 47 water column samples from Fishers Island Sound, Watch Hill, the Connecticut portion of Block Island Sound and the Race. Samples were collected from the top of the water column, one meter below the surface, and one meter off the bottom. All sample results were below the TPH detection limit of 0.05 ppm indicating that the oil had not entered these waters. These data are described in detail in French (1998a).

Nearshore sediment samples provide additional documentation of bottom oiling. Most of the 17 sediment samples collected on January 21 between 0.5 and 1.0 miles from shore, at locations between Point Judith and the grounding site, show evidence of contamination from *North Cape* oil that had undergone very limited weathering. The four sediment samples collected on January 25 show evidence of further weathering.

4.1.6 Human Use Impacts

To alleviate potential seafood quality concerns, RIDEM closed coastal pond and state offshore water fisheries on January 22. The area of closure was expanded to the northeast the following day. By January 26, federal offshore waters were closed officially (61 FR 3602). The offshore fishery reopened for selected types of gear on March 13. Other fish and shellfish restrictions were lifted during the next three weeks, although in some areas the lobster fishery remained closed for five months. In addition to fishery restrictions, recreational fishing impacts occurred in the aftermath of the spill. Based on Technical Working Group analysis, the Trustees believe that the *North Cape* oil spill adversely impacted party and charter boat recreational anglers from January 20, 1996 through June 30, 1996.

4.2 ASSESSMENT STRATEGY

The goal of injury assessment under OPA is to determine the nature and extent of injuries to natural resources and services, thus providing a technical basis for evaluating the need for, type of, and scale of restoration actions. The assessment process occurs in two stages: injury determination and injury quantification.

Injury determination begins with the identification and selection of potential injuries to investigate. In a manner consistent with the OPA regulations, the Trustees considered several factors when making this determination, including:

The natural resources and services of concern;

The evidence indicating exposure, pathway and injury;

The mechanism by which injury occurred;

The type, degree, spatial and temporal extent of injury;

The adverse change or impairment that constitutes injury;

Available assessment procedures and their time and cost requirements;

The potential natural recovery period; and

The kinds of restoration actions that are feasible.

A list of the potential injuries investigated for the *North Cape* spill is provided in the first column of Exhibit 4-1. As indicated in the exhibit, the Trustees evaluated possible injuries to 14 categories of ecological and economic resources. These categories were selected based on input from preassessment activities, local, state, and federal government officials, the Responsible Party and academic and other experts knowledgeable about the affected environment.

For each potential injury, the Trustees determine whether an injury has occurred, identify the nature of the injury and a pathway linking the injury to the incident. Injury is defined by the OPA regulations as "an observable or measurable adverse change in a natural resource or impairment of a natural resource service. Injury may occur directly or indirectly to a natural resource and/or service" (15 CFR Section 990.30). The assessment methodologies used for the *North Cape* spill are described in the second column of Exhibit 4-1.

In selecting appropriate assessment procedures, the Trustees consider: (1) the range of procedures available under section 990.27(b) of the OPA regulations; (2) the time and cost necessary to implement the procedures; (3) the potential nature, degree, and spatial and temporal extent of the injury; (4) the potential restoration actions for the injury; and (5) the relevance and adequacy of information generated by the procedures to meet information requirements of

Exhibit 4-1

***NORTH CAPE* OIL SPILL: ASSESSMENT METHODS FOR POTENTIAL RESOURCE AND SERVICE INJURIES**

Potential Injuries Assessed	Injury Assessment Method(s)
1. Lobster Mortality	1. Estimate lower bound mortality based on lobster beach strandings data. 2. Estimate total mortality based on sampling of impact and reference areas. 3. Estimate recovery time based on population modeling.
2. Surf Clam Mortality	1. Estimate lower bound mortality based on strandings analysis. 2. Estimate total mortality based on fate and effects modeling. 3. Estimate recovery time based on normal survival rates, assuming return to normal recruitment levels from plankton.
3. Loss of Primary Production in the Offshore Water Column	1. Estimate lost production based on fate and effects modeling. 2. Assume complete recovery shortly after toxicity gone (based on historical observations).
4. Mortality of Offshore Benthic Fauna Other than Lobsters and Surf Clams	1. Estimate mortality based on fate and effects modeling. 2. Use available sampling data to show species exposed, abundances, and evidence of injury. 3. Estimate recovery time based on normal survival rates, assuming return to normal recruitment levels.
5. Fish Mortality	1. Estimate mortality based on fate and effects modeling. 2. Use available sampling data to show species exposed, abundances, and evidence of injury. 3. Estimate recovery time based on normal survival rates, assuming return to normal recruitment levels.
6. Loss of Piping Plover Production	1. Compare impact area plover productivity with historical and reference area data.
7. Seabird and Wintering Waterfowl Acute Mortality	1. Estimate minimum mortality based on beach strandings data. 2. Estimate total mortality by applying a multiplier to the strandings estimate, to account for dead birds that were not recovered. 3. Estimate recovery time using model of expected survival, based on survival rate data from the literature and the best professional judgment of bird experts. 4. Estimate lost fledgling production for bird species with recovery times greater than one year.
8. Waterfowl Habitat Degradation	1. Evaluate the results of salt pond injury assessment for potential impacts to waterfowl habitat and food supply.
9. Mortality of Salt Pond Water Column and Sediment Biota	1. Assess injury to resources exposed to oil in the water column and sediments based on: a) estimation of acute exposure by comparing time-series water column and sediment sampling data with appropriate toxicity thresholds for different species; b) pre-spill species abundance data; c) population and damage assessment studies conducted for winter flounder and shellfish resources; and d) bioassay data. 2. Estimate recovery time from pre-spill mortality rates, assuming return to normal recruitment levels.
10. Loss of Salt Pond Vegetation	1. Assess vegetative injury based on: a) general visual surveys and detailed pre-/post spill biomass studies at one marsh; and b) an available chemical analysis of marsh substrate to determine sediment toxicity potential.
11. Lost Beach Use	1. Compare attendance data from impact area beaches with historical and reference area data.
12. Lost Party and Charter Boat Fishing Trips	1. Develop estimate of lost trips based on interviews with boat captains and owners.
13. Lost Recreational Diving Trips	1. Assess the likelihood of injury through interviews with divers and dive shop owners.
14. NWR Refuge Visitation Reduction	1. Compare visitation data since the spill with historical and reference area data.

restoration planning. Accordingly, depending on the injury category, the Trustees rely on information and methodologies from the relevant scientific literature, literature-based calculations and models and/or field injury determination and quantification studies in assessing injury. Selected methodologies reflect the Trustees' efforts to use cost-effective procedures and methods to document resource injuries.

If the Trustees determine that a resource has been injured, the injury must be quantified. The injury quantification process determines the degree and spatial and temporal extent of injury relative to baseline, and therefore forms the basis for scaling restoration actions. Baseline refers to the condition that the resource would have maintained but for the effects of the oil spill.

4.3 SUMMARY OF INJURIES

A summary of injury assessment results is provided in Exhibit 4-2 and described in the following sections.

4.3.1 Summary of Methodology

Injury quantification for offshore, salt pond and bird resources begins with estimates of the number of animals killed as a result of the incident, as well as information describing the size and age of these animals. As appropriate, the Trustees also consider the number of young that these individuals would have produced. Finally, possible sublethal injuries also are considered if the Trustees determined that evaluation of these injuries would be appropriate under the criteria provided in the OPA regulations (15 CFR Part 990).

Once the magnitude of injury is established, Trustees estimate the recovery time required for the resource to return to baseline condition. In general, species that are limited by food or habitat availability and/or enjoy rapid reproduction cycles may recover relatively quickly if the loss of some animals eases food or habitat constraints and/or new animals are reproduced quickly. On the other hand, species with slower reproductive cycles or environmental constraints not eased by the loss of some animals may recover more slowly. The actual biological processes that determine recovery from an oil spill are more complex than these simple examples suggest, and the knowledge and data to estimate recovery times precisely are difficult and costly to obtain.

The Trustees have reviewed available information presented to them about population dynamics for the injured species and relied on straightforward calculations and best professional judgment to determine the estimated recovery time for each injured resource. For many injured species, the Trustees make the simplifying assumption that the recovery period is equal to the additional amount of time these biota would have lived in the absence of the spill. This period is estimated using information on lifespans and mortality rates obtained from scientific experts and the literature.

Exhibit 4-2

***NORTH CAPE* OIL SPILL: SUMMARY OF INJURIES**

OFFSHORE

Injured Resource/Service	Injury Quantification				Recovery Time
	Number Killed	Biomass Killed (kg)	Production Foregone (kg)	Total Injury[1] (kg)	
Lobsters	9,039,200	312,400	--[2]	--[2]	4-5 years
Surf Clams	19,402,300	547,600	422,800	970,400	3-5 years
Other Marine Benthic Organisms:					
Worms/Amphipods	4,890,219,000	489,000	310,000	800,000	5 months
Crabs (Rock, Hermit)	7,619,500	45,500	51,700	97,200	1-3 years
Mussels	20,246,800	880	1,200	2,100	1 year
Fish	4,200,000	30,000	81,000	111,000	1-2 years

SALT PONDS

Injured Resource/Service	Injury Quantification				Recovery Time
	Number Killed	Biomass Killed (kg)	Production Foregone (kg)	Total Injury (kg)	
Worms/Amphipods	6,591,836,000	66,000	98,000	164,000	5 months
Crabs and Shrimp	642,000	3,300	3,800	7,100	1-2 years
Softshell Clams and Oysters	648,500	7,600	4,800	12,400	1-2 years
Forage Fish	533,400	2,700	2,400	5,000	1-2 years
Winter Flounder	1,600	1,400	1,100	2,500	1 year

BIRDS

Injured Resource/Service	Injury Quantification	Recovery Time
Piping Plovers	Lost production of 5-10 fledged chicks	Federally-listed threatened species: population not currently self-sustaining
Seabirds and Wintering Waterfowl:		
Common Loons	402 loons killed: 3,641 loon-years	6 years
Grebes	228 grebes killed: 705 grebe years	2 years
Other (primarily sea ducks)	1,452 birds killed: 2,549 bird-years	Between 1 and 3 years, depending on species
Pond Birds	198 birds killed: 476 kg biomass lost[2]	1 year

HUMAN USE

Injured Resource/Service	Injury Quantification	Recovery Time
Party and Charter Boat Fishing	3,305 trips lost, with a value of $281,685	Approximately 6 months

1 Total injury may not equal the sum of biomass killed plus production foregone due to rounding.

2 Production foregone is not calculated for lobsters and bird-years lost are not calculated for pond birds because restoration scaling for these resources are based on different methods. This is explained further in Chapter 5.

As described in later sections of this document, this assumption reflects the finding that in many cases the spill did not have an effect on the production of young in the year following the spill, nor are reproductive impacts expected in the future. Thus, for these species, the loss is generally limited to the individuals that died as a result of the spill. By estimating the amount of time these individuals would have lived, the Trustees are able to assess the duration of the loss caused by the spill.

Overall, both the magnitude of the injury and the recovery time must be considered in the injury quantification process. This is accomplished for some resources, such as birds, by multiplying the number of lost animals by the recovery period to generate a number denominated in units such as bird-years. For other resources, such as benthic fauna, it is more appropriate to express the injury in terms of weight of biomass lost, in kilograms or similar units. To compensate for the loss of services before a resource is fully restored, the Trustees calculate the "production foregone" for animals killed by the spill during each year of the recovery period. In concept, production foregone includes the growth in biomass that would have occurred in the absence of the spill, assuming normal mortality rates and lifespans, as well as lost production of young, as appropriate. The importance of each of these components of production foregone will vary by species, and will reflect several factors, including the age of the organisms killed, mortality rates, reproduction rates and timing, population size and species position in the ecological community. For most injured offshore and salt pond species, production foregone calculations include lost biomass growth. Reproductive losses for these species (except lobster) are expected to be insignificant given the magnitude of injury relative to local population size. For most injured bird species, "production foregone" includes reproductive losses when recovery periods exceed one year (i.e., for loons and grebes). Reproductive losses associated with shorter term injuries are expected to be insignificant. For most bird species, the loss in biomass growth due to the spill is also expected to be insignificant.

All of these methods produce an estimate of direct plus interim loss of resources resulting from the injury. Injury estimates in later years are discounted at three percent per year, summed, and added to the injury in the year of the spill to generate an estimate of total injury.[1] Also, since restoration of the resource will not occur until some time in the future, the total injury estimate is increased by three percent for each year between the injury and the date of expected restoration. The calculations for each resource are described in more detail later in this section and in Chapter 5.

Injury quantification for lost human uses is measured in units appropriate to the activity. As indicated in Exhibit 4-2, party and charter boat fishing losses are quantified in terms of lost trips. The Trustees also have quantified the value of this injury in dollars. This estimate is a measure of the value lost by recreational anglers who were either unable to fish because of the spill, spent additional money traveling to alternative sites and/or experienced a reduction in trip quality.

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[1] The annual discount rate of three percent approximates the additional amount of a good or service required by society as compensation for delaying consumption of the good or service by an additional year (15 CFR Part 990.53).

4.3.2 Summary of Results

Exhibit 4-2 summarizes the injuries from the *North Cape* spill. Losses are presented as numbers of organisms killed and total biomass lost (direct kill and production foregone). Losses were largest in the offshore environment. Approximately 19.4 million surf clams (970,000 kilograms) and 9.0 million lobsters (direct kill only, totaling 312,000 kilograms) were lost as a result of the spill (French 1998b and c, Cobb and Clancy 1998).[2] Large numbers (4.9 billion) of worms/amphipods died from spill effects, although their relatively small size (0.01 gram each) resulted in a biomass loss of 800,000 kilograms (French 1998b). Losses of rock and hermit crabs totaled 7.6 million animals, with a biomass of 97,000 kilograms (French 1998b, 1999b). Fish losses, primarily skates, cunner and Atlantic sea herring, totaled 4.2 million animals (111,000 kilograms) (French 1998b).

In the salt ponds, injury to worms/amphipods via contaminated sediment pore water totaled approximately 6.6 billion organisms, with an associated biomass loss of 164,000 kilograms (French and Rines 1998). In addition, approximately 7,100 kilograms of crabs and shrimp, 12,400 kilograms of soft-shell clams and oysters, and 5,000 kilograms of forage fish also were lost due to the spill (French and Rines 1998).

Expert analysis indicates that 1996 productivity of the piping plover, a federally-listed threatened species, was reduced by approximately five to ten fledged chicks. Mortality to birds is estimated at 2,292 birds (Sperduto *et al*. 1999). Losses of common loons, eiders, and grebes were largest, totaling 402, 354, and 228 birds, respectively, and responsible for 5,199 of the 7,105 bird-years lost (Sperduto *et al*. 1999).

Approximate estimates of recovery time for these injuries are also provided in Exhibit 4-2. For marine and salt pond fish and invertebrates, recovery time is assumed to be equal to the additional time injured biota would have lived in the absence of the spill. The expected number of years an animal would have lived depends on its age at the time of the spill, typical life-span, and survival rates. The estimated recovery time in Exhibit 4-2 encompasses the life-span of the majority of animals killed. In the offshore environment, recovery of surf clams is expected to take approximately three to five years, similar in duration to lobster recovery (4 to 5 years). Fish, crabs, and starfish will likely recover within one to three years. Amphipods and worms in the offshore and coastal environment likely recovered within five months. In the salt ponds, recovery of other injured species is expected within two years of the spill. For seabirds and wintering waterfowl, recovery time varies for different species, ranging from approximately one to six years. Because piping plovers are a federally-listed threatened species, the injury to fledged chicks will delay management efforts to restore this population to self-sustaining levels.

As indicated in the exhibit, boat-based recreational fishing was the only human use activity for which the Trustee assessment was able to estimate a loss that could be measured and documented. Trustee analysis indicates that 3,305 trips were lost (Curry and Meade 1997). Fishing activity returned to baseline levels within approximately six months after the spill.

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[2] Production foregone is not calculated for lobsters because restoration scaling for this resource is based on a different method. This is explained further in Chapter 5.

4.4 INJURIES TO SPECIFIC RESOURCES

The following sections of this chapter describe the results of injury determination and quantification efforts for the *North Cape* spill. Potential injuries are organized into four categories: offshore; salt ponds; birds; and human uses.

4.4.1 Offshore Communities: Overview of Data and Strategy

4.4.1.1 Determination of Injury

Clear evidence of injury to offshore communities is provided by beach strandings data. Rhode Island Division of Fish and Wildlife (DFW) staff identified 26 species of fish and large invertebrates (e.g., lobsters, crabs, and clams) that washed up dead on shore between Charlestown Breachway and Point Judith during the days immediately following the spill (Gibson 1997). A list of these species is provided in Exhibit 4-3 below, ranked in approximate order of beach strandings abundance. Due to the enormous volume of fish and invertebrates stranded on the beach, investigators could count only the more abundant higher level organisms.

Exhibit 4-3

OFFSHORE ORGANISMS IDENTIFIED IN POST-SPILL BEACH STRANDINGS RANKED BY ABUNDANCE[1] (GIBSON 1997)

1. American Lobster	8. Spider Crabs	15. Atlantic Razor Clam	22. Striped Killifish
2. Atlantic Surf Clam	9. Hermit Crabs	16. Cunner	23. Atlantic Herring
3. Green Crabs	10. Grubby	17. Blue Crabs	24. Windowpane Flounder
4. Starfish	11. Mud Crabs	18. Little Skate	25. Atlantic Silverside
5. Lady Crabs	12. Rock Gunnel	19. Tautog	26. Sea Cucumber
6. Blue Mussel	13. Sea Urchins	20. Longhorn Sculpin	
7. Rock Crabs	14. Northern Moonsnail	21. Winter Flounder	

[1] Species are listed in decreasing order of abundance (i.e., most frequent first, least frequent last) based on data provided by RIDEM (Gibson 1997).

Several sources of data trace the path of spilled oil through the offshore environment. Relevant data applicable to all offshore communities include:

> Overflight maps from January 20 to 25, 1996 document the presence and location of oil sheens, streamers and patches over several square miles of ocean surface (RPI 1996a).
>
> Concentrations of total petroleum hydrocarbons (TPH) and component polynuclear aromatic hydrocarbons (PAH) were measured in the water column from January 21 to 28, 1996. The aromatic composition shows that significant portions of the aromatic hydrocarbons were contamination from the *North Cape* spill rather than pyrogenic (fuel burning, i.e., from boat engines) sources. Concentrations recorded in samples were above standard reference toxicity thresholds (RPI 1996a and b).

> Concentrations of TPH and component aromatics were measured in bottom sediments on selected dates from January 21 to March 21, 1996. The aromatic composition shows that significant portions of the aromatic hydrocarbons contamination were from the *North Cape* spill rather than pyrogenic (fuel burning) sources (RPI 1996a and b).

4.4.1.2 Injury Quantification Strategy

The Trustees relied on a combination of methods to quantify injury to offshore community natural resources. For lobsters, the Trustees used field data collected from impact and reference areas to quantify losses due to the spill. For other offshore resources, the Trustees used a combination of field data and modeling.[3] Where available, field data were used to document the abundance of biota in impact and reference areas and concentrations of TPH and PAH in sediment, water and biota. These data are combined with information about oil fate and toxicity, and species abundances, to estimate the magnitude of injury through the use of a fates and effects model. Based on analysis of information collected during the Preassessment Phase, the Trustees determined that comprehensive field sampling of offshore species other than lobster (e.g., benthic, planktonic and fish communities) was not feasible given the difficulty of implementing a program of the required size.

The fates and effects model used by the Trustees (SIMAP) is based on the Natural Resource Damage Assessment Model for Coastal and Marine Environments (NRDAM/CME, Version 2.4, April 1996), which is included in the Code of Federal Regulations (43 CFR Part II) for performing natural resource damage assessments for spills under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA, 42 USC 9601 *et seq*.). The model is described briefly below and in more detail in the associated report by French (1998a).

SIMAP estimates the distribution of spilled oil (as mass and concentrations) on the water surface, on shorelines, in the water column and in the sediments. The model is three-dimensional, using a latitude-longitude grid to map environmental data. Algorithms based on state-of-the-art published research account for spreading, evaporation, transport, dispersion, emulsification, entrainment, dissolution, volatilization, partitioning, sedimentation and degradation of the oil. Acute mortality of water column and benthic resources is estimated as a function of temperature, concentration of dissolved aromatics and the length of exposure. Acute mortality of other wildlife is estimated as a function of area swept by oil, dosage and vulnerability. Chronic effects of long-term exposure to sediment concentration of oil or via ingestion are not considered by this model.

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[3] The model also estimates lobster injury. Because substantial lobster field data were collected for this case, the Trustees relied on these data for the quantification of lobster loss.

SIMAP, as opposed to the NRDAM/CME, is designed to use site- and incident-specific data if such data are available. In this instance, extensive site- and incident-specific data either were available or had been collected during the spill as part of response activities. Thus, the Trustees chose to use SIMAP, rather than the NRDAM/CME with its default databases, to estimate injuries resulting from this spill. The types of data used include: fine resolution (300 meter grid) shoreline, habitat types and water depths; water temperature and salinity; wind data measured hourly during January and February 1996 near Ninigret Pond; tidal current data based on current atlases for Block Island Sound; biological abundances based on observations near the spill site (i.e., at references sites outside the area of impact) in 1996, or on historical data where 1996 data were not available; and oil characteristics taken from current databases on home heating (No. 2) fuel and from measurements of samples taken from *North Cape* cargo. In addition, because SIMAP originally modeled oil spills as occurring on the water surface and did not account for large entrainment by high waves in the surf zone, a surf entrainment algorithm was added to more closely simulate the conditions for this spill.

Over the course of the *North Cape* damage assessment, the Trustees concluded that two types of home heating oil were spilled, with different PAH concentrations. Based on several laboratory analyses and discussions with parties involved with barge loading operations, spill response, and salvage operations, the Trustees determined that the weighted average PAH concentration of spilled oil was 4.5 percent (Morin and Donlan 1998). This average PAH content was used in the fates and effect model.

The results and output of the fates portion of the model are validated by comparison with overflight maps made during the response to the spill and with the measured concentrations of TPH and PAH in samples taken during the week following the spill. A complete description of the modeling is available in French (1998a).

4.4.2 <u>Offshore Communities: Individual Resource Injuries</u>

4.4.2.1 Lobsters

1. <u>Determination of Injury</u>

Several sources of data, in addition to those described for the offshore community in general, confirm the exposure of lobsters to the spilled oil:

> Trap sampling and diver surveys showed lobsters were present in the waters where oil concentrations were measurable, and were exposed to oil by these pathways.
>
> Existing juvenile lobster habitat was mapped in the areas affected by significant water concentrations of *North Cape* oil. Divers observed juvenile lobsters in these habitats.

In the fishery closure monitoring program, chemical measurements and visual assessment were performed on lobster samples collected from the fishery closure area. Contamination of lobsters was documented both for areas where oil was observed following the spill and for areas outside of the observable sheen.

Evidence of lobster injury is summarized below. This evidence is for direct injury caused by exposure to aromatic concentrations in the water and sediments. Evidence of indirect injury (e.g., caused by reduced food resources) is treated in other injury categories (e.g., mortality of marine benthic fauna other than lobsters).

Strandings: Daily surveys of dead and moribund lobsters stranded on beaches were made, recording numbers per unit area, size and sex for 18,000 of the estimated 2.9 million stranded lobsters collected. Collections were conducted on beaches from Point Judith to Charlestown Beach between January 21 and February 2, 1996. Very few lobsters were found during daily surveys at reference beaches outside the affected areas. These data indicate that in the absence of oil exposure, the storm itself was not sufficient to cause the observed strandings (Gibson *et al*. 1997).

Depleted abundances: Diver surveys showed that abundances of juvenile lobsters in impacted cobble and boulder habitats were significantly lower than in nearby reference sites (Cobb and Clancy 1998).

Approximately one-half the lobsters found in traps by URI researchers in the spill-impacted area during January and February 1996 were lethargic, moribund or dead (French 1999a).

Additional information was collected to assess injury to lobster recruitment. These results, outlined below, suggest that this particular impact was limited.

Egg counts on berried (egg-bearing) female lobsters collected in the winter of 1996 showed no significant differences associated with exposure to oil.

Planktonic postlarval counts over 10 weeks in the summer of 1996 showed that 1996 abundances were at the low end of the previously-observed range in Rhode Island coastal waters. From observations made in Connecticut and Maine, 1996 appears to have been a low recruitment year all over New England.

2. Quantification of Injury

The Trustees and the RP collected data to estimate total lobster losses and the expected time of natural recovery. The studies were designed to evaluate and quantify lobster losses resulting from the acute toxicological effects (immediate mortality) of the spill, delayed mortality and factors affecting the natural recovery of the local lobster population, including migration, larval abundance and egg production.

The lobsters stranded on the beaches in the spill impact area provide a lower bound estimate of lobster mortality caused by the spill, as it is likely that substantial numbers of lobsters killed by the spill did not wash up on the beaches where counts were made. To estimate the total number of stranded lobsters, transects were set up by RIDEM on beaches from Point Judith to Charlestown Beach. Sample quadrats along those transects were counted daily, classifying lobsters by sex and size. The areas sampled were swept so that lobsters coming ashore on subsequent days could be identified. The statistical analysis of the data provided an estimate of cumulative (summing daily counts up to February 2 when new strandings had tapered off to negligible levels) abundance of lobsters on the beach in the affected area. Corrections were made for sampling biases, including lack of observations on the smallest (young-of-the-year) lobsters. Details are provided in Gibson *et al*. (1997).

Based on this analysis, the Trustees estimate that 2.92 million of the lobsters killed by the spill washed up on the beach (Gibson *et al*. 1997). The majority of these lobsters (by number) were less than 40 millimeters in carapace length, although about 6,000 legal lobsters (greater than 82.6 millimeters or 3.25 inches carapace length) were included in the strandings. Again, this number is a lower bound estimate of mortality, as it is extremely unlikely that all lobsters killed by the spill washed ashore.

In order to estimate total lobster mortality, diver surveys of lobster abundances were performed directly in their habitat (Cobb *et al.* 1998). The sampling stations were classified as impact (nearest the site of the spill), control (clearly unaffected by oil), and transitional (between control and impact areas) based on reported records of beach strandings of lobsters and results of model simulations of the trajectory of the oil in the sediments. Specifically, impact sites are located between 71° 36.00' and the west wall of the Harbor Refuge and offshore. Sampling stations just east of the Charlestown Breachway and the east end of Green Hill Beach (between 71° 39.15' and 71° 36.00') are classified as transitional sites. Sampling sites west of the Charlestown Breachway and to the east of Point Judith are located in areas where no oil was observed (Cobb and Clancy 1998).

By comparing lobster densities in impact and reference areas, the Trustees and the Responsible Party developed estimates of acute mortality that include both immediate and delayed impacts. Based on habitat maps developed in the fall of 1996 using side-scan sonar, the Trustees and the Responsible Party determined that roughly 12 square kilometers of the nearshore benthic habitat along the Rhode Island south coast in the affected area are suitable for lobsters (Golder Associates, Inc. 1996). During the spring, summer and fall of 1996, diver surveys were made at 21 stations in spill impact and reference lobster habitat (Cobb and Clancy 1998, Cobb *et al.*

1998). Historical survey data were available from 1991 to 1995 at six sites, three of which were included in the reference sites sampled in 1996. The diver surveys were of two types: airlift samples, used to count the smallest lobsters (less than 60 millimeters carapace length); and visual counts, used for larger (greater than 20 millimeters carapace length) lobsters. Abundance by size class was derived from these data for each sample station. Abundances were interpolated to all affected habitat areas, and estimates were made of total lobsters missing from the affected area.

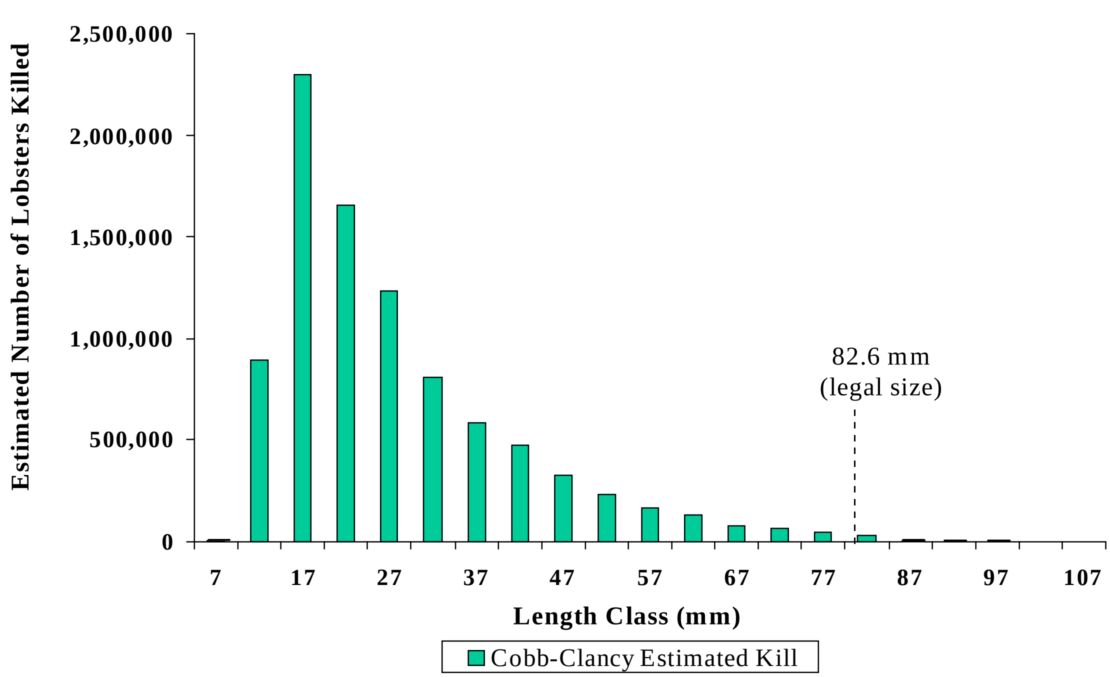
Based on these data, the Trustees estimate that approximately 9.0 million lobsters were killed by the spill. Exhibit 4-4 presents the estimated size distribution of the killed lobsters. Roughly 82 percent of the lobsters were in their first or second year of life. Legal lobsters, which are five or more years old, accounted for about 15,300 of the killed lobsters (French 1999a).

3. Recovery Time

Available information indicates that the affected lobster population will naturally return to baseline levels within four to five years after the spill. Analysis of the lobster recovery rate is contained in the reports by Gibson (1997) and French (1998c, 1999a). In general, this estimate reflects the fact that juvenile lobsters grow to legal size within four to five years. After lobsters reach this size, most are quickly caught by lobstermen.

Exhibit 4-4

SIZE DISTRIBUTION OF LOBSTERS LOST IN THE NORTH CAPE SPILL



4.4.2.2 Surf Clams

1. <u>Determination of Injury</u>

The following sources of data, in addition to those described for the offshore community in general, confirm the exposure of surf clams to the spilled oil:

> From benthic surveys, surf clams are known to inhabit nearshore sediments of Block Island Sound in areas affected by oil.

Evidence of exposure causing injury to surf clams is summarized below. Available evidence is for direct injury, caused by exposure to aromatic concentrations in the water and sediments.

> Strandings: Daily surveys of dead and moribund surf clams stranded on beaches were made, recording numbers per unit area and shell size. Trustees estimate that at least 330,491 dead surf clams were stranded on beaches from Point Judith to Charlestown Beach in the first week after the spill. Surveys of strandings at control beaches within the area affected by the storm but outside the area affected by the oil spill observed significantly fewer surf clams (0.04 clams/square meter as opposed to 3.65 clams/square meter in the affected area), demonstrating that the storm alone was not sufficient to cause the observed mortality to surf clams. Control beach data were used to correct the estimated kill of clams for storm-induced strandings (Gibson 1997).

2. <u>Quantification of Injury</u>

The strandings surveys documented a small fraction of the total surf clam mortality and were not designed to quantify total injury to surf clams within the assessment area. Because of resource limitations, sampling of stranded clams was only performed for a few days following the spill. In addition, sampling was difficult because dead clams appeared in various forms, including whole closed clams, whole opened clams, empty paired shells and meats without shells. Dead clams counted were not removed from the beaches, so some of them may have been recounted on subsequent days. The strandings data do provide information about the size structure of the larger affected clams. The majority of the clams washed ashore and counted were 4 to 5 years old (75 to 95 millimeter shell width), but substantial numbers of smaller and larger clams were killed as well.

At approximately 18 months and 2 years after the spill, the RP conducted sampling in impact and reference areas to gather additional information about surf clam densities and size structure (Beak Consultants 1997, DeAlteris 1998). These data show exceptional recruitment of young-of-the-year surf clams in 1996 and 1997 in the area impacted by the spill, as compared to non-impacted sites further west from the grounding site. However, the sampling was insufficient to quantify the abundance of older surf clams or to determine the areal extent of the impact, and does not account for fishing mortality that may have taken place during the period between the spill and sampling. Thus, data from the non-impacted sites, as well as abundance data from previous studies in the literature were used to estimate pre-spill abundance of surf clams. Areal extent of injury was estimated by modeling.

The SIMAP computer model that was used by the Trustees was used to quantify the surf clam injury. Surf clam exposure modeling accounted for all surf clams injured in the spill, not just those clams that washed up on shore. The modeling was based on exposure to dissolved aromatic compounds in water at the bottom. Effects considered were acute toxicity as a result of this exposure. Chronic effects of long-term exposure to sediment concentrations of oil or via ingestion were not assessed in this analysis (French 1998a).

Based on the model results, the Trustees estimate that a total of 19.4 million surf clams of all sizes were killed by the spill, with a combined weight of 550,000 kilograms. Production foregone for all surf clams killed by the spill amounted to 420,000 kilograms, for a total injury of 970,000 kilograms. Approximately 65 percent of this total injury (630,000 kilograms, including production foregone) were young-of-the-year surf clams (YOY).

3. Recovery Time

The Trustees estimate that the injured surf clam population will return to baseline levels through natural recovery within 3 to 5 years after the spill. This period of time encompasses the expected lifespan of the surf clams killed by the spill. Thus, based on information currently available to the Trustees, there is no indication that surf clam larval abundance (and therefore future generations of surf clams) will be affected significantly in future years. In the absence of the spill, these surf clams would have lived up to three to five additional years.

This estimate of recovery time is intended to provide a general approximation of the duration of the injury to surf clam populations. As discussed in Chapter 5, restoration scaling is based on more detailed calculations.

4.4.2.3 Other Marine Benthic Organisms

1. Determination of Injury

The following sources of data, in addition to those described for the offshore community in general, confirm the exposure of marine benthic organisms (other than lobsters and surf clams) to the spilled oil:

> Trawls by the *R/V Albatross* and *R/V Cap't Bert* in January 1996 showed several benthic species in the area contaminated by oil (RPI 1996a).

In the fishery closure monitoring program, chemical measurements were performed on samples from the closed area. Contamination of ocean quahogs and blue mussels was documented for the area where oil was observed after the spill.

Evidence of exposure causing injury to benthic organisms (other than lobsters and surf clams) is summarized below. Available evidence is for direct injury, caused by exposure to aromatic concentrations in the water and sediments.

Strandings surveys: As previously described, daily surveys of dead and moribund shellfish and other large benthic species stranded on beaches were made. Numerous benthic organisms were observed and recorded. In surveys at reference beaches outside the affected area, far fewer benthic organisms were observed, demonstrating that the storm alone would not have caused the strandings (Gibson 1997).

Observations of smaller benthic species stranded on the beaches from Point Judith to Ninigret Pond also were made. The species killed by the spill were primarily those which inhabit nearshore (shallow-water) hard-bottom habitats, in this case amphipod crustaceans, as opposed to those typical of deeper muddy sediments of Block Island Sound (Pratt 1996a). The absence of the common amphipod *Amphiporeia virginiana* in beach surveys also may be indicative of oil exposure effects (SAIC 1996).

Bioassays of sediment samples off Moonstone Beach showed evidence of toxicity to benthic invertebrates (RPI 1996a).

Depleted abundances: Diver surveys of large benthic species abundances were made in September 1996 to determine whether these species were significantly lower in abundance nine months after the spill in the affected area as compared to reference sites nearby. Evidence of lower abundances would indicate that recovery from the impact was not complete at that time. While abundances were not statistically different at oiled versus control sites, the size distribution of rock crabs at the impact sites showed smaller individuals, indicating recent recruitment, consistent with recolonization after oil-induced mortality (Witman 1997).

2. Quantification of Injury

The SIMAP computer model was used to estimate injury to benthic organisms. The physical fates model quantified exposure to these organisms. The model assumed contact with dissolved aromatic compounds in bottom water to be the main pathway of exposure of benthic epifauna (animals on the sediment surface). The main exposure pathway of benthic infauna was contact with dissolved aromatics in sediment pore water. The model evaluated the effects of exposure on acute toxicity. Chronic effects of long-term exposure to sediment concentrations of oil or via ingestion were not considered because they were not expected to be significant (French 1998a).

A summary of model results is provided in Exhibit 4-5. These estimates indicate that approximately 4.9 billion worms/amphipods were killed by the spill, totaling approximately 800,000 kilograms of lost biomass (including direct kill and production foregone). Approximately 3.9 million rock crabs also were killed, with an associated loss in biomass of 91,000 kilograms. Fish injuries (primarily cunner and skates), totaled 4.2 million animals. However, most of these individuals were small, such that the total injury amounted to 111,000 kilograms.

Exhibit 4-5

ESTIMATES OF OFFSHORE INVERTEBRATE KILL AND FISH (All Age Classes Summed)

Species Category	Numbers Killed	Biomass Killed (kg)	Production Foregone (kg)	Total Injury (kg)
Total fish	4,193,167	30,067	80,509	110,576
Herrings, river	10	3	3	6
Herring, sea (Atlantic)	391,796	3,044	4,193	7,237
Hakes (red, white)	1,705	125	824	949
Cod	35,970	350	1,253	1,604
Dogfish	460	1	194	195
Haddock	5	4	3	7
Pollock	236	2	3	4
Searobins, sea raven	12,156	94	130	225
Whiting (silver hake)	4,957	39	53	92
Eels, eelpouts	45,229	351	484	835
Flounders	554	480	398	879
Sculpin	28,627	222	306	529
Skates	1,947,847	15,133	20,845	35,978
Tautog	16,493	459	544	1,004
Cunner	1,739,494	9,758	51,274	61,033
Crabs, rock (Cancer spp.)	3,887,756	41,734	49,275	91,008
Crabs, hermit	3,731,715	3,732	2,426	6,157
Quahog (Mercenaria spp.)	37,454	7	798	805
Clams, surf	19,402,290	547,579	422,776	970,355
Mussels	20,246,750	879	1,203	2,082
Benthic macrofauna	4,890,219,000	489,022	310,480	799,502

3. Recovery

The Trustees estimate that affected worm/amphipod populations returned to baseline levels through natural recovery within five months after the spill. This estimate reflects their short lifespan and the Trustee expectation that a new generation of these organisms was produced in that time frame (S. Pratt, pers. comm. 1997).

Injured rock crab populations are expected to return to baseline levels through natural recovery within 2 to 3 years after the spill. This period of time encompasses the expected lifetime of the rock crabs killed by the spill. Thus, in the absence of the spill, these rock crabs would have lived up to two to three additional years. Based on information currently available to the Trustees, there is no indication that rock crab reproduction (and therefore future generations of rock crabs) will be affected significantly.

Injured hermit crab, starfish, quahog, and mussel populations are expected to recover through natural recovery within one year, reflecting the fact that the injuries are small relative to total populations of these organisms in the assessment and near-by unaffected areas.

These estimates of recovery time are intended to provide a general approximation of the duration of the injury to these species. As discussed in Chapter 5, restoration scaling is based on more detailed calculations.

4.4.2.4 Offshore Water Column (Plankton)

1. <u>Determination of Injury</u>

The following data, in addition to that described for the offshore community in general, confirm the exposure of water column organisms (phytoplankton and zooplankton, including fish and shellfish eggs and larvae) to the spilled oil:

> Plankton tows by the National Marine Fisheries Service on the *RV Albatross* in January 1996 showed that larval stages of several fish and invertebrate species, as well as zooplankton common to Block Island Sound, were present in the area contaminated by oil (RPI 1996a).

2. <u>Quantification of Injury</u>

The SIMAP computer model was used to estimate injury to water column organisms. The physical fates model quantified exposure to these organisms. The model assumed contact with dissolved aromatic compounds in water at the depths these organisms inhabit to be the pathway of exposure of water column organisms. The model evaluated acute toxicity resulting from exposure to spilled oil. Chronic effects of long-term exposure to resuspended sediment concentrations of oil or via ingestion were not considered (French 1998a).

Injuries to planktonic fish eggs and larvae are included in the total fish injury, described below. Injuries to benthic invertebrate larvae in the plankton were insignificant because very few larvae are present in the plankton in the winter season. Injuries to phytoplankton and zooplankton were estimated, but are insignificant relative to total production of Block Island Sound in winter.

3. Recovery Time

As described above, injury to the offshore water column was minimal. Natural recovery of phytoplankton and zooplankton was estimated to be complete by the spring of 1996.

4.4.2.5 Fish

1. Determination of Injury

The following data, in addition to that described for the offshore community in general, confirm the exposure of fish to the spilled oil:

> Trawls by the *RV Albatross* and by the *RV Cap't Bert* in January 1996 showed several fish species in the area contaminated by oil (RPI 1996a).

Evidence of exposure causing injury to fish is summarized below. Available evidence is for direct injury, caused by exposure to aromatic concentrations in the water and sediments.

> Strandings: As previously described, dead and moribund fish of several species were observed stranded on beaches during daily surveys (Gibson 1997).

2. Quantification of Injury

The SIMAP model was used to estimate injury to fish. The pathway of exposure to fish was quantified in the physical fates model, and was assumed to be through contact with dissolved aromatic concentrations in water at the depth the species inhabits (either in the water column or on the bottom). Movements of fish in and through the affected area were accounted for according to species' behavior. Effects considered were acute toxicity from exposure. Chronic effects of long-term exposure to sediment concentrations of oil or via the ingestion pathway were not assessed in this analysis because these impacts were not expected to be significant relative to the acute toxicity (French 1998a).

Fish injuries estimated by the model are summarized in Exhibit 4-5. The largest fish injury (including direct kill and production foregone) was for cunner (61,000 kilograms), followed by skates (36,000 kilograms), and Atlantic herring (7,200 kilograms). Total fish injury was approximately 110,600 kilograms (French 1998b).

3. Recovery Time

The Trustees estimate that affected fish populations will return to baseline levels through natural recovery within 1 to 2 years after the spill. This estimate reflects the fact that the injury is small relative to the total fish population in the spill-impacted area, and is intended to provide a general approximation of the duration of fish injury. As discussed in Chapter 5, restoration scaling is based on more detailed calculations.

4.4.3 Salt Pond Communities: Overview of Data and Strategy

Rhode Island's coastal salt ponds are a critical part of the South Shore Coastal ecosystem, serving as essential spawning, nursery and growth areas for coastal fish and shellfish (Baczenski *et al*. 1979, Crawford and Carey 1985, Ganz *et al*. 1992). Like most estuaries, the ponds also are important links between terrestrial and marine environments, converting terrestrial nutrients into marine biological production; in the shallow, well-lit waters of the salt ponds, benthic activity is an important component of this process (Nixon 1982, Nowicki and Nixon 1985).

The ponds' ability to sustain this contribution to the South Shore coastal ecosystem has been reduced over time, and is further threatened by a number of human impacts. Fishing has eroded once-abundant harvests of fish and shellfish in the ponds, as has habitat destruction caused by such activities as breachway management, dredge and fill operations, and damming of brooks and rivers (Crawford 1984, Lee *et al*. 1985, Nixon 1982, Olsen and Lee 1993). Habitats also have been lost or degraded as a result of human impacts on water quality. In particular, increased nutrient loadings to the ponds from residential development have caused eutrophication, leading to declines in eelgrass, increased sediment anoxia, and other detrimental effects to fish and wildlife habitats (Lee *et al.* 1985, Short *et al*. 1996).

Because of the salt ponds' importance to the regional ecosystem and potential susceptibility to human impacts, the Trustees and RP completed more than a dozen studies designed to evaluate the effects of the *North Cape* oil spill on the salt pond environment. The results of these studies are described in the following sections of this chapter.

4.4.3.1 Determination of Injury

Oil from the *North Cape* entered the salt ponds as surface slicks and exchange with oil-contaminated water through breachways, as well as via beach overwash and aerial deposition during the high winds and water at the time of the release, resulting in significant exposure of water column and benthic resources in the salt ponds.

The Trustees documented exposure of resources in the ponds to oil from the *North Cape* at levels and durations which are of ecological significance, as estimated by the technical working group. This finding is based on several sources of information, including chemical analysis of water and shellfish tissue samples and oil fate modeling. All available data were used to delineate the area of each pond exposed to *North Cape* oil, as reported in Michel (1997a) and shown graphically in Exhibits 4-6 through 4-8. The percentages shown on Exhibits 4-6 through 4-8 are the percent of the area of each pond exposed to oil.

1. Shellfish Tissue Sampling

As part of the seafood safety monitoring program, the Trustees and RP collected 28 samples of oysters, mussels, quahogs and soft shell clams in early March and April from all of the ponds with permanent breachways (i.e., Winnapaug, Quonochontaug, Ninigret, Potter and Point Judith ponds). Bivalves are excellent indicators of water-column exposures because they concentrate oil in their tissues by up to 10,000 times the concentration in the water (Scott *et al*. 1984).

The Trustees and Responsible Party measured the levels of PAHs in the bivalve samples and interpreted the PAH distributions in bivalve tissues to apportion the PAHs found in the samples to various sources (Boehm *et al*. 1996). Based on chemical analysis of *North Cape* oil, the Trustees and Responsible Party determined that most of the 2- and 3-ringed PAHs came from oil released during the spill. Exhibit 4-9 shows the mean total PAHs for the 28 bivalve samples taken from the ponds as part of the Trustee monitoring program. At least 85 percent of the PAH concentrations listed in the exhibit are due to *North Cape* oil (Boehm *et al*. 1996).

Exhibit 4-9

MEAN CONCENTRATION OF TOTAL PAHS IN BIVALVE TISSUES COLLECTED FROM SALT PONDS (BOEHM *ET AL*. 1996)*

Pond	Soft Shell Clam	Oyster	Blue Mussel	Ribbed Mussel
Point Judith (Mar)	18,400 (4)**	13,500 (2)		
Point Judith (Apr)	10,250 (2)	7,800 (2)		
Potter (Mar)		3,240 (2)		8,300 (1)
Potter (Apr)		1,400 (2)		4,200 (2)
Ninigret	8,500 (2)	2,550 (1)		
Quonochontaug	10,000 (2)	1,400 (1)		
Winnapaug			24,300 (1)	

* Measurements are in ppb, wet weight.
** Number in parenthesis indicates the number of samples in the mean.

The levels and sources of PAHs in bivalves showed differences among species, ponds and over time. Quahogs contained relatively low levels of total PAHs (44 to 1,780 ppb wet weight) and none allocated to oil from the *North Cape*. Quahogs are temperature-sensitive and stop feeding when water temperatures fall below 6°C (Stanley 1985), while soft shell clams have a wider temperature tolerance range (Abraham and Dillon 1986). It is therefore likely that the quahogs had slowed or stopped feeding during the very cold conditions at the time of the spill, and thus did not take in significant amounts of oil from the water column. Therefore, the PAHs in quahog tissues are likely representative of background levels.

Exhibit 4-6

AREAS OF PT. JUDITH AND POTTER PONDS EXPOSED TO *NORTH CAPE* OIL

(The percentages shown on this exhibit are the percent of the area of each pond exposed to oil.)

Exhibit 4-7

AREAS OF TRUSTOM AND CARDS PONDS EXPOSED TO *NORTH CAPE* OIL

(The percentages shown on this exhibit are the percent of the area of each pond exposed to oil.)

Exhibit 4-8

AREAS OF OTHER PONDS EXPOSED TO *NORTH CAPE* OIL
(The percentages shown on this exhibit are the percent of the area of each pond exposed to oil.)

Based on the bivalve sample locations and North Cape PAH concentrations, it appears that oil entered the breachway at Winnapaug Pond, but very little oil mixed into the body of the pond. Both Quonochontaug and Ninigret Ponds received about the same level of exposure with soft shell clams averaging 10,000 and 8,500 ppb, respectively, and oysters averaging 1,400 and 2,550 ppb. In Quonochontaug Pond, tissues from the western ends of the pond did not have elevated levels of PAHs, indicating that the oil did not reach the extreme ends of the pond. Oil spread throughout the main body of Ninigret Pond, but apparently did not spread into the two northern arms of the pond (Foster and Fort Neck coves).

In Point Judith Pond, PAH levels in soft shell clams collected in March averaged 18,400 ppb (twice as high as the other exposed ponds) and oysters averaged 13,500 ppb. By April, these levels had dropped by about half. A similar trend was observed in Potter Pond, where oysters averaged 3,240 ppb on March 9 and 1,400 ppb on April 2, and ribbed mussels dropped from 8,300 ppb to 4,200 ppb over the same period. The fact that PAH levels in tissue were elevated above background levels between 7 to 11 weeks after the spill suggests that there were still sources of *North Cape* oil which were bioavailable, most probably from contaminated sediments.

2. <u>Water Sampling and Oil Fate Modeling</u>

Several groups conducted water sampling in the salt ponds, with most of the samples collected over the period of January 22 to 26, 1996. A few samples were collected during February and March in Point Judith Pond. These results were used in a model developed by Hinga (1997) to estimate the water column concentrations of oil in each salt pond over time. Parameters used in the model were the measured values (used to initiate the model), mixing and exchange rates for the ponds, and hydrocarbon loss rates based on previous studies at URI on the behavior of No. 2 fuel oil in mesocosms (Olsen *et al*. 1982). These studies were used to predict the behavior of *North Cape* oil in Rhode Island salt ponds since they were conducted with a similar oil type, included winter experiments and were composed of similar habitat settings.

Hinga (1997) estimated the concentrations over time for the aromatic fraction of the oil only, for two reasons. Hinga used a simple flushing model and collected data on the degradation rate of No. 2 fuel oil to estimate concentrations over time. Unfortunately, samples for most of the ponds were only analyzed for total petroleum hydrocarbons (TPH), so it was necessary to convert the results to total aromatics. Based on detailed analyses of selected samples, Hinga estimated that aromatic compounds from *North Cape* oil were 22.3 percent of the TPH as measured in the salt pond water samples for Point Judith Pond and Potter Ponds, 4.5 percent for Cards and Trustom Ponds, and 10.8 percent for Ninigret, Quanochantaug, Winnapaug, and Green Hill Ponds. Analyses conducted by Reddy and Quinn (1996) and Boehm *et al*. (1996) confirm that PAH levels in the water column are attributable to the *North Cape* source oil. The basis for these assumptions are discussed in Hinga (1997).

Hinga (1997) estimated oil concentrations over time for each pond. Where available, data from field samples were used to verify his estimates. There was general agreement between the calculated and measured concentrations.

4.4.3.2 Quantification of Injury

To quantify the injury to salt pond communities resulting from exposure to oil from the *North Cape* spill, concentrations of oil in the water column and sediment over time (Hinga 1997) are compared to acute toxicity levels for different species and species groups found in the salt ponds. Injury is then quantified by applying the results of this analysis to species abundance data. These calculations are made using the same toxicity data and sub-model used in the offshore water column injury assessment (SIMAP) (French 1998a, French and Rines 1998). This sub-model calculates the acute (short-term) toxicity, accounting for the effects of temperature and time of exposure on mortality.

4.4.4 <u>Salt Pond Communities: Individual Resource Injury Determination</u>

4.4.4.1 Winter Flounder

Impacts to winter flounder from the *North Cape* oil spill were of great concern because of their reduced population levels and because these fish migrate into several of the coastal ponds (Potter, Point Judith, Ninigret, Quonochontaug, Winnapaug and Green Hill) during the early winter and spawn from January to April (Klein-McPhee 1978). The adult females spawn in multiple waves throughout this period (i.e., one group of adult fish moves into the ponds, spawns and moves out, to be replaced by a new group of spawning adults). The eggs are deposited on the bottom sediment, hatch to larvae and then develop to young-of-the-year (YOY) within the ponds. Therefore, winter flounder spawning adults, eggs, larvae and juveniles were potentially at risk of exposure to high levels of oil via both water-column and sediment pathways.

Few other commercially or recreationally important fish are present in the ponds during winter. Therefore, the Trustees focused salt pond fishery impact assessment on winter flounder. Five related studies were conducted on various life stages:

Sublethal effects on embryos (Hughes 1997);

Sampling of larval abundance during and following the spill (M. Gibson, pers. comm. 1997);

Abundance, growth and survival of YOY juvenile fish (Gibson and Gray 1997);

Assessment of the levels of exposure of adult fish (Collier *et al*. 1997); and

Modeling of injury to greater than one year old fish from acute exposures (French and Rines 1998).

Based on the results of these studies, the Trustees determined that injury to winter flounder was minimal. Adult fish, egg, and larvae exposures may have resulted in limited acute mortality and adversely affected one or two of the spawning waves that occurred soon after the spill. However, monitoring of juvenile fish abundances indicates that later spawning efforts were successful and likely offset any early season losses.

4.4.4.2 Shellfish

Substantial populations of quahog, soft shell clam, American oyster, bay scallop and blue mussel occur in the salt ponds affected by the *North Cape* oil spill. RIDEM has published shellfish surveys for each of the ponds (Grey *et al*. 1971, Reardon and S.C.C.A.P. 1979, Baczenski *et al*. 1979, Constas *et al*. 1980, Delancey and Ganz 1981, Ganz 1988, Ganz *et al*. 1992).

RIDEM conducted a salt pond shellfish mortality survey in Point Judith Pond on 20 February, Potter Pond on 8 February, Ninigret Pond on 1 April and Quonochuntaug Pond on 26 March (RIDEM 1996). One survey per pond was conducted. Survey sites included intertidal and subtidal communities with documented shellfish populations. The approach was to first conduct visual inspections for the presence of oil and evidence of recent mortality (dead shellfish having gaped valves with viscera remaining or gaped valves free of sediment or fouling). Buried clams and scallops were collected using a clam rake, whereas intertidal areas were visually surveyed.

No significant shellfish mortality was observed in any of the sample locations, except for juvenile scallops held in cages suspended from the docks at the RIDEM Coastal Fisheries Laboratory in Jerusalem (RIDEM 1996). Disruption of the sediments during sampling released significant oil sheens only in Point Judith Pond. Because the surveys were conducted three to ten weeks after the spill, however, it is likely that any dead shellfish tissues were scavenged. RIDEM conducted follow-up visits at several sites in the salt ponds between April and June, in response to reports of shellfish mortality and/or tainting. In all cases, samples were collected for organoleptic and chemical analyses and met applicable safety guidelines.

To further assess the potential for shellfish injury, the Trustees compared water column concentrations of oil over time with acute toxicity thresholds for shellfish described in French *et al*. (1996). Quahogs were not included in the list of injured species because, as discussed in Section 4.4.3.1, monitoring of PAHs in quahog tissues showed that they were not exposed (they had stopped feeding during the very cold water temperatures). On the other hand, soft shell clams (which are also buried in the sediments) contained very high levels of PAHs in their tissues, indicating that they were feeding and exposed to the oil in the water column. The results of this analysis indicate a low level of adult shellfish injury, primarily to soft-shell clams.

Based on these data, the Trustees conclude that there was limited acute adult shellfish mortality in salt ponds attributable to the *North Cape* oil spill. The shellfish surveys did not assess the potential for acute injury to juvenile shellfish, which are more sensitive than adults to both lethal and sub-lethal effects of exposure to No. 2 fuel oil (Scott *et al*. 1984).

Impacts from the spill to shellfish eggs and larvae are not expected to be significant because oil concentrations in the water column are believed to have dropped to below toxic levels prior to the onset of spawning. The timing of spawning depends on water temperature and occurred in 1996 during the period June through August, with peaks in July (J. Karlsson, pers. comm. 1997).

4.4.4.3 Worms/Amphipods

Early in the spill there was evidence that intertidal and subtidal sediments were contaminated by the spilled oil. Since contaminated sediments can provide a long-term pathway of exposure to benthic communities, the Trustees undertook several studies to determine the extent and duration of sediment contamination and the impacts to benthic communities. Very little pre-spill data on the abundance and diversity of benthic communities were available. Thus, the injury quantification approach consisted of:

> Sediment chemical analyses and modeling to determine the degree and duration of exposure;
>
> Bioassay testing as an indicator of sediment toxicity;
>
> Limited sampling to characterize the benthic communities and identify general trends in relative abundance and species diversity; and
>
> Use of literature values to indicate the contamination levels at which biological effects occurred.

Exposure of benthic communities to oil from the *North Cape* was documented through sediment sampling. USFWS collected sediment samples from the edges of all seven ponds in January and April. These samples were analyzed for PAHs and fingerprinted to allocate the percent of contamination by *North Cape* oil by Boehm *et al*. (1996). NMFS collected and analyzed sediment samples from the deeper parts of Point Judith and Ninigret Ponds. Boehm *et al*. (1996) also interpreted these results for percent *North Cape* oil. Because sediments are sinks for petroleum hydrocarbons from many sources, it is important to distinguish between *North Cape* oil and other sources of petroleum hydrocarbons. *North Cape* oil contained only trace amounts (about one percent) of the 4- and 5-ringed PAHs, while combustion-sourced petroleum hydrocarbons contain very few 2- and 3-ringed PAHs. Thus, it can be assumed that nearly all 2- and 3-ringed PAHs represented *North Cape* oil and all 4- and 5-ringed PAHs represented background contamination. This approach was used by Boehm *et al*. (1996) in their fingerprinting work.

Sediment samples collected from the salt ponds contained from 5 to 100 percent background petroleum hydrocarbons (Boehm *et al*. 1996). All but one of the sediment samples from Winnapaug and Quonochontaug Ponds contained mostly background oil. The four samples collected by NMFS from Ninigret Pond in late February contained elevated total PAHs (3,300 to 33,000 ppb) with 80 to 95 percent allocated to *North Cape* oil. Samples from Point Judith Pond contained 0 to 39,000 ppb PAHs, with 67 to 95 percent from the *North Cape*. By July, PAHs in sediments from Ninigret and Point Judith Ponds had decreased by more than 80 percent, indicating rapid degradation of the *North Cape* oil.

Hinga (1997) estimated the concentrations over time of oil in the salt ponds. By summer, low-molecular weight PAHs in most pond sediments had decreased by 80 to 95 percent, with only three stations in middle Point Judith Pond remaining at elevated levels (5,700 to 6,000 ppb).

Based on these estimates, the areal extent of sediment contamination in the ponds may be summarized as: no sediment contamination in Winnapaug, Quonochontaug, Green Hill, Trustom and upper Point Judith Ponds; two segments of contamination in Central Ninigret (see Exhibit 4-6) with the western segment averaging 3,900 ppb and the eastern segment averaging 30,000 ppb; contamination throughout all of Potter Pond (averaging 230 ppb) and Cards Pond (averaging 3,200 ppb); and four areas of varying levels of contamination in Point Judith Pond, ranging from an average of 3,400 to 44,000 ppb (Michel 1997b).

The Trustees undertook several studies to further evaluate injury to salt pond benthic organisms. Bioassay testing (sea urchin fertilization tests) of elutriates from pond edge sediments collected in January and April showed greatest toxicity in sediments from Point Judith, Potter and Trustom Ponds. Studies of benthic communities in the ponds documented extensive mortality of infauna (primarily amphipods) in Cards and Trustom Ponds (Michael 1996, Pratt 1996b). The Audubon Society sponsored a study of Cards Pond which indicated a normal and healthy benthic community by summer and early fall (Beatty *et al*. 1997), suggesting that benthic impacts were most likely short-term. These results are consistent with the rapid degradation of *North Cape* oil in surficial sediments. Thus, the Trustees have focused on injury quantification for the acute mortality of benthic communities in the salt ponds.

4.4.4.4 Other Species

The salt ponds support a variety of other benthic organisms that may have been affected by the oil spill, including zooplankton, fish, and shellfish. USFWS response teams observed dead and moribund forage fish, clams, crabs, shrimp, squid, worms, and amphipods in both Trustom and Card ponds (Sperduto 1996). The shoreline assessment teams noted dead and dying forage fish on several of the survey forms. The available field evidence and modeling analyses, however, indicate that the magnitude of these injuries was small. Therefore, the Trustees did not undertake additional studies to determine injury for these benthic species other than those described for the salt pond community in general. Substantial numbers of birds that utilize the salt pond environment were injured. These injuries are described in the seabird and wintering waterfowl section of this chapter.

4.4.5 <u>Salt Pond Communities: Individual Resource Injury Quantification</u>

As previously described, the Trustees quantify injury to salt pond resources by comparing concentrations of oil in the water column over time (Hinga 1997) to acute toxicity levels for different species and species groups identified in the literature. Injury then is quantified by applying the results of this analysis to species abundance data. These calculations are made using the same toxicity data and model used in the offshore water column injury assessment (French 1998a and b, French and Rines 1998). This model calculates the acute (short-term) toxicity, accounting for the effects of temperature and time of exposure on mortality. The results of this analysis are shown in Exhibit 4-10 below.

Exhibit 4-10

QUANTIFICATION OF SALT POND WATER COLUMN AND SEDIMENT INJURY

Species or Group	Numbers Killed	Biomass Killed (kg)	Production Foregone (kg)	Total Injury (kg)
Winter flounder	1,589	1,377	1,142	2,519
Forage fish	533,357	2,667	2,370	5,037
Soft shell clam	499,102	5,712	3,888	9,600
Oyster	149,367	1,857	905	2,762
Bay scallop	159	5	0	5
Crabs	318,111	3,181	3,756	6,937
Shrimp	323,844	81	88	169
Zooplankton	5,397,186	229	-	229
Benthic macrofauna	6,591,836,102	65,918	81,904	147,822

These results indicate that an estimated 6.6 billion worms/amphipods were killed by the spill, with an associated biomass (including direct kill and production foregone) of148,000 kilograms. Large kills of amphipods were observed after the spill in Cards Pond (Pratt 1996b), although the dead amphipods only were observed once the water level dropped after the pond was breached. Michael (1996) observed unusually low abundances of benthic organisms in several of the ponds, but reference data from before the spill were not available for comparison.

Other injuries in the salt ponds were substantially smaller. Total injury to crabs (7,000 kilograms), forage fish (5,000 kilograms), and soft shell clams (9,600 kilograms) were the largest of the remaining injuries. Numerous dead mummichogs and northern silver-sides were observed, and a liter container of dead mummichogs was collected and frozen. Impacts on winter flounder and other shellfish were slight. These findings are consistent with the field data addressing injury to winter flounder and shellfish discussed above.

The Trustees estimate that populations of worms/amphipods naturally recovered to baseline conditions within five months. This estimate is based on the rapid recovery of these organisms in Cards Pond documented by Beatty *et al*. (1997), who found a normal benthic community by late summer of 1996, and the Trustee expectation that a new generation of these organisms was produced within five months of the spill (S. Pratt, pers. comm. 1997).

For the other species injured in the salt ponds, the Trustees estimate a recovery period of 1 to 2 years. This estimate reflects the life history characteristics of injured species and the relatively small magnitude of the injuries compared to the size of local populations.

Injuries to both water column and benthic resources in the salt ponds can be summarized as follows. There were minimal or no impacts to water column and benthic resources in Winnapaug, Quonochontaug, Ninigret West, and Trustom Ponds because of either very low exposures or low abundances of organisms present at the time of exposure. There were minor impacts to the water column resources in Green Hill, Cards, and Potter Ponds, and Potter Pond also had a small (1 percent) mortality of benthic crustaceans. Most of the impacts occurred in central Ninigret Pond and lower and middle Point Judith Pond, where both water and sediment concentrations were high enough to cause acute mortality to relatively abundant organisms.

4.4.6 Intertidal Wetlands

There were two types of intertidal wetlands potentially affected by the *North Cape* oil spill; salt marshes in the permanently breached ponds, primarily in Point Judith and Potter, and brackish to fresh water marshes in Cards and Trustom Ponds. No. 2 fuel oil is the most acutely toxic type of oil to wetland vegetation (Webb 1995), often resulting in death of the roots and loss of habitat under heavy loading (Hampson and Moul 1978, Matsil 1996). However, overflight maps and shoreline surveys indicate that the amount of floating oil which entered the salt ponds during the spill was very small.

To determine if there had been injury to intertidal wetlands, two types of studies were conducted: visual assessment of the degree of oiling along the most heavily oiled wetland shorelines in Point Judith Pond and Potter Pond; and a detailed vegetation study of the Bluff Hill Cove marsh in Point Judith Pond for which there were pre-spill (1992 and 1994) data.

The visual surveys included the shoreline assessment conducted on January 22 and 23, 1996 as part of the shoreline assessment work during the emergency response operations. At that time, the shoreline assessment teams reported visible oil in the marshes occurring as rainbow sheens at the water's edge along the shoreline and in a few ponds on the marsh surface, and as sheens that could be released by disturbing the nearshore sediments and the marsh scarp. The shoreline assessment observations are included in the Preassessment Data Report (RPI 1996a).

The Preassessment survey teams were concerned that the oil penetrated the organic, peat-like sediments at the marsh scarp, because rainbow sheens could be released by compressing the marsh edge under water. The sections of the marsh with the greatest oil exposure reported in January were revisited on March 21 and 22, when 31 sediment cores were taken for later analysis and study quadrats were established (Michel 1996). Further study of individual sites and chemical analysis of sediment coves were postponed until an assessment was made of the extent of vegetation injury in the summer.

A summer shoreline assessment was conducted by the Trustees on June 7, 1996. The survey team did not visually detect any differences in the growth patterns or relative abundance of the above-ground vegetation between areas known to have been exposed to oil from the *North Cape* and areas with little or no oil exposure. They recommended that a detailed field study of the impacts to salt marsh vegetation would not be necessary at this time (Michel 1996). The survey team did observe the presence of sheens in the substrate in many marsh and tidal flat areas originally reported as oiled. Some of these sites were re-visited again on October 17, 1996; very little or no oil was released from the marsh scarp at this time (Hebert 1996).

Vegetation studies at Bluff Hill Cove marsh repeated the methods and sites of a long-term study as part of the Galilee Bird Sanctuary restoration project (Myshrall and Golet 1996). Measurements of stem density, stem height, and total biomass were collected at 61 quadrats in *Spartina alterniflora* and compared to similar data for 1994. The results, summarized in Raposa (1996), indicated that there were no significant differences in these characteristics of the marsh at Bluff Hill Cove pre- and post-spill.

Two sediment cores collected from the Bluff Hill Cove marsh interior on January 26, 1996 contained total PAHs of 1.7 and 2.0 ppm, mostly attributed to background sources of petroleum hydrocarbons (Quinn 1996). These levels are well below those known to cause acute mortality to marsh vegetation. For example, no regrowth of salt marsh vegetation occurred where the sediment concentrations of No. 2 fuel oil were greater than 2,000 ppm at the *Florida* spill in Buzzards Bay (Burns and Teal 1979). At a No. 2 fuel oil spill in the Arthur Kill, New York, salt marsh vegetation died and did not regrow in areas where the oil levels remained elevated (40 samples taken four months after the spill had a mean TPH concentration of 6,400 ppm; Matsil 1996).

Based on the results of the marsh assessment studies, the Trustees conclude that there has been no significant injury to salt marsh vegetation as a result of the *North Cape* oil spill. The lack of pre-spill data and low exposure levels prevented assessment of other impacts to the salt marsh community, such as the effects on algal, invertebrate, and fishery populations. No further injury assessment studies are recommended for the intertidal wetlands.

4.4.7 <u>Birds/Foreshore</u>

4.4.7.1 Piping Plover

Moonstone Beach consistently provides nesting and brood habitat for the piping plover, a federally-listed threatened species (USFWS 1985). In the summer of 1996, nine pairs of piping plovers nested on Moonstone Beach near the site of the *North Cape* grounding. Piping plovers typically arrive at Rhode Island beaches by early April. By mid-April, they establish pairs and begin construction of their nests. Egg laying and chick rearing generally take place from May through July, with the majority of chicks fledging in July. The birds feed on invertebrates in intertidal pools, washover areas, mudflats, sandflats, wracklines of barrier beaches and shorelines of coastal ponds, lagoons and salt marshes.

The Trustees completed several studies to determine if Moonstone Beach piping plovers were adversely affected by the spill. Moonstone Beach piping plover behavior and productivity were studied after the spill, and compared with similar data from prior years at Moonstone Beach and other piping plover sites in Rhode Island and Connecticut (Casey 1996). Another study monitored piping plover behavior and productivity at nesting locations on the coast of Rhode Island that were not impacted by the spill (McGourty 1997). Two analyses were conducted to assess the impact of the spill on piping plover prey (Gould 1996, SAIC 1996).

1. Injury Determination

To assess piping plover injury, the Trustees compared Moonstone Beach piping plover behavior and productivity during 1996 to historical and reference area data. These comparisons support the following conclusions:

> Less food was available to Moonstone Beach piping plovers in 1996 than at a control beach (East Beach). Invertebrate pit-trap samples indicate that the wrack at the control beach had 8.5 times more organisms by weight and 6.5 times more organisms by volume than the beach at Trustom Pond NWR (Gould 1996).
>
> Moonstone Beach chicks foraged further in 1996 than in previous years. The average daily distance traveled by 1996 chicks was two to three times the distance traveled in 1994 and 1995 (Casey 1996). This finding is consistent with reduced food availability.
>
> Oil contamination of Rhode Island beaches was highest at Moonstone Beach in the high tide and storm high tide sands (Mulhare and Therrien 1996). This is the same area where most piping plovers nested (Casey 1996).
>
> Moonstone Beach piping plovers abandoned four of nine initial nest attempts (25 percent of all their nests) in 1996, the highest rate since management activities were initiated in 1992 (Casey 1996). This abandonment rate also is higher than observed rates at reference area piping plover nests (Casey 1996).
>
> Abandonment of 44 percent of first nest attempts delayed the chick rearing period from May to June. Between the years of 1992 and 1995, the two years of lowest productivity corresponded to years when chick rearing was delayed until late May. Highest productivity was observed when chick rearing occurred earlier in May (Casey 1996).
>
> Finally, Moonstone Beach piping plover productivity (number of chicks fledged per pair) dropped 37 percent in 1996, after steadily increasing for five years (Casey 1996). Piping plover productivity at Rhode Island reference area sites <u>increased</u> six percent in 1996 (Casey 1996).

These observations indicate that Moonstone Beach piping plovers experienced lower productivity than expected after the spill and exhibited unusual behavior consistent with reduced food supply and reproductive impairment. By comparing Moonstone Beach piping plover activity after the spill to historical and reference area data, the Trustees have attempted to control for causal factors unrelated to the spill. Because 1996 piping plover productivity at Rhode Island reference areas increased slightly from 1995, it is unlikely that changes in weather are responsible for the 1996 productivity decline at Moonstone Beach. Likewise, historical data from Moonstone Beach suggest that productivity in 1996 was lower than expected, and do not identify any non-spill factor unique to this site that might explain the 1996 decline.

2. Injury Quantification

To quantify lost piping plover productivity on Moonstone Beach, the Trustees assume that in the absence of the spill, productivity in 1996 would have at least equaled productivity in 1995. Productivity steadily improved from 1992 to 1994, and increased dramatically in 1995. USFWS biologists attribute the improvement in 1995 to a new management program that expanded predator controls. This same management program was in place during 1996, and was expected to sustain the productivity gains realized in 1995.

Based on these assumptions, lost piping plover productivity in 1996 can be calculated using the following equation:

(1995 productivity - 1996 productivity) * number of plover pairs in 1996 = lost chicks
(1.56 chicks per pair - 1.00 chicks per pair) * 9 pairs = 5.0 fledged chicks

The future production from these chicks also is lost. Assuming a chick over-winter survival rate of 48 percent (Melvin *et al*. 1992), two or three of the five chicks likely would have survived the winter and returned to breed the following year, in the absence of the spill.[4] Assuming a 1997 fledging rate equal to that in 1995 (1.56 chicks per pair), the chicks lost because of the spill likely would have produced one or two fledgings of their own in 1997.[5] Based on this analysis, the Trustees conclude that five chicks is the minimal loss attributable to the spill; depending on actual over-wintering survival rates and future fledging rates, the Trustees estimate a total loss over time of between five and ten piping plover chicks.

3. Recovery Time

The Rhode Island piping plover population has had difficulty maintaining its size, as evidenced by its federal listing as a threatened species and state protection efforts. Thus, the Trustees conclude it is unlikely that the local piping plover population will naturally compensate for this loss, delaying efforts to restore this population to self-sustaining levels.

---

[4] 5.0 fledged chicks * 0.48 over-winter survival rate = 2.4 surviving breeders

[5] 1 plover pair * 1.56 chicks per pair = 1.6 fledged chicks

1.5 plover pairs * 1.56 chicks per pair = 2.3 fledged chicks

4.4.7.2 Seabird and Wintering Waterfowl Acute Mortality

The salt pond and offshore habitats of the Block Island Sound coastal ecosystem are valuable wintering habitats for a variety of bird species. Marine waters support regionally important waterfowl populations including loons, grebes, sea ducks (e.g., eiders and scoters) and diving ducks (e.g., goldeneye, bufflehead and scaup). Winter diving ducks and dabbling ducks such as scaup, American black duck and mallard inhabit area salt ponds. Great black-backed gulls, herring gulls, ruddy ducks, Canada geese, red-breasted mergansers, great blue herons and mute swans also are common to this area.

Substantial numbers of these birds died from the effects of the spill. Within nineteen days after the initial release of oil, 405 oiled birds were recovered by rescue workers. Although 114 birds were alive when collected, all but 13 died or were euthanized. Based on this information, observed mortality is 392 birds. All of these birds are assumed to have died as a direct response to oil exposure. Total mortality attributable to the spill is substantially greater, as a large number of birds were never found because they sank, drifted out to sea, or were scavenged (Hlady and Burger 1993).

1. <u>Injury Determination</u>

The Preassessment data clearly indicate that birds were oiled by the *North Cape* spill and died as a result of this exposure. Oiling of the feathers can cause matting and loss of insulating and water-repellent properties, leading to hypothermia, starvation or drowning (Leighton 1995). Oil ingestion, primarily from preening behavior, also can cause mortality (Leighton 1995). Although ingestion can lead to non-lethal bird injuries, such as reproductive impairment and behavioral abnormalities (White 1991, Grau *et al*. 1977, Coon and Dieter 1981), given the low temperatures during the *North Cape* spill, virtually all of the birds exposed to oil died.

Oil spills also can injure birds indirectly through habitat loss and disruption of nesting and foraging activities. The potential impacts of the *North Cape* spill on birds that utilize offshore or salt pond habitats for nesting or foraging are addressed in the next chapter of this document.

2. <u>Injury Quantification</u>

To arrive at an estimate of total bird mortality, the Trustees applied a multiplier, based on a qualitative analysis of the factors influencing oil spill-related bird mortality, to the number of water birds known to have died as a result of the oil spill (12 of the recovered birds were non-water birds, for which the use of a multiplier was not appropriate). This multiplier accounts for birds that were never found because they sank, drifted out to sea or were scavenged (Hlady and Burger 1993).

The Trustees examined the literature to identify a range of multipliers applied to past spills and the evidence supporting these estimates (see Sperduto *et al*. 1997 for a list of these studies). In poorly documented spills, total mortality often is assumed to be ten times the number of birds retrieved (Burger 1993). The mean estimate from an analysis of 45 spills was four to five times the number of birds retrieved. Based on this information and a preliminary assessment of the conditions during the *North Cape* oil spill, the Trustees assumed a range of 1 to 10 for the *North Cape* multiplier. Additional analysis was undertaken to determine a specific multiplier for the spill.

Based on a review of the literature, the Trustees identified 17 factors that can affect the magnitude of an acute mortality multiplier. These factors are listed in Exhibit 4-11. The Trustees then evaluated the importance and likely impact of each factor. The results of this analysis, summarized below, are described in detail in Sperduto *et al*. (1997).

Two of the most important parameters affecting the likelihood that birds were oiled and that oiled birds washed ashore were wind direction and the location of the spill. The nearshore location of the spill increased the likelihood that oiled birds would make it to shore. However, beginning five hours after the spill, offshore winds blew for approximately 60 hours, increasing the spatial extent of oiling, therefore increasing the probability of exposure, and likely preventing birds which died at sea from reaching shore. Considered together, these factors suggest that a multiplier in the middle of the 1 to 10 range may be appropriate.

The combined impact of other significant factors slightly increase the multiplier. Thousands of birds winter off the Rhode Island coast and frequently move between Point Judith and Newport. Data from before, during and after the spill indicate that common eider and loons in particular may have been present in large numbers compared to historical averages, although the exact location and number of birds during the spill are uncertain. The volume of oil spilled was substantial. Finally, the cold water temperatures increased the likelihood that birds exposed to oil quickly died of hypothermia. Partly mitigating these factors is the fact that the extensive search and collection effort and the predominantly sand shorelines contributed to nearly 100 percent collection of beached birds within the extent of the spill, a finding that is generally consistent with lower multiplier estimates. While these two factors are critical in determining the percentage of beached birds retrieved, they do not address the number of birds that sank or drifted to sea.

Exhibit 4-11

CHARACTERISTICS AFFECTING THE *NORTH CAPE* BIRD ACUTE MORTALITY MULTIPLIER

Characteristics of the Spilled Oil		
Volume	Evaporation potential	Dispersal
Characteristics of the Biological Resources		
Location of birds during spill	Number of birds present during the spill	Types of birds (buoyancy, size, etc.)
Mobility	Search and collection effort	Location birds were found
Environmental Conditions		
Wind direction	Wind speed	Current direction
Current speed	Water temperature	Tidal stage
Location of spill	Type of shoreline	

The Trustees also note that currents and wind speed likely increased the extent of oiling and contributed to the transport of dead birds to sea. The locations where birds were found also suggest that birds may have drifted out to sea; approximately 20 percent of beached birds were collected from Block Island, where birds would be expected to drift based on winds and currents.

Based on their analysis of relevant parameters, the Trustees estimate a multiplier of six for the *North Cape* spill. Thus, in the best judgment of the Trustees, approximately 2,292 birds were killed directly by the spill. The number of birds by species are indicated in Exhibit 4-12. As shown, gulls were killed in the greatest numbers (444), followed by common loons (402), eider (354), grebes (228), mergansers (204) and goldeneye (192).

To estimate interim losses, the Trustees multiply the number of birds killed by species-specific estimates of recovery periods. Recovery time estimates are based on life history and population information for the primary groups of birds injured: non-water birds (owls, doves); pond birds (black duck, geese, herons); and marine birds (sea ducks, loons, grebes, alcids, gulls, cormorants).

Available data on fledging rates, survival rates, and population abundances indicate that non-water birds, pond birds, and alcids (murres, dovekies, gannets, and razorbills) likely were restored through natural recovery during the first breeding season following the spill. Relatively few individuals of each of these species were estimated to have been killed (less than 40 of any one species) and natural compensatory mechanisms are expected to quickly restore the affected bird populations to baseline levels.

In the best judgment of the Trustees, natural compensatory mechanisms also quickly restored populations of gulls and cormorants to baseline levels. While these species were estimated to have been killed in larger numbers (444 gulls and 96 cormorants), populations of these species are known to be increasing in size, and therefore natural recovery was assumed complete after the first post-spill breeding season.

Recovery time for sea ducks, loons, and grebes was determined to continue beyond the first breeding season following the spill. Sea duck, loon and grebe mortality was greatest among all birds injured by the *North Cape* spill; the TWG estimated that 1,476 of these birds were killed (834 sea ducks, 402 common loons, 12 red-throated loons, and 228 grebes). While regional breeding populations of these species may be adequately large to quicken natural recovery, the Trustees believe that life history traits of these species, including the relatively late age of first breeding and their low reproductive success, combined with the large number of these birds killed by the spill, are sufficient to prolong natural recovery beyond one breeding season.

The Trustees estimate recovery times for sea ducks, loons and grebes that approximate their expected remaining lifetimes in the absence of the spill. This calculation requires information on the age of birds killed by the spill and natural mortality rates. Because recovery teams were unable to age birds found during the recovery effort, the Trustees assume that birds killed by the spill were the average age of their respective populations. Survival rates and maximum age data were obtained from a review of available literature cited in the NRDAM/CME (French *et al*. 1996) and other relevant literature and species experts (Eadie *et al*. 1995, Neuchterlein 1998, Johnsgard 1987).

As described in Sperduto *et al*. (1999) this information was combined to develop the recovery times listed in Exhibit 4-12. Multiplying the recovery time by the number of individuals affected by the spill provides an estimate of the total direct bird injury. The total direct bird injury for each species group is as follows: marine birds with recovery period greater than one year (4,025 bird-years), marine birds with recovery period equal to one year (606 bird-years), non-water birds (12 bird-years), and pond birds (198 bird-years).

In addition, for marine birds with recovery periods greater than one year (scoters, mergansers, goldeneye, bufflehead, eider, loons, and grebes), the Trustees also estimated the lost bird-years associated with the first generation of fledglings that would have been produced by the birds killed by the spill. Details of this calculation are also provided in Sperduto *et al*. 1999.

Exhibit 4-12

INJURY QUANTIFICATION FOR BIRDS KILLED BY THE *NORTH CAPE* SPILL

Species	Number Collected	Multiplier	Total Kill	Recovery Time (years)	Total Bird-Years Lost
Marine Birds-Long Term Impacts Likely					
Scoters	3	6	18	2.8	111
Mergansers	34	6	204	1.4	337
Goldeneye	32	6	192	1.7	408
Bufflehead	11	6	66	1.4	125
Eider	59	6	354	2.1	853
Common Loons	67	6	402	6.4	3,641
Grebes	38	6	228	1.6	705
Red-Throated Loons	2	6	12	6.4	109
Total	246	6	1476	--	6,289
Marine Birds-Long Term Impacts Unlikely					
Murres	5	6	30	1	30
Dovekie	1	6	6	1	6
Gannet	3	6	18	1	18
Razorbill	2	6	12	1	12
Cormorants	16	6	96	1	96
Gulls	74	6	444	1	444
Total	101	6	606	1	606

Exhibit 4-12 (Continued)

INJURY QUANTIFICATION FOR BIRDS KILLED BY THE *NORTH CAPE* SPILL

Species	Number Collected	Multiplier	Total Kill	Recovery Time (years)	Total Bird-Years Lost
Pond Birds-Long Term Impacts Unlikely					
Black Duck	5	6	30	1	30
Coot	1	6	6	1	6
Mallard	3	6	18	1	18
Pintail	2	6	12	1	12
Ruddy Duck	2	6	12	1	12
Geese	6	6	36	1	36
Swans	4	6	24	1	24
Scaup	4	6	24	1	24
Herons	6	6	36	1	36
Total	33	6	198	--	198
Non-Water Birds	12	1	12	1	12
Grand Total	392	--	2,292		7,105

In the final step of the bird interim loss analysis, lost bird-years in the future are discounted using an annual rate of three percent and summed to develop a present value estimate of lost bird-years. Based on this approach, the Trustees estimate a total bird loss of 7,105 bird-years. Losses are greatest for loons (3,749 bird-years) and eider (853 bird-years).

3. Recovery Time

For the pond birds, non-water birds and a subset of marine birds identified in Exhibit 4-12, available data on fledging rates, growth rates, natural mortality rates, population abundances and similar information suggest that recovery likely will take place within one year. In the best judgment of the Trustees, impacts longer than one year are only likely for the other marine birds identified in Exhibit 4-12 (e.g., scoters, mergansers, goldeneye). The recovery time for these species approximates the expected remaining life of the birds killed by the spill.

4.4.7.3 Waterfowl Habitat Degradation

Assessment of spill impacts on offshore and salt pond communities indicate that waterfowl intertidal habitat was not injured significantly. As previously described, intertidal wetlands were not injured by the spill. Although some waterfowl prey species were injured, there is no indication that these impacts had an appreciable effect on waterfowl food supplies.

4.4.7.4 Tiger Beetle

The Trustees and RP also investigated the potential impact of the *North Cape* oil spill on the roughnecked tiger beetle *Cicindela hirticollis* (Nothnagle 1996). *Cicendela hirticollis* is a small (12-15 mm) predatory beetle that lives in sandy habitats near coastal areas, lakes and rivers. This beetle was of concern to the State Natural Heritage Program because of recent declines in abundance. Populations of this beetle inhabit two areas of Moonstone Beach; one in front of Trustom Pond, and the other in front of Cards Pond. Based on the results of censuses of tiger beetle densities in impact and control areas after the spill (Nothnagle 1996), the Trustees determined that there was no injury to this resource.

4.5 IMPACTS ON HUMAN USE

The following sections describe natural resource damages associated with human-use impacts of the *North Cape* oil spill. These damages include lost consumer surplus experienced by users of resources affected by the spill. Under the provisions of the Oil Pollution Act of 1990, wages and other income lost by private individuals are not included in Trustee claims for damages. These may be the subject of lawsuits brought by the individuals suffering the loss. The Trustees have determined that boat-based recreational angling is the only category of human use for which there was a measurable loss of consumer surplus.

4.5.1 Boat-Based Recreational Angling

Trustee analysis indicates that the *North Cape* oil spill had a direct adverse impact on party and charter boat recreational anglers fishing in and around Block Island Sound. For the period of January 20, 1996 to June 30, 1996 the Trustees estimate spill-related losses of approximately 3,305 party and charter boat angler-trips. Based on a value of $85.23 per party and charter boat angler-trip, and adjusting for time between January 20, 1996 and the date of the study, the Trustees value these losses at $281,685.[6] The data and methodology used to develop this estimate are summarized in the following sections, and described in Curry and Meade (1997).

4.5.1.1 Estimation of Lost Trips

To estimate lost angler-trips, the Trustees interviewed party and charter boat captains in Rhode Island, New York, and Connecticut. Based on these interviews, the Trustees estimate the total number of lost angler-trips attributable to the *North Cape* oil spill. The analysis only considers the *North Cape* oil spill's impacts on party and charter boat recreational anglers. We do not calculate impacts on private boat or shore-based recreational anglers.

[6] 3,305 trips x $85.23 per trip = $281,685.

The Trustee analysis measures oil spill impacts for the period of January 20, 1996 through June 30, 1996. This time frame reflects the following factors:

> ***Fishery Closures.*** As a result of the *North Cape* oil spill, the State of Rhode Island and the National Marine Fisheries Service closed a portion of the commercial fishery in Block Island Sound from January 22 through April 9, 1996. This closure was widely publicized and may have contributed to a perception that the fishery was severely impacted by spill. In addition, party and charter boat anglers typically live at some distance from the area and they may not have direct knowledge regarding the quality of fishing in Block Island Sound subsequent to the oil spill. Since these anglers may perceive long-term fishery impacts, it is reasonable to assume that the effects of the closure extended through June of 1996.
>
> ***Winter/Spring Cod Fishing Season.*** The *North Cape* oil spill primarily impacted Block Island Sound's winter/spring cod fishery. The cod fishing season typically runs from January through late spring. During this period, party and charter boat anglers limit their activity to nearshore waters and the associated winter/spring cod fishery due to weather and sea conditions.

The interviews of party and charter boat captains (respondents) took place over a seven-month period, September 1996 through March 1997. The respondents did not appear to have any difficulty recalling the impact of the spill on their party/charter boat fishing operations, probably due to the uniqueness of the event and the singular importance of the spill's adverse impacts on the party/charter boat businesses in the area.

Respondents were interviewed individually and informed that their identity would be kept confidential. They were also told that any information they provided during the interview would be used only in the Trustee's natural resource damage claim and would not affect any private claims made by third parties (e.g., boat captains and/or owners). Thus, respondents would not realize any personal gain from information conveyed to Trustee experts.

The Trustees requested that respondents take account of the possible effects of weather when providing estimates of the number of lost party/charter boat fishing trips caused by the *North Cape* oil spill. Uniformly, the respondents stated that inclement weather (cold, rain, snow, etc), short of strong winds or fog, does not usually affect their clients decisions on whether or not to take a fishing trip. The fishermen often face cold, inclement weather when fishing for winter cod during the typical winter cod fishing season in Block Island Sound. Most respondents reported that the 1996 winter cod fishing season experienced normal weather conditions and each one indicated that their estimates of lost fishing trips caused by the oil spill did not include any weather-related lost trips.

Finally, respondents also were asked about substitute fisheries/locations for fishermen who canceled trips to Block Island Sound for winter cod fishing due to the *North Cape* spill. Their responses indicated that only party/charter boats located in RI and Long Island ports provide party/charter services for the Block Island Sound winter cod fishery. Furthermore, the respondents stated that their clients are dedicated winter cod fishermen who do not have an alternative/substitute fishery to turn to when Block Island Sound winter cod fishing is adversely affected by an event such as the *North Cape* oil spill.

Based on the consistency of responses obtained from interviews with different party/charter boat operators and the fact that their responses would not affect any private claims, the Trustees believe that the estimates of the number of lost trips provided by each party/charter boat operator are accurate and unbiased.

Party Boats

To assess the impact of the *North Cape* oil spill on party boat anglers, the Trustees contacted six of the seven captains or owners of party boats from New York or Rhode Island operating in Block Island Sound.[7] Through these interviews, the Trustees identified three spill-impacted party boats in Rhode Island and two in New York. For each boat, the Trustees collected information on dates of operation, vessel capacity and the number of lost vessel-trips. The Trustees also asked each captain to estimate the average number of anglers per vessel-trip. Based on this information, the Trustees estimate that Block Island Sound party boat anglers lost a total of 2,225 angler-trips between January 20 and June 30, 1996 because of the *North Cape* oil spill, as shown in Exhibit 4-13.

Exhibit 4-13

PARTY BOAT IMPACTS
LOST ANGLER-TRIPS DUE TO THE *NORTH CAPE* OIL SPILL

State	Party Boat	Impact Dates	Lost Vessel-Trips Per Vessel	Average Anglers Per Trip	Lost Angler-Trips
Rhode Island	1	January - June	16	25	400
	2	January - June	20	45	900
	3	April - June	8	25	200
New York	1	January - June	15	45	675
	2	January - June	5	10	50
TOTAL	5	January - June			2,225

Charter Boats

To assess the impact of the *North Cape* oil spill on charter boat anglers, the Trustees contacted a sample of charter boat captains operating in Block Island Sound. Through these interviews, the Trustees identified 15 to 20 spill-impacted charter boats in Rhode Island and 12 to 15 in New York. In addition to identifying specific impacted boats, information obtained during the interviews indicates that the vessel capacity, dates of operation, and fishing destination of

[7] The Trustees were unable to reach the seventh New York/Rhode Island captain. The Trustees also contacted captains in Connecticut, but these individuals fish primarily in Long Island Sound and therefore did not report any spill-related impacts. Based upon discussions with RI operators, Massachusetts-based boats were assumed not to operate in Block Island Sound.

charter boats fishing for Winter/Spring cod are relatively similar throughout Block Island Sound. The Trustees used this information to develop a standard charter boat profile to estimate lost angler-trips, which was applied to all charter boats impacted by the oil spill. Exhibit 4-14 summarizes the lost trip calculations for charter boats. Based on this information, the Trustees conclude that Block Island Sound charter boat anglers lost a total of 1,080 angler-trips between March 15 and June 30, 1996 as a result of the *North Cape* oil spill.

Exhibit 4-14

CHARTER BOAT IMPACTS
LOST ANGLER-TRIPS DUE TO THE *NORTH CAPE* OIL SPILL

State	Number of Impacted Charter Boats	Lost Vessel-Trips Per Vessel	Average Anglers Per Trip	Lost Angler-Trips
Rhode Island	15	8	5	600
New York	12	8	5	480
TOTAL	27	8	5	1,080

The Trustees found no evidence that anglers employing two other popular recreational fishing modes common to Block Island Sound, fishing from shore and from private boats, were adversely affected by the *North Cape* oil spill. Because of the cold weather and seasonal absence of many of the most sought-after sport fish species, few private boat and shore-based angler trips are taken during a typical winter and early spring in Block Island Sound. By mid-April, all areas closed to commercial fishing and most of the areas closed to shellfishing were reopened. This coincides with the beginning of the early private boat and shore-based recreational fishing season in the area, so few if any such trips were likely affected by the spill and associated closures. Nonetheless, it is possible that some private boat and shore-based anglers avoided taking trips to Block Island Sound for a period of time in the spring/summer of 1996 because of the possible perception that recreational fishing there had suffered a reduction in quality. However, lacking evidence to the contrary, the Trustees assume that private boat and shore-based recreational fishermen were not adversely affected by the *North Cape* oil spill.

4.5.1.2 Valuation of Lost Trips

The Trustees use the benefits transfer method to quantify the per-occasion value of party and charter boat angler-trips in Block Island Sound. To identify angler-trip values relevant to the Block Island Sound fishing experience, the Trustees reviewed more than 100 recreational value economic research papers and reports. Based on this review, the Trustees estimate a mean annual willingness to pay per angler-trip of $58.52 in 1988 dollars as reported in McConnell and Strand (1994). For the purposes of this analysis, the Trustees use the equivalent 1999 value of $85.23.

Several per angler-trip values are provided in McConnell and Strand (1994), representing different types of fisheries in each Mid-Atlantic and Southeastern coastal state in the U.S. and alternative methods for estimating angler-trip values. The Trustees chose the $58.52 per angler-trip value ($85.23 in 1999 dollars) from McConnell and Strand (1994) because the type of fishing and the geographical location of the fishing activities from which that value was derived most closely matches the winter cod fishery in Block Island Sound. The $58.52 figure was based on New York State recreational fishermen, some of whom were party/chart boat fishermen in Long Island Sound (which is adjacent to Block Island Sound). Furthermore, the economic methodology used to estimate that value, the random utility model/travel cost method, is a well-accepted, frequently-used approach for estimating the value of outdoor recreational activities, such as sport fishing, hunting, wildlife viewing, etc.

The value of party and charter boat anglers' lost interim use resulting from the *North Cape* oil spill is calculated in Exhibit 4-15. The Trustees quantify this loss by multiplying the number of lost angler-trips by an $85.23 per trip value, which is the $58.52 figure inflated to 1999.[8] Therefore, based on 3,305 lost trips and a value of $85.23 per trip, the Trustees calculate that the *North Cape* oil spill is responsible for $281,685 in lost use value to Block Island Sound party and charter boat anglers for the period January 20 through June 30, 1996.

Exhibit 4-15

TOTAL INTERIM LOST USE VALUE
BLOCK ISLAND SOUND PARTY AND CHARTER BOAT ANGLERS

State	Party/Charter Angler-Trips Lost Due to the *North Cape* Oil Spill	Value Per Angler-Trip	Interim Lost Use Value Due to the *North Cape* Oil Spill
Rhode Island	2,100	$85.23	$178,983
New York	1,205	$85.23	$102,702
TOTAL	3,305	$85.23	$281,685

4.5.2 Recreational Diving

Rhode Island contains a large number of popular dive sites, including wrecks and rock formations. The shallow depths of many sites, relatively warm water temperature and convenience combine to make Rhode Island an attractive dive destination. Primary users of the resource reside in Rhode Island, Massachusetts, Connecticut and New York. As a result of the *North Cape* spill, recreational divers may have reduced the number of dives taken in Rhode Island and/or experienced a reduction in dive quality.

To determine if the *North Cape* oil spill adversely affected service flows to recreational divers, the Trustees explored two primary sources of information. First, the Trustees interviewed divers, dive shop owners and dive boat captains. Second, the Trustees contacted industry trade organizations and regional equipment dealers. The Trustees contacted these two groups to evaluate responses from direct users of the resource as well as evaluate aggregate diving trends across New England.

[8] We adjust values to 1998 dollars using the Consumer Price Index in the *Economic Report of the President*, February 1998 and assume a three percent inflation rate for 1999.

The interviews were designed to collect information on the characteristics of Rhode Island diving, diver preferences, and diver reaction to the spill. Between October 24 and December 6, 1996, the Trustees conducted a total of 18 in-person and telephone interviews, each of which lasted approximately 45 minutes to one hour. Exhibit 4-16 lists the number of individuals interviewed by group and state of residence. The results of these interviews, summarized below, are described in more detail in a separate report (Curry 1997).

Exhibit 4-16

RECREATIONAL DIVING INTERVIEW PARTICIPANTS

Group	Number of Interviews	States of Residence
Divers	8	Rhode Island -- 2 Connecticut -- 2 Massachusetts -- 3 New York -- 1
Dive Shop Owners	6	Rhode Island -- 6
Dive Boat Captains	4	Rhode Island -- 3 Massachusetts -- 1

The majority of divers interviewed did not believe the oil spill affected their decision to dive in Rhode Island. Some evidence, however, does suggest that the *North Cape* oil spill had the potential to reduce the number of dive trips taken in Rhode Island during 1996. These impacts are associated with a small minority of divers that either canceled planned January trips or avoided the spill area later in the year because of a perception of substandard conditions. Available evidence from the interviews suggests that the oil spill did not actually reduce dive quality.

The available data are not sufficient to quantify the number of trips that may have been lost as a result of the spill. In addition, there are no other easily accessible data sources that would significantly improve the Trustee's ability to estimate potential spill-related losses to recreational divers. Further, developing reliable estimates of trip reductions and then apportioning those reductions to the *North Cape* spill would require research funds that could exceed the value of the potential lost trips. The Trustees conclude that it would not be cost-effective to pursue additional quantification of recreational diving losses resulting from the *North Cape* oil spill.

4.5.3 Beach Use

Charlestown, East Matunuck, Roger Wheeler, Salty Brine and South Kingstown public beaches all lie within the immediate area of the spill (see Exhibit 4-17). RIDEM surveys conducted in January, February and April 1996 detected oil from the *North Cape* spill on these five beaches (Mulhare and Therrien 1996). Although it is likely that all physical traces of oil were gone by the beginning of the beachgoing season in mid-May, some members of the public may have canceled trips to these beaches or visited other areas because of uncertainty about spill impacts or adverse perceptions about beach quality.

To evaluate this potential injury, the Trustees compared attendance at the five assessment beaches to both in-state and out-of-state controls. Oil from the spill did not reach Misquamicut, Scarborough South, Scarborough North or Fort Adams beaches in Rhode Island. The Trustees refer to these four beaches as Rhode Island control beaches. The Trustees also compare attendance records from the assessment beaches to two northern Connecticut state beaches (Rocky Neck and Hammonasset) and two southern Massachusetts state beaches (Horseneck and Demarest Lloyd).

Comparison of data from the summer of 1996 with data from the summer of 1995 does not suggest a decline in beach attendance due to the effects of the *North Cape* spill in January 1996. Although attendance decreased on many beaches oiled by the spill in 1996, attendance decreased by an equal or greater amount on Rhode Island beaches that were not oiled and on nearby beaches in Connecticut and Massachusetts. Combined attendance at all assessment beaches dropped 7.3 percent from 1995 to 1996, compared to a 12.8 percent decrease at Rhode Island controls and a 8.3 percent decrease at out-of-state controls.

To further evaluate the general, area-wide decrease in attendance at control and assessment beaches, the Trustees compare attendance to temperature and precipitation patterns. While water temperature, vacation scheduling and other factors also will influence beach attendance, weather is an important parameter that may partly explain area-wide attendance trends. Weather data indicate a 2.5 °F decrease in average maximum daily temperature from the summer of 1995 to the summer of 1996 (Lookingbill *et al*. 1996). Also, the number of days without precipitation between 10:00 a.m. and 6:00 p.m. decreased from 86 over the summer of 1995 to 79 over the summer of 1996 (Lookingbill *et al*. 1996). The cooler, rainier weather during 1996 helps explain the observed, region-wide decreases in 1996 beach attendance.

Based on these data, the Trustees conclude that the *North Cape* oil spill did not adversely affect beach attendance during the summer of 1996. These results are described in more detail in a separate report (Lookingbill *et al*. 1996).

4.5.4 Refuge Visitation

The Ninigret National Wildlife Refuge Complex contains six separate refuges: Ninigret NWR, Block Island NWR, Pettaquamscutt Cove NWR, Sachuest Point NWR, Stewart B. McKinney NWR, and Trustom Pond NWR. Portions of the Trustom Pond NWR were oiled during the *North Cape* spill. In addition to the ecological injuries described in other sections of this chapter, public visitation to the refuge might have been adversely affected by the spill.

In an October 15, 1996 telephone interview, the Ninigret Complex staffer who compiles visitation data indicated that there have been no reported cancellations of group visits to the refuge complex attributable to the oil spill (Charbonneau 1997).

Exhibit 4-17

Analysis of historical and reference area data from fiscal years 1994 through 1996 support the finding that visitation to the Trustom Pond NWR was not affected by the oil spill.[9] In fiscal year 1995, visitation at the Ninigret Complex as a whole and Trustom Pond NWR in particular decreased substantially from fiscal year 1994 levels. In fiscal year 1996 (which includes the spill), there was a resurgence in visitation to a level below the fiscal year 1994 level but well above the fiscal year 1995 level.

Based on these data, the Trustees conclude that the *North Cape* oil spill did not adversely affect Trustom Pond NWR visitation. These results are described in more detail in a separate report (Charbonneau 1997).

[9] Visitation data for the Ninigret complex are available on a fiscal year basis. The USFWS fiscal year runs from October 1 through September 30 of the following calendar year. For example, fiscal year 1996 begins October 1, 1995 and ends September 30, 1996.

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