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

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

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

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

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

Cost

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

Environmental Consequences

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

Criteria Evaluation

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

2. Habitat Acquisition (Not proposed)

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

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

Cost

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

Environmental Consequences

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

Criteria Evaluation

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

3. No Action (Not proposed)

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

Cost

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

Environmental Consequences/Criteria Evaluation

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

4. Summary

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

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

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

IV. BUDGET SUMMARY

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

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

V. FIGURES

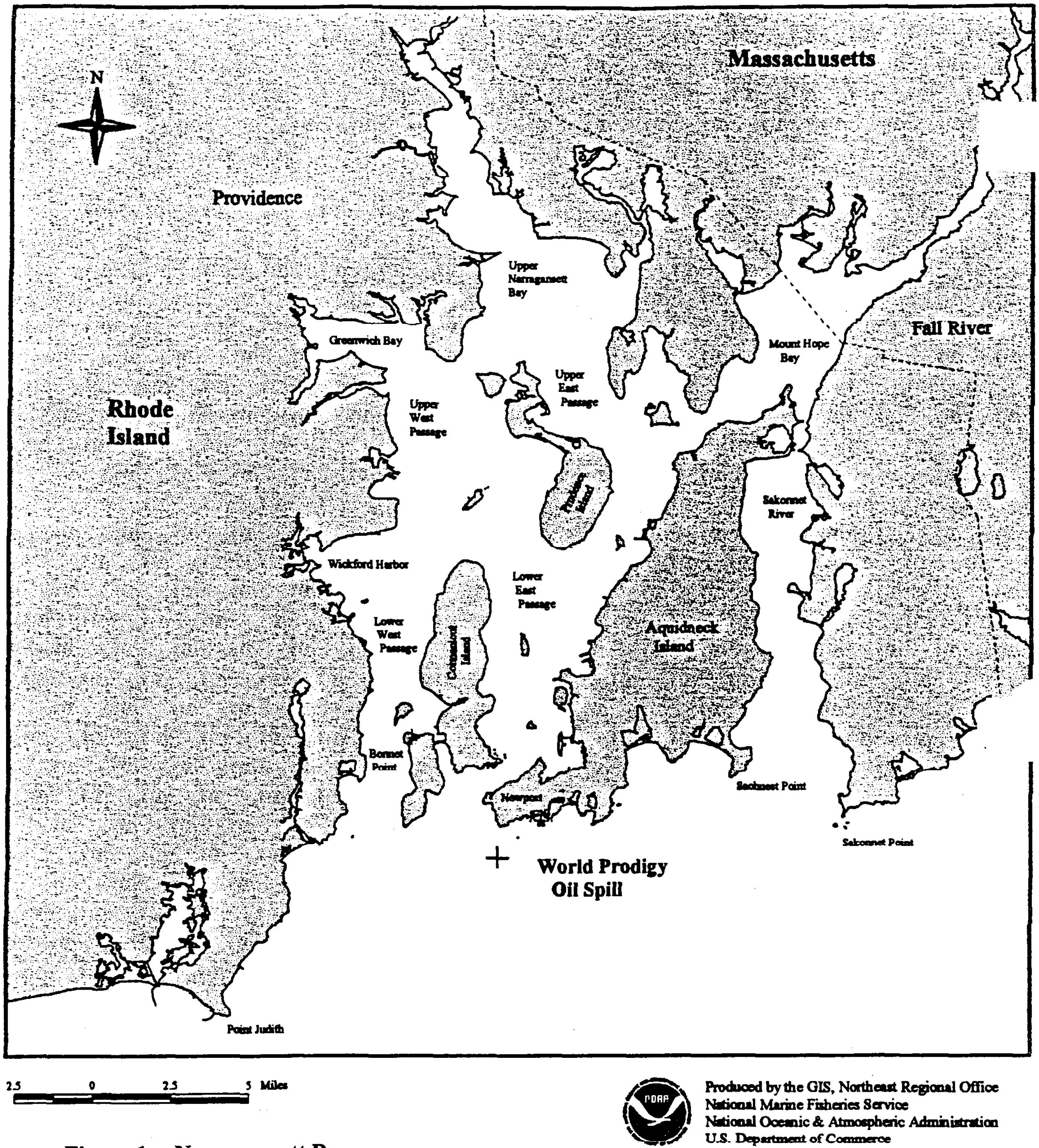


Figure 1 – Narragansett Bay

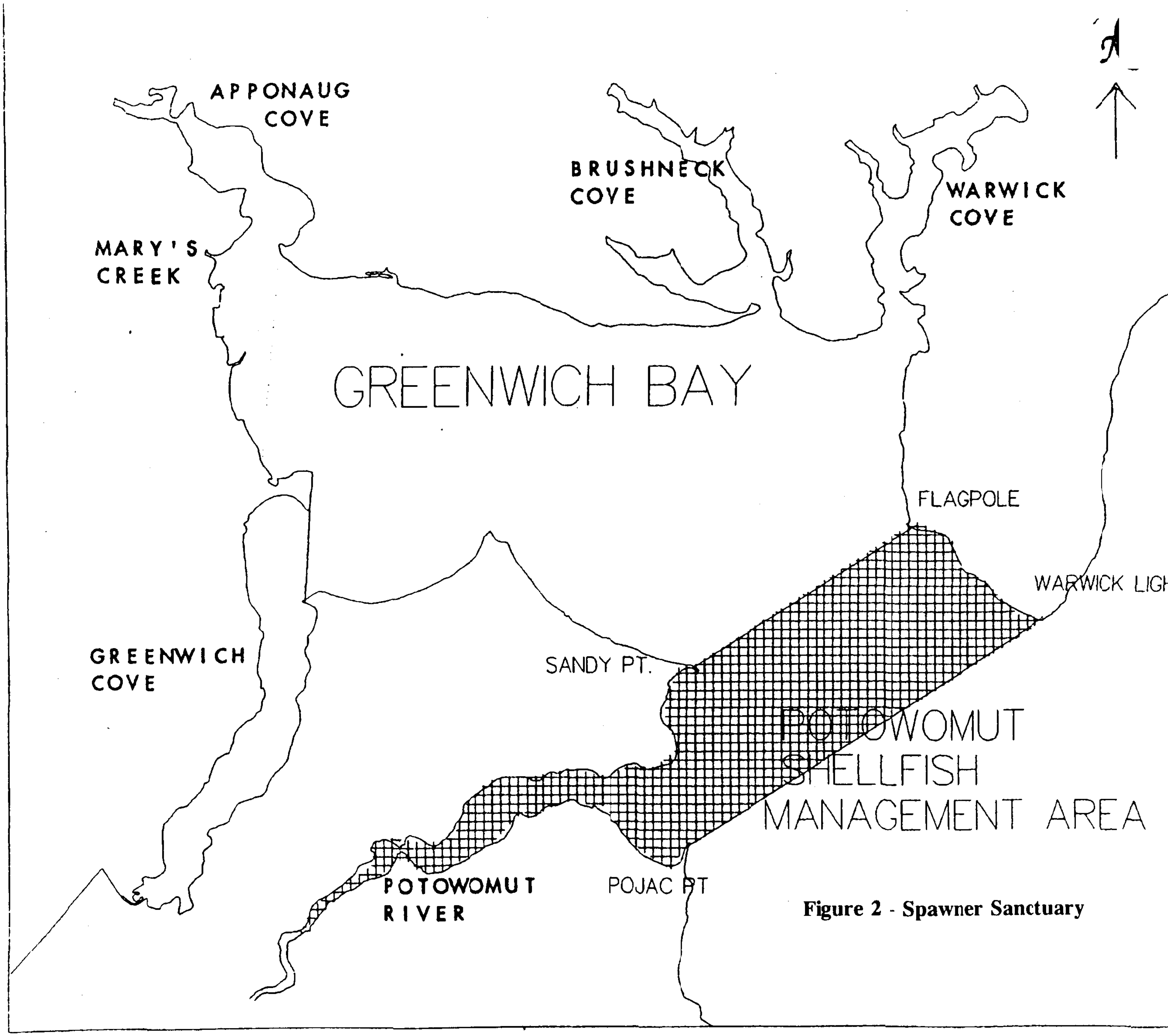


Figure 2 - Spawner Sanctuary

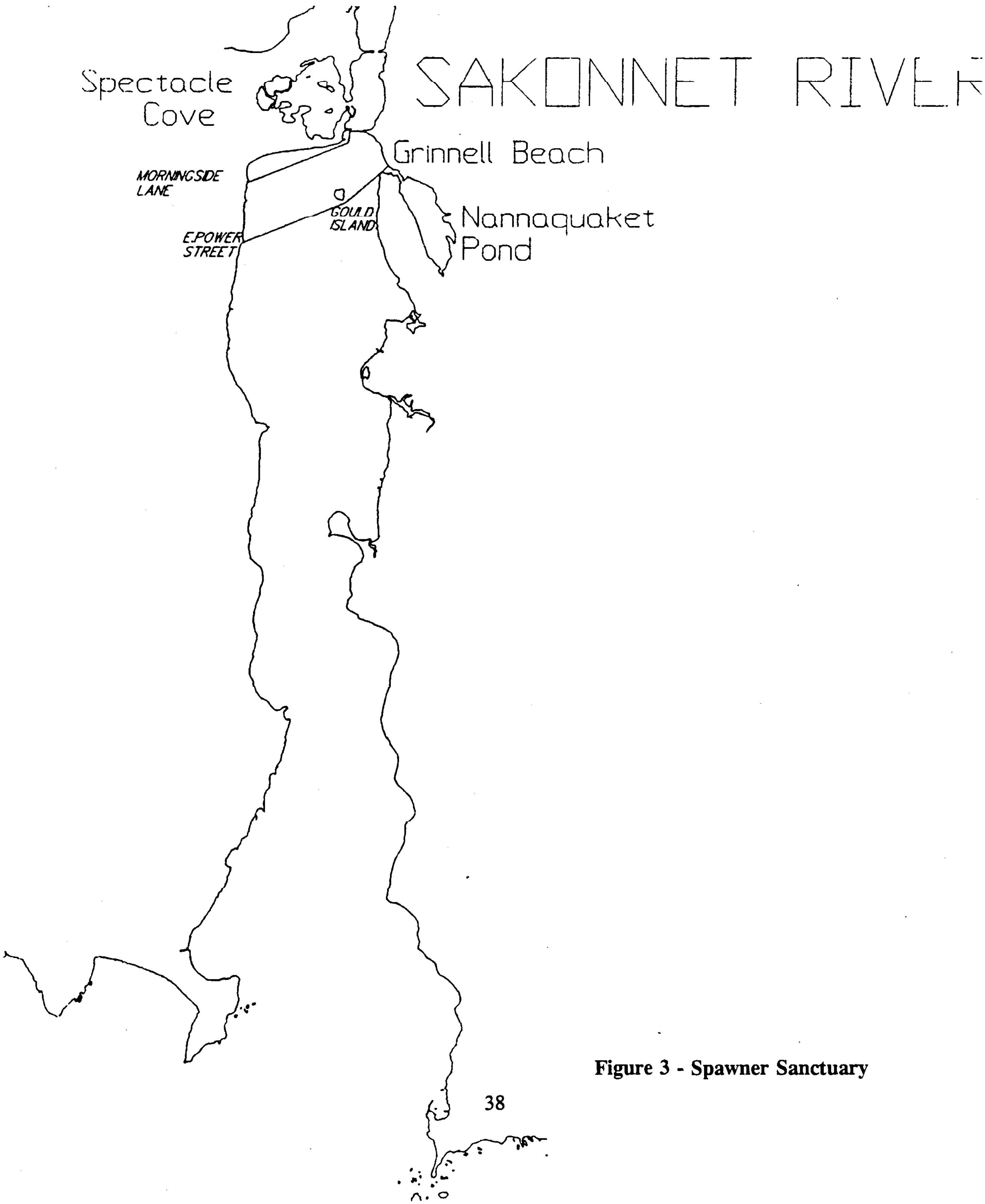


Figure 3 - Spawner Sanctuary

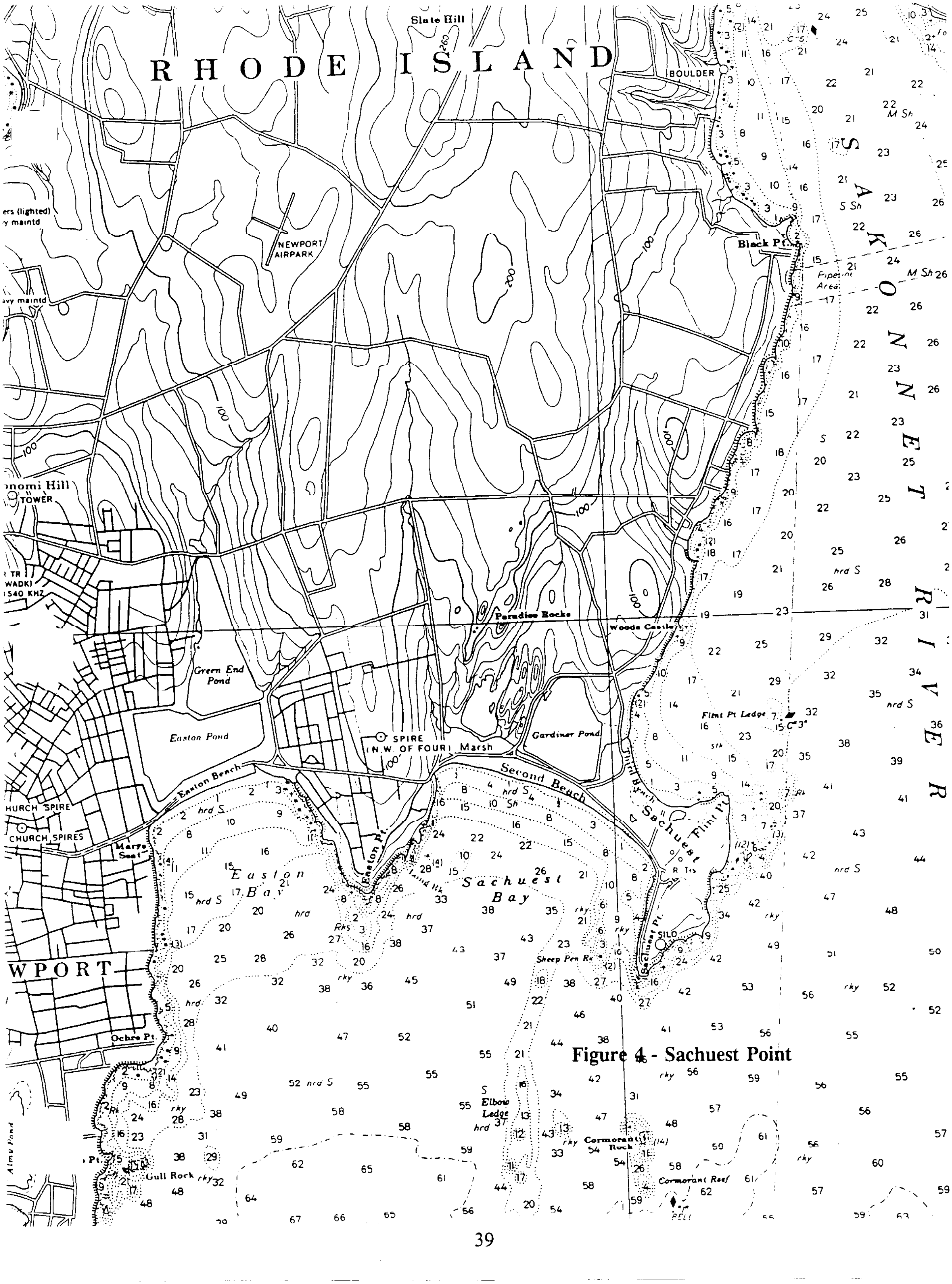
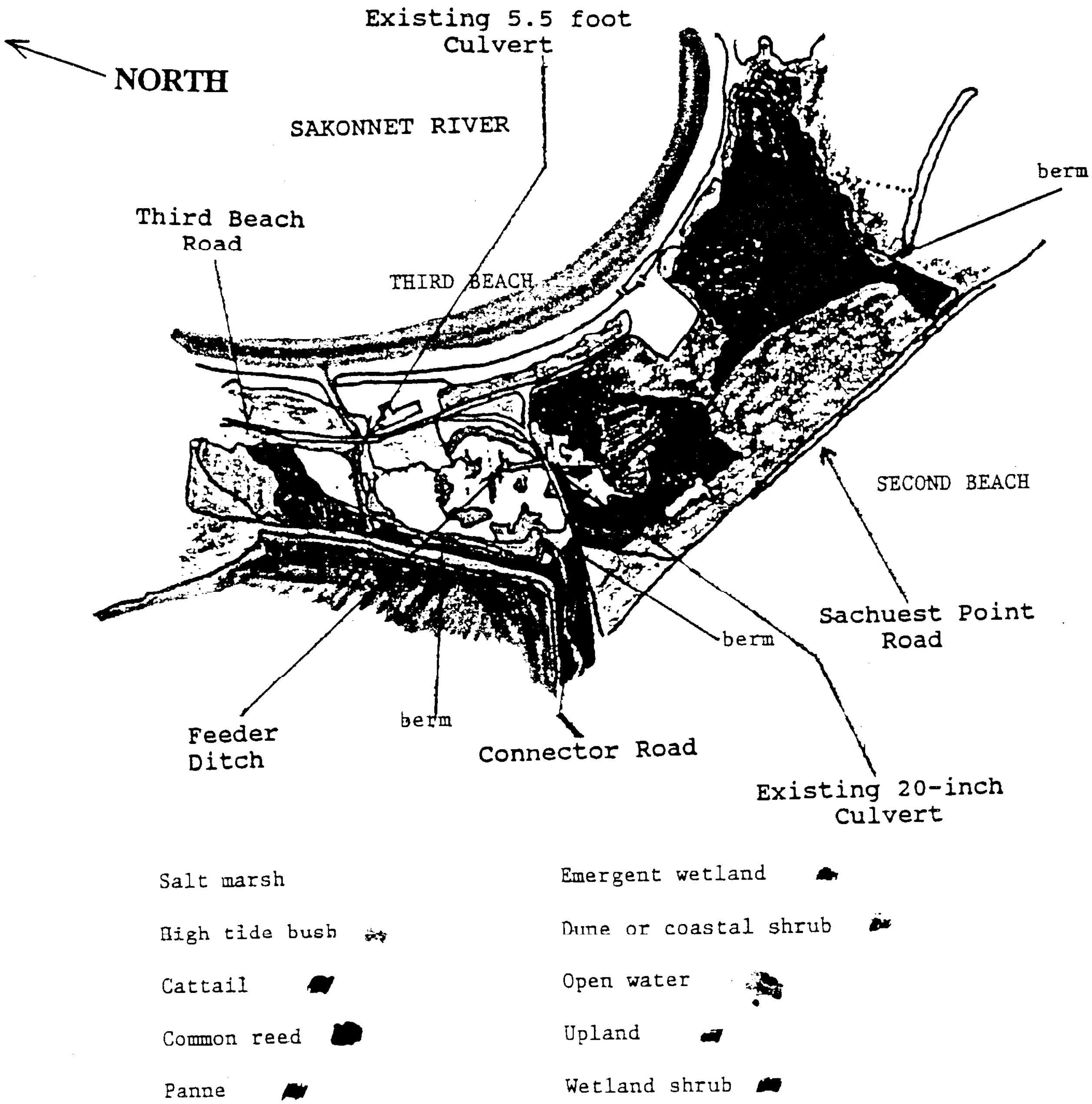


Figure 4 - Sachuest Point

SACHUEST POINT WETLAND



Approx. Scale 1"=800'

FIGURE 5