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Identification of Important Casco Bay Fish and Wildlife Habitats at Risk from Future Development

Arnold Banner
United States Fish and Wildlife Service

Melissa Gromley
Casco Bay Estuary Project

IDENTIFICATION OF IMPORTANT HABITATS IN THE LOWER CASCO BAY WATERSHED

Arnold Banner and Jon Libby

U.S. Fish and Wildlife Service
Gulf of Maine Project

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Casco Bay Estuary Project
312 Canco Road, Portland, Maine 04103
(207)-828-1043

Abstract

The U.S. Fish and Wildlife Service Gulf of Maine Project has identified important habitats for a variety of plants, invertebrates, fishes and birds, in the lower Casco Bay watershed of Southern Maine. Habitat identification was based on species occurrences and also was projected from environmental parameters favorable to those species, such as suitable vegetation, water depth, or presence of food resources. Numerical scores were assigned to each habitat, reflecting level of use and apparent environmental quality for the evaluation species. Scores were adjusted according to the relative abundance of each habitat within the study area, and the relative ranking of the evaluation species on the Gulf of Maine Council regional listing. Habitat maps for the individual species were aggregated into a final map highlighting areas important to numbers of species. This information will be used in an analysis of threats to important habitats from development activities, performed in cooperation with the Casco Bay Estuary Project.

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Introduction

As with most areas of the country, the Casco Bay watershed faces the prospect of decline in natural resources with increased development. Residential and commercial development of natural areas may simply replace important fish and wildlife habitats. Land use change may also degrade habitats by affecting water quality, fragmenting a landscape, or disturbing wildlife by introduction of domestic animals and increased human activities. It is possible to reduce the extent of these losses by conservation efforts directed at important habitats remaining in the watershed. We see two components for the success of such initiatives: enthusiasm and support for conservation measures, and a clear depiction of important habitats in the area. This report focusses on the latter aspect, offering maps of known and likely habitats for an assortment of species and species groups significant in the Gulf of Maine, and particularly in Casco Bay. The final chapter lists funding opportunities which local conservation interests may use to protect habitats.

The important habitats identified by this analysis will be incorporated into another analysis which will identify natural resources at risk from future development. This will rely on a build-out analysis, estimating the extent to which development may occur in Casco Bay area under present zoning, wetland regulation, and land ownership patterns. This analysis will be the subject of a second report, also by the U.S. Fish and Wildlife Service (FWS), and by the Casco Bay Estuary Project (CBEP). Digital products from the analyses will be available through the CBEP, and also from the FWS Gulf of Maine Project.

Organization of this Report:
The first Chapter of this report summarizes the purpose, materials and methods, and the findings of the biological investigations. Subsequent chapters provide detailed accounts of the individual themes, and explain the basis for the habitat maps.

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Maine Office of GIS, Augusta ME (digital coverages of roads, streams, lakes, coast)
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Chapter 1. Summary of the Analysis

Study Area and Themes Portrayed:
The evaluation species and the extent of the study area were determined cooperatively with the CBEP. Based on the intensity of development and the coastal focus of CBEP, the study area included the lower or coastal 15 towns of the watershed (Brunswick, Cape Elizabeth, Cumberland, Falmouth, Freeport, Harpswell, North Yarmouth, Phippsburg, Portland, Long Island, Pownal, South Portland, West Bath, Westbrook, and Yarmouth). To insure that habitats near the outer boundaries of these towns were adequately assessed, we appended a one mile wide strip of neighboring land and water to the study area (Appendix A: Figure 1).

In accordance with the focus of the National Estuary Program, evaluation species were those predominantly associated with wetland and coastal features. The FWS has particular interest in migratory wildlife, wetlands, anadromous fishes, and endangered species. The species for which habitats were identified included saltmarsh cordgrass, eelgrass, shellfish, commercially important marine worms, resident and migratory fishes, endangered species, waterbirds, seabirds and wading birds. Their selection was also based upon institutional, commercial and ecological importance (as evidenced by rank on the Gulf of Maine Council's Ranked List of Evaluation Species, Appendix B). We also required that sufficient data be available to insure that habitat maps could be produced and satisfy scrutiny of technical reviewers. Some species of high local interest, such as harbor seal, various marine fishes and American lobster were not selected either because they were not on the GOMC list, because of limited distributional information, or because they would not be sensitive to the development impacts being examined. In contrast, several of the avian evaluation species are at a high trophic level, thus relatively sensitive to perturbation and likely to be exposed to disturbance from development activities.

General Methods For Habitat Characterization and Scoring:
The analysis was conducted by use of a Geographic Information System. We identified important habitats in Casco Bay according to the aggregate of their values for each of the evaluation species. This was accomplished by creating gridcell maps of the study area in which each cell was evaluated and assigned a numerical score as habitat for each of the species, then combining the scores for each species by map overlay techniques. These scores were adjusted for relative scarcity of habitats and for the species' rank on the Gulf of Maine Council's list. The final map scores were the products of the scores for habitat quality, habitat abundance, and species rating (see Table 1).

Information on habitat distribution and value for the selected species were derived from agency reports and digital coverages, where available; otherwise this information was developed as part of our analysis. First we created species profiles or habitat suitability models, reflecting habitat needs and tolerances. These models were entered into the

GIS, and operated on digital environmental information to yield maps showing where suitable combinations of conditions occur within the species' range. Our data sources included scientific literature, advice from species experts, occurrence records (from surveys, collections, or incidental observations), and base maps of environmental information. We thus expanded upon the occurrence information to depict probable habitats, such as feeding areas for wading birds. Where information was less complete we used occurrence records (e.g., bald eagle nest sites) to depict habitat components We also incorporated state designated significant habitats where this information was available, and gave these areas relatively higher habitat scores. These included Moderate and High Value Wetlands (MHVW), draft Maine Natural Resource Protection Act (NRPA) seabird islands, and MDIF&W Essential Habitats..

Sensitivity Zones:
One of our objectives was to identify buffer or sensitivity zones in which development activities (human occupation, domestic animals, vehicular traffic) would likely affect the value of neighboring habitats. For each species, the extents of these sensitivity zones were based on disturbance distances derived from 1) technical literature, 2) analyses we conducted (identifying the observed minimum distance between developed land and occupied habitat), 3) expert observation, and 4) agency rules. Distances depended on habitat function (e.g., reproduction, foraging) and quality (greater distance for highest habitat quality). Sensitivity zone distances were used to assess impacts from existing development, and will be used to estimate potential impact from the buildout analysis.

Assigning of Habitat Scores:
The habitat scoring for each evaluation species was similar to the process used in the FWS Habitat Evaluation Procedures (1980). One or more habitat components were identified, based on biological function (reproduction, foraging). Suitability of these components was assessed according to the presence, absence, or level of relevant environmental factors (for example, vegetation type, depth, substrate). Habitat suitability was numerically scored or indexed on a fixed scale. We gave the top quality habitats (or habitat components), based on the occurrence of optimal conditions or highest actual level of use, a score of 8; average quality habitats (intermediate habitat conditions, probably or potentially used) were scored 4, and non-habitats scored 0.

Adjustments to Habitats Scores:
1) Just as sensitivity zones were extended around habitats, so impact zones were extended out corresponding distances from existing development. Developed areas (land surface dominated by paved surfaces or buildings) themselves were regarded as having no habitat value for the evaluation species. Habitat scores within the relevant impact zones were reduced by half, based on infringement by development and associated activities.

2) We indexed the habitat scores for the species according to their ratings on the Gulf of Maine Council's list (see Table 1). The evaluation species all are prominent in regard

to the institutional, socio-economic, and ecological factors considered in that list, and so rated between 5.1 and 7.2 on a scale of 0 to 8.

3) Scores were reapportioned to increase values for relatively scarce habitats, and correspondingly decrease values of habitats which were more abundant in the study area. Thus shorebird habitat was accorded higher value per unit area than the more abundant waterbird habitat of the same quality. In the same way multiple component habitats (for instance, nesting and foraging components for wading birds, seabirds, or roseate terns) were further apportioned relative to a hypothetical 50 - 50 division. While we lacked information on the biologically appropriate amount of each component, it seemed reasonable that the relative importance of the components would be related to their abundance. For example, loss of 1 out of 1000 acres of feeding area would probably be far less damaging than loss of 1 acre out of 5 acres of nesting colony. Accordingly, we raised the relative scores of the habitat components in limited supply and reduced the scores of the abundant components. Habitats were indexed inversely to the most abundant type, on a 0.8 - 8 scale (Table 1).

Aggregation of Scores:
The final habitat map was created by multiplying the habitat quality, species rating, and habitat abundance scores for each species, then adding these products. Draft species/habitat profiles and habitat maps were sent to species experts for technical review. Intermediate and final maps were displayed and discussed at two technical workshops. Comments and advice have been incorporated in the final analysis.

Intermediate Products: Environmental Data Layers

Following are summaries of the major environmental data layers acquired or developed for use with models to characterize the habitats of the evaluation species.

Casco Bay Wetlands:
Since most of the evaluation species are closely associated with wetland or open water habitats, we relied on wetland maps as a primary basis for characterizing their habitats. Wetlands are generally significant for a number of environmental functions (Chapter 2). Our main source of wetland locations and types was National Wetland Inventory (NWI) digital maps. We made corrections to several polygons which originally were estuarine but, due to impoundment, are now freshwater marsh, then combined data from the 18 7.5- minute quadrangles into a single coverage.

CBEP requested that the 26 NWI classes be simplified for display purposes. We also added an attribute giving the size of aggregations of adjacent freshwater wetlands (for regulatory screening purposes). Other attributes specify wetland type and size of each polygon. The combined NWI coverage is depicted in Appendix A: Figure 2. Further explanation is given in Chapter 3.

Table 1. Calculations to Combine Habitat Scores for the Evaluation Species

STEPS:

1) Habitat Qualtity Rating: assign values according to environmental conditions, needs of each species and observed levels of use (see relevant Chapters by species)

Scores: 0 - 8

2) Gulf of Maine Council Rating: value habitats according to their use for constituent species; these evaluation species were selected and scored according to criteria based on economic, environmental, and institutional factors (Appendix B)

Evaluation Species	Species Rating	Species Rating Scores* (values indexed on 0-8 scale)
eelgrass	59	7.2
shellfish (average of scores, 4 spp.)	59	7.2
cordgrass	57	6.9
eagle	54	6.5
roseate tern	53	6.4
seabirds (average of scores, 2 spp.)	52	6.3
shorebirds (average of scores, 2 spp.)	52	6.3
waterbirds (average of scores, 3 spp.)	50	6.1
marine worms (average of scores, 2 spp.)	50	6.1
fishes (average of scores, 9 spp.)	46	5.6
wading birds (great blue heron)	42	5.1

**indexed to the highest rating on the list (66) made = 8.0*

3) Abundance / Scarcity Rating: value habitats or habitat components inversely to their abundance

Habitat / Component	Habitat Area (in 30 m sq cells)	Relative Abundance Value** (apportioned by component)	Abundance Scores*** (values indexed on 0.5-8 scale)
eelgrass	35509	6.3	1.7
shellfish beds	99874	2.2	1.3
cordgrass	15281	14.6	2.2
eagle nest areas	163	1368.6	8.0
roseate tern nesting	118	945.2	7.2
roseate tern foraging	23359	4.8	1.6
seabird nesting	1760	63.4	3.3
seabird foraging	129294	0.9	1.0
shorebird nesting	976	114.3	3.9
shorebird foraging	5989	18.6	2.3
waterbirds	223078	1.0	1.0
marine worms	25991	8.6	1.9
freshwater and anadromous fishes	60127	3.7	1.5
wading bird nesting	856	130.3	4.1
wading bird foraging	175486	0.6	0.9

*** Relative Abundance Value = no. cells in most abundant habitat / (no. of components x no. of cells in a particular habitat component)*

**** Abundance Score = Relative Abundance Value ^.2875*

4) Combining Ratings: Habitat Abundance x Gulf of Maine Council Rating x Habitat Quality

Potential Scores per Species: (8 x 8 x 8) = 1 to 512

Actual Scores: 1 to 429

5) Combining Scores for Final Map: for each grid cell sum scores for all species from step (4)

Landcover of Casco Bay:
Upland areas also are used as wildlife habitats, or affect the use or quality of the adjacent wetlands for fish and wildlife. We required maps of landcover for the habitat analysis, and also for estimating effects from future development. The information was developed from a June 6, 1991, Landsat scene, classified by Earthsat Corp. and by Jed Wright (FWS). We compared and corrected the classification by relating output to aerial photos and previous photo-interpreted landcovers of the area. Details are given in Chapter 4. Landcover is displayed in Appendix A: Figure 3.

Coastal Marine Geologic Environments:
In 1976, Maine Geological Survey published a series of 7.5 minute quadrangles of coastal features titled "Coastal Marine Geologic Environments" (CMGE). Features of supratidal, intertidal and subtidal environments were mapped, and classified by substrate type, salinity, vegetative or animal cover, or hydrodynamics. While some of the more dynamic features have probably changed since that interpretation, the information complements NWI data and is useful for assessing habitat suitability for marine and shoreline dependent wildlife. We used digital versions of CMGE for habitat and landcover interpretation.

Bathymetry:
Water depth is an important habitat parameter for wildlife using coastal resources. We obtained draft 10 m contours of Casco Bay from MGS, then digitized a 6 ft (1.8 m) mean low water (mlw) contour from NOAA charts 13290 and 13293 (Casco Bay and Sheepscot Bay, respectively). Mean low water itself was mapped by selecting the outer boundary of intertidal habitats from NWI or CMGE, whichever was more extensive. This GIS line coverage was converted into a lattice (grid coverage) in ARCINFO. The grid had 30 m sq cells to match the units of the Landsat data. Depth values were integers, ranging from +3 m (approximately mean high water) down to -60 m mlw. Unless otherwise indicated, depths in this report are referred to mlw.

Intermediate Products: Habitat maps for the Evaluation Species

Following are summaries of the information used in mapping habitats for the evaluation species; detailed descriptions are given in subsequent chapters. All of the species named below are on the Gulf of Maine Council list; certain species groups (fishes, seabirds, wading birds) included other taxonomically related species or species with similar habitat requirements.

Eelgrass: (treated here as an evaluation species; eelgrass is also a habitat element for other species). Chapter 5; Appendix A: Figure 4.

HABITAT LOCATIONS, TYPES: actual eelgrass distribution
DATA SOURCES: digital data as mapped by Seth Barker, DMR

SCORING: 2 to 8 based on bed density classes
SENSITIVITY ZONE: none

Cordgrass: (treated here as an evaluation species; cordgrass is also a habitat element for other species). Chapter 5; Appendix A: Figure 5.

HABITAT LOCATIONS, TYPES: estuarine emergent vegetated areas
DATA SOURCES: NWI; some editing required
SCORING: No density information available, therefore all sites were scored 4
SENSITIVITY DISTANCE: none

Shellfish: (softshell clam, blue mussel, northern quahog, sea scallop; also a habitat element for other species). Chapter 6; Appendix A: Figure 6.

HABITAT LOCATIONS, TYPES: Beds mapped by species
DATA SOURCES: digital data from Seth Barker, DMR
SCORING: No density information, all sites were scored 4
SENSITIVITY ZONE: none

Marine Worms: (bloodworms and sandworms). Chapter 6; Appendix A: Figure 7.

HABITAT LOCATIONS, TYPES: Beds mapped, but not by species
DATA SOURCES: digital data from Seth Barker, DMR
SCORING: No density information, all sites were scored 4
SENSITIVITY ZONE: none

Waterbirds: (common loon, black duck, Canada goose). Chapter 7; Appendix A: Figure 8.

HABITAT LOCATIONS, TYPES: coastal; loon, black duck, Canada goose winter feeding areas, resting areas. Interior; black duck, Canada goose foraging; black duck post-fledging, brood-rearing.
DATA SOURCES: Maine Audubon Society database, MDIF&W's Coastal Wildlife Concentration Areas (CWCA), eelgrass coverage, bathymetry, MHVW, NWI, shellfish coverage.
SCORING:

Loon: CWCA polygon used by 1% or more of the observed loons and < 6 m deep, score = 4, if eelgrass also present score = 8, if used more than one season and < 6 m deep, score = 8, if not within CWCA but with eelgrass in < 6 m, score = 4.

Black duck: brood-rearing habitats scores range from 8 (having marshes and within MHVW) to 6 (not within MHVW, lesser wetland types), foraging scored 8 or 4 (within MHVW or not, respectively), post-fledging scored 8 or 6(< or > 1 ha, respectively), wintering scored 8 (shallow, with resources, and in CWCA) or 4 (shallow, with resources, or in CWCA).

Canada goose: If suitable depth and inside a CWCA or if within MHVW and of suitable wetland type, scored 8; CWCA's used by geese in more than one season scored 8; if outside CWCA but of suitable depth and wetland type, scored 4; agricultural fields > 5 acres or open water within 90 m of vegetated wetlands, scored 4.

SENSITIVITY ZONE: areas scored 6 or higher have a 90 m zone, those scored 4 have a 30 m zone (corresponding to MDIF&W buffers for high value and moderate wetlands, Jones et al. 1988); agricultural areas are not buffered.
REVIEWER: Jerry Longcore (FWS).

Bald Eagle: Chapter 8; Appendix A: Figure 9.
HABITAT LOCATIONS, TYPES: Nest site buffer zones
DATA SOURCES: MDIF&W published Essential Habitats
SCORING: Nest site areas scored 8
SENSITIVITY ZONE: 402 m, (Essential Habitat distance).

Roseate Tern: Chapter 9; Appendix A: Figure 10.
HABITAT LOCATIONS, TYPES: Nesting islands, feeding areas
DATA SOURCES: Designated Essential Habitats; MDIF&W seabird database, CWCA, Jane Arbuckle pers. com.; bathymetry.
SCORING: Islands designated Essential Habitat or having persistent nesting by common tern (nesting associate), scored 8; unidentified tern and cormorant feeding in CWCA polygons, within range of tern nesting islands and < 10 m deep, scored 8; unidentified tern or cormorant feeding within range of tern nesting islands and < 10 m deep, scored 4.
SENSITIVITY ZONE: 402 m for nesting islands only, based on Essential Habitat distance.
REVIEWERS: Jane Arbuckle, Steve Kress (National Audubon Society), Jeff Spendelow (Patuxent Res. Center), Ralph Andrews.

Seabirds: (Common eider, common tern). Chapter 10; Appendix A: Figure 11.
HABITAT LOCATIONS, TYPES: Nesting islands, feeding areas, draft Maine NRPA seabird nesting islands.
DATA SOURCES: MDIF&W seabird nesting islands database, CWCA, shellfish beds, eelgrass, CMGE, bathymetry.
SCORING: all nesting islands having 1% or more of Casco Bay population for that species, or draft NRPA, scored 8; foraging areas used by eiders with depths < 10 m scored 4; if these also have mussel beds, eelgrass or other submerged vegetation, scored 8; mussel beds, eelgrass or other submerged vegetation outside eider CWCA's but having depths < 10 m, scored 4 for eiders; CWCA's used by terns are scored 4.
SENSITIVITY ZONE: eider nesting islands 500 m, tern nesting islands 300 m (based on literature and known use in Casco Bay); 90 or 30 m for preferred and low feeding areas, respectively.

REVIEWER: Jennifer Megyesi (FWS),

Shorebirds: (piping plover, least tern). Chapter 11; Appendix A: Figure 12.

HABITAT LOCATIONS, TYPES: Nesting beaches, feeding areas.

DATA SOURCES: Shorebird database (MDIF&W), Audubon nesting and feeding records (Jones and Camuso 1994), CMGE, NWI (for intertidal flats, nesting substrate).

SCORING: Nesting locations scored 8; potential nesting areas scored 4; feeding areas (observed) scored 8.

SENSITIVITY ZONE: 90 m for all (Jones et al. 1988, other literature) or to boundaries of Essential Habitat, whichever is greater.

REVIEWER: John Atwood (Manomet Bird Observatory)

Wading Birds: (great blue heron). Chapter 12; Appendix A: Figure 13.

HABITAT LOCATIONS, TYPES: Nesting islands, inland and coastal feeding areas.

DATA SOURCES: MDIF&W wading bird database, CWCA's, MHVW, NWI, CMGE.

SCORING: Nesting islands scored 8; foraging areas were scored 8 or 4 based on their wetland types, proximity to the nesting islands, and whether they were within MDIFW CWCA or MHVW.

SENSITIVITY ZONE: 800 m for nesting islands; 90 m for preferred foraging areas, 30 m for lower value foraging areas (distances correspond to MDIF&W buffers).

REVIEWERS: Katherine Parsons (Manomet Bird Observatory), Brad Allen, Richard Dressler (MDIF&W), Michael Erwin (Patuxent Environmental Science Center).

Fishes: (alewife, American eel, American shad, American smelt, Atlantic salmon, Atlantic tomcod, brook trout, redbreast sunfish and shortnose sturgeon) Chapter 13; Appendix A: Figure 14.

HABITAT LOCATIONS, TYPES: General freshwater fishery habitat. All streams and lakes having either a habitat score assigned by MDIF&W, a fishery data set from which to create a surrogate score, or information on at least the anadromous fish species.

DATA SOURCES: MDIF&W data analyses, electrofishing data, and published reports on anadromous fishes.

SCORING: MDIF&W ratings of F1 ("low value"), equivalent rating from fish collection data, or occurrence of 1 to 3 anadromous species, scored 2; F2 or intermediate abundance of resident and/or anadromous species, scored 4; F3 or highest numbers of species, scored 8.

SENSITIVITY ZONE: Based generally on MDIF&W riparian buffers (Jones et al., 1988) streams and lakes with MDIF&W ratings of F1 ("low value") or occurrence of 1 to 3 anadromous species were given a 30 m (~100 ') sensitivity zone. Higher rated streams were given a 80 m (~260') zone.

REVIEWER: Owen Fenderson (MDIF&W)

Final Coverage: Attributes and Provision for Updates

The output of the analysis of important habitats is an ARCINFO grid coverage (FINTEST3) having attribute fields for each of the evaluation species, and for the sum of the species scores, by cell. This format makes it possible to display or plot habitat maps by species, or compute summary scores for any combination of the evaluation species.

The analytical approach makes it easy for users to update or revise habitat information for any of these species, or to incorporated additional evaluation species. The top ranked species on the Gulf of Maine Council's list (see Appendix B) are prime candidates for future updates. In general, data requirements will include biological distribution (spatially, seasonally, by life stage) environmental conditions within the study area, and adequate information on the tolerances and requirements of the species.

Steps to update the coverage:
1) Any of the species maps may be used or revised. For species having multiple habitat components, any or all components may be revised. To add evaluation species the user must create new maps, using the same cell size and grid origin, within the same study area boundaries. All components must have habitat suitability or quality indexed on a 0 - 8 scale, with the "optimal" habitat being 8, and unsuitable conditions being 0.

2) The abundance of each habitat or component must be accounted for by adjusting scores as shown in Table 1. Habitat quality scores are multiplied by the "Relative Abundance Value", which is (223078 / the number of habitat components x the number of cells in the component). This value is indexed to a 0.5 to 8 scale by raising to the exponent ^0.2875. Habitat scores for all species in the output coverage have been adjusted in this way.

3) The output coverage attribute "SCORE" includes adjustment for the Gulf of Maine Council rating (see Table 1.) The user may apply GOMC ratings for additional species, or apply an alternative method of relating the "importance" of the evaluation species.

Intermediate products from development of these habitat maps remain available through the U.S. Fish and Wildlife Service Gulf of Maine Project.

Conclusions

The final product of this phase of the analysis is a coverage in which each grid cell has a score for each of the evaluation species or species groups (Appendix A: Figure 15). The coverage also sums the scores for all evaluation species, indicating areas having the greatest values for the largest proportions of these species. While this clearly discloses areas having high habitat value, it is important to keep in mind that a) other areas are likely to be important to an alternative suite of species (e.g., terrestrial plants, songbirds, mammals, marine fishes), and b) the evaluation is a synthesis of the best available information but may not accurately portray most recent conditions or actual occupation by the evaluation species. Field verification of habitat conditions and use by the evaluation species is indicated prior to management actions.

Chapter 2. General Wetland Values

The U.S. Fish and Wildlife Service defines wetlands as lands that "are transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water (Cowardin et al. 1979)." Wetlands typically have one or more of the following attributes :

1. At least periodically, the land supports predominately hydrophytes.
2. The substrate is predominantly undrained hydric soils.
3. The substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growth season of each years.

In contrast to wetlands, deepwater habitats are permanently flooded and have a depth of 2 m or more (in freshwater), or are waterward of extreme low tide (in saltwater areas).

Historically, wetlands were perceived as places of evil and disease. A perception of wetlands as wastelands carried over into early legislative acts which supported the draining and "reclaiming" of wetlands for "more suitable" uses. From the mid-50's to the mid-70's approximately 11 million acres of wetlands were altered or converted to uplands, mostly for agricultural, industrial and urban use (Frayer et al. 1983).

During the 1960's scientific studies began to document the importance of coastal wetlands as critical habitats for commercially important finfish. This, in turn, led to studies documenting a wide variety of wetland values, resulting in wetland protection laws. As a result of these studies, the American public began to appreciate wetlands as places with unique social, environmental, and biological values (Table 2).

Table 2. List of Major Wetland Values (Calhoun et al. 1995).

Floral and Faunal Values

- Breeding habitat for reptiles and amphibians (vernal pools)
- Fish and shellfish habitat
- Waterfowl and other bird habitat
- Mammal and other wildlife habitat
- Endangered species habitat (plant and animal)

Environmental Quality Values

- Water quality maintenance
  - Pollution abatement
  - Sediment removal
  - Nutrient cycling
  - Chemical and nutrient absorption

Aquatic productivity
Microclimate regulator
World climate (ozone layer)

Socio-economic Values

Flood control
Shoreline erosion control
Groundwater discharge/recharge
Water supply
Timber and other natural resources
Energy source (peat)
Fish and shellfishing
Hunting and trapping
Recreation
Aesthetics
Education and scientific research

Wetland Floral and Faunal Values

Coastal and inland wetlands provide essential breeding, nesting, feeding, and predator escape habitats for many species of waterbirds, mammals, and reptiles. Systems including wetlands and adjacent upland buffer areas are among the richest wildlife habitats in the world (Odum 1989). Their diversity is attributable to abundant water, diverse and productive vegetation, and adequate cover provided by both wetland and shore vegetation.

The values of wetlands for wildlife depend on the following factors: requirements of the particular species, diversity, constituent species, and arrangement of vegetation, the proportion of open water, the size of the wetland and surrounding habitat, water chemistry, hydro-period, and the relationship of the wetland to other aquatic areas. Therefore, preservation of a few so-called high value wetlands will not necessarily make up for extensive loss of wetlands that offer supplementary requisites for their communities.

Environmental Quality Values

Sediment Control - Wetlands reduce the velocity of flood waters, limiting erosion and causing flood waters to release sediments. Wetland vegetation filters and holds sediment which would otherwise enter lakes and streams. Unretarded, this sediment could rapidly fill lakes and reservoirs, destroying fish habitat.

Pollution Control / Nutrient Uptake - Wetlands control pollution by buffering the sediment, nutrient, and other natural and man-made pollutants conveyed to streams, lakes and estuaries. Mechanisms for removing pollutants from waters include seasonal uptake by plants and microbes, long-term storage in woody tissue, sedimentation, adsorption on soil surfaces, and microbial transformations in the biologically active zone of the soil profile. Nitrogen and phosphorus released by septic systems, agricultural activities, or lawn care are temporarily assimilated by many wetland plants, particularly marsh plants. Micro-organisms attached to wetland vegetation utilize dissolved nutrients and break down organic matter. Wetland soils may also serve as nitrate sinks. Contamination of the drinking water supplies by nitrate is thought to be the largest remaining water quality problem in the United States and has been linked to both human and environmental health threats (Newberry 1992).

Forested wetlands, the dominant palustrine wetland in the Casco Bay Study Area, also are effective in reducing concentrations of phosphorus and nitrogen. Recent research in riparian forested wetlands in Rhode Island show removal of groundwater nitrate consistently in excess of 80% in both the dormant and growing seasons (Nixon and Lee 1986, Simmons et al. 1992). Research done in other parts of the United States suggests that hardwood swamps have a high potential for removal of pesticides, heavy metals, nutrients, and sediment (Winger 1986; Chescheir et al. 1991). Strips of riparian forests located along stream banks are important in maintaining water quality, especially in areas of intense agricultural use (Peterjohn and Correll 1984; Jacobs and Gilliam 1985, Kundt et al. 1988).

Socio-Economic Values

Flood Conveyance and Retention - Wetlands often form within natural floodways. Such wetlands may store water and slowly release it downstream, lowering flood peaks and maintaining stream flows. Fills or structures located within floodplain areas block flows, causing increased flood heights on adjacent and upstream lands and increased downstream velocities.

Barriers to Waves and Erosion - Coastal wetlands and inland wetlands adjoining larger lakes and rivers reduce impact of storm surge and waves before they reach upland areas. Waves break on beaches and wetlands, dissipating much of their energy. Mats of wetland vegetation with their complicated root systems bind and protect soil against erosion.

Mediation of Ground Water - Depressional and slope wetlands are areas of groundwater discharge, and their underlying aquifers may provide quantities of water sufficient for public water supplies, in maintaining wildlife habitat, and in diluting open water bodies potentially degraded by excess nutrients or chemicals (Adamus 1986). Discharge is important not only for maintaining flows necessary to fisheries, but also for maintaining vegetation and drinking water for wildlife. Seepage discharged through gravel is essential to spawning and rearing of salmonid fishes (Scarnecchia 1981, Bilby 1984). In summer, springs provide a cool refugium for salmonids; this is particularly important in wide rivers and developing watersheds where natural sources of shade are limited. Discharging springs often keep important northern wetlands free of ice for long periods in winter, increasing their use by waterfowl. Elevated water hardness levels associated with discharge reduce the toxicity of many chemicals. A disproportionate number of rare plant species are also found in ground water discharge wetlands (e.g., springs, seeps, fens), especially in calcareous regions (Williams and Dodd 1979).

Production of Fish and Shellfish - Coastal wetlands yield vegetative materials leading to production of commercial fin and shellfish. The net primary productivity (net plant growth) of salt marshes exceeds that of all but the most intensively managed agricultural areas. Coastal Maine has approximately 79 km^2 of salt marsh, slightly more than one-half of the total area of salt marsh found in the Gulf of Maine (Jacobson et al. 1987). As wetland plants die and decay, bacteria and fungi transform plant tissues into minute fragments of vitamin rich detritus which are carried into tidal creeks, bays, and offshore waters. Many species of sport and commercial fish and shellfish depend on this food source. Additionally, salt marsh ponds, channels and embayments provide protected nursery areas for important species such as alewife, smelt, winter flounder and lobster. Up to 90% of commercially important species either pass their entire lives in estuarine environments or require estuaries as nursery grounds.

Recreation - Wetlands also support a wide variety of recreational activities including boating, swimming, sport fishing, hunting, trapping, and bird watching, - activities that generate billions of dollars annually. Nationally, in 1985 fish and wildlife recreation was a 55 billion dollar industry, largely dependent on wetland resources.

Wetlands of Casco Bay

Maine's wetlands make up almost one fourth of its surface area. Approximately 160,000 acres are saltwater and more than 5 million acres are freshwater (Maine State Summary 1992-93). Wetlands in Maine provide habitat for up to 42 percent of the official state-listed endangered and threatened plants. Table 3 lists the types and relative abundance of wetlands and deepwater areas in the lower Casco Bay watershed.

TABLE 3. TYPES AND AREAS OF WETLANDS AND UPLANDS IN THE CASCO BAY STUDY AREA

Types	Area in hectares	Area in acres	% Total Area
Freshwater Wetlands:			
Palustrine, Forested	3768	9310	2.36
Palustrine, Scrub/Shrub	1235	3053	0.77
Palustrine, Emergent	699	1727	0.44
Palustrine, Aquatic Bed	8	20	0.01
Palustrine, Unconsolidated Bottom	428	1058	0.27
Deep Freshwater:			
Lacustrine, Limnetic, Unconsolidated Bottom	567	1401	0.36
Riverine, Upper Perennial	5	12	0.00
Riverine, Lower Perennial	266	658	0.17
Riverine, Tidal	407	1006	0.26
Saltmarsh:			
Estuarine, Emergent	1393	3442	0.87
Flats:			
Estuarine, Intertidal	2868	7087	1.80
Marine, Intertidal	1997	4935	1.25
Subtidal Waters	51210	126542	32.11
Upland	94642	233865	59.34

Wildlife found in Maine wetlands falls into three broad categories:

1) Facultative users (species living predominantly in terrestrial habitats, but that tolerate wet conditions); examples are white-tailed deer (*Odocoilus virginianus*), and garter snakes (*Thamnophis sirtalis*).

2) Aquatic species commonly found in wetlands include great blue heron (*Ardea herodias*), snapping turtles (*Chelydra serpentina*), and otters (*Lutra canadensis*). Some species visit wetlands for only a limited time; spotted salamanders (*Ambystoma maculatum*) and wood frogs (*Rana sylvatica*) visit to breed in the spring; raccoons (*Procyon lotor*) visit to forage at night; fish (bluefish and others) visit at high tides to forage.

3) Obligate users, which are uniquely associated with wetlands and thrive nowhere else; examples are muskrats (*Ondatra zibethicus*), beavers (*Castor canadensis*), pickerel frogs (*Rana palustris*), mummichogs (*Fundulus* spp.), and amphipods (*Corophium volutator*).

Table 4 lists prominent species associated with general classes of wetlands common in Casco Bay.

TABLE 4: SPECIES CHARACTERISTIC OF WETLAND CLASSES

SUB-TIDAL WATERS - (includes Marine and Estuarine unconsolidated bottom)

Species *	Scientific Name	Occurrence	Comment	Category
Invertebrates:				
Jellyfish	*Cyanea capillata*	R	seasonally abundant; shelter for small fishes	E
Copepod	*Calanus finmarchicus*	R	Form 80% GOM zooplankton	E
Marine Plants:				
Eelgrass	*Zostera marina*	R	important substrate, food source for ducks	E
Dulse	*Palmaria palmata*	R	intertidal to -20 meters	C/E
Fishes:				
Atlantic cod	*Gadus morhua*	R	major pop. decline	C/S
Winter flounder	*Pseudopleuronectes americanus*	R	overfished	C/S
Atlantic tomcod	*Microgadus tomcod*	R	eco. important, prey of eagles & seabirds	E
Alewife	*Alosa pseudoharengus*	R	imp. prey, commercial value, managed	C/S/E
Atlantic salmon	*Salmo salar*	R	decline due to harvest/habitat loss	S
Birds:				
Roseate tern	*Sterna dougallii dougallii*	M	breeds GOM islands, threatened gulls/pollution	E
Bald eagle	*Haliaeetus leucocephalus*	R	ME has >90% breeding sites in NE.	E
Arctic tern	*Sterna paradisaea*	M	breeds in GOM, pop declining	E
Mammals:				
Harbor porpoise	*Phocoena phocoena*	R	at risk from pollution, fishing (by catch)	E
Gray seal	*Halichoerus grypus*	R	dispersed; remote ledges and shoals	E

Ecological Significance	Occurrence
C - Commercial	R - resident
E - Ecological	M - migratory
S - Sport	

* Species from "Identification of Species for Prority Habitats" (Gulf of Maine Council; Habitat Panel, 1994)

TABLE 4 (contd.) : SPECIES CHARACTERISTIC OF WETLAND CLASSES

FLATS - (includes estuarine and marine inter-tidal flats)

Species *	Scientific Name	Occurrence	Comment	Category
Invertebrates:				
Sandworm	*Nereis virens*	R	common, bait , prey of fishes	C/E
Blue mussel	*Mytilus edulis*	R	prey of birds, fishes, inverts, form reefs.	C/E
Green crab	*Carcinas maenas*	R	abun. GOM, introduced, tol. low salinity	E
Bloodworm	*Glycera dibranchiata*	R	comm. bait. prey of shorebirds, fishes, swarm	C/E/S
Fishes:				
American sand lance	*Ammodytes americanus*	R	prey of fish, birds, whales	E
Mummichog	*Fundulus heteroclitus*	R	prey of birds, fishes, common	E
Birds:				
Piping plover	*Charadrius melodus*	M	decline from habitat loss	E
Least tern	*Sterna albifrons*	M	pop. declining, habitat loss, predation	E
Semipalmated sandpiper	*Calidris pusilla*	M	preys on small inverts, important in spring /fall	E

Ecological Significance	Occurrence
C - Commercial	R - resident
E - Ecological	M - migratory
S - Sport	

* Species from "Identification of Species for Prority Habitats" (Gulf of Maine Council; Habitat Panel, 1994)

TABLE 4 (contd.): SPECIES CHARACTERISTIC OF WETLAND CLASSES

SALTMARSHES - (estuarine emergent)

Species*	Scientific Name	Occurrence	Comment	Category
Invertebrates:				
Soft-shelled clam	*Mya arenaria*	R	prey of ducks, mammals, fishes	C/E/S
Grass shrimp	*Palaeomonetes pugio*	R	prey of fishes, birds	E
Plants:				
Cordgrass	*Spartina alterniflora*	R	important as cover, primary producer	E
Sea lavender	*Limonium carolinianum*	R	salt marsh/rocky; shore harvested	C
Fishes:				
Mummichog	*Fundulus heteroclitus*	R	prey of fishes, birds, some commerc. value	E/C
Birds:				
Black Duck	*Anas rubripes*	R	winters in open water, grad. decline	S
Willet	*Catoptrophorus semipalmatus*	M	breeds in salt marshes, pop. increasing	E
Sharp-tailed Sparrow	*Ammodramus caudacutus*	M	common in GOM, breeds saltmarsh/dune grass	E

Ecological Significance	Occurrence
C - Commercial	R - resident
E - Ecological	M - migratory
S - Sport	

* Species from "Identification of Species for Prority Habitats" (Gulf of Maine Council; Habitat Panel, 1994)

TABLE 4 (contd.): SPECIES CHARACTERISTIC OF WETLAND CLASSES

DEEP FRESHWATER - (riverine and lacustrine-limnetic)

Species*	Scientific Name	Occurrence	Comment	Category
Fishes:				
Brook trout	*Salvelinus fontinalis*	R	lk runs, spawn on gravel preferentially	C/S
Redbreast sunfish	*Lepomis auritus*	R	common; shallow warmer lakes, streams	S
Birds:				
Osprey	*Pandion haliaetus*	M	breeds coastal islands, found along rivers, etc.	E
Common loon	*Gavia immer*	M	summers on protected lakes, winters on coast	E
Bald Eagle	*Haliaeetus leucocephalus*	R	ME has >90% breeding sites in NE.	E
Mammals:				
River Otter	*Lutra canadensis*	R	taken both comm and sport, prey on inverts, fish	C/S

Ecological Significance	Occurrence
C - Commercial	R - resident
E - Ecological	M - migratory
S - Sport	

* Species from "Identification of Species for Prority Habitats" (Gulf of Maine Council; Habitat Panel, 1994)

TABLE 4 (contd.): SPECIES CHARACTERISTIC OF WETLAND CLASSES

FRESHWATER WETLANDS - (includes all Palustrine wetlands)

Species*	**Scientific Name**	**Occurrence**	**Comment**	**Category**
Plants:				
Sphagnum moss	*Sphagnum spp.*	R	emer. veg. perennial/mosses form dense mats	E
Fishes:				
American eel	*Anguilla rostrata*	M	juvenile to adult stage in freshwater	E/C/S
Birds:				
Great Blue heron	*Ardea herodias*	M	Lakes,rivers,coastal, common colony nest GOM	E
American woodcock	*Philohela minor*	M	feeds on invertebrates of moist soils	E/S
Mammals:				
Black bear	*Ursus americanus*	R	primarily forests/swamps	S/C/E

Ecological Significance	Occurrence
C - Commercial	R - resident
E - Ecological	M - migratory
S - Sport	

* Species from "Identification of Species for Prority Habitats" (Gulf of Maine Council; Habitat Panel, 1994)

Chapter 3. Wetlands of the Casco Bay Study Area

GENERAL: In addition to the wildlife habitat analysis, CBEP requested that we recategorize National Wetlands Inventory information for 15 coastal towns of the Casco Bay watershed. While retaining their original NWI attributes, we assigned polygon and line features to the following generalized classes: intertidal flats, rocky shores, salt marshes, subtidal waters, freshwater wetlands, and deep freshwater, (including lakes, rivers and streams). Coastal islands and mainland uplands also were distinguished as distinct categories.

SOURCES OF DATA: Digital data were obtained from the National Wetland Inventory, St. Petersburg, Florida for 14 of the 18 7.5-minute USGS quadrangles encompassing the study area. We digitized the necessary portions of 4 other quads, following NWI digitizing conventions. All data were based on 1985-7 aerial photography. Coverages included polygon and line features. Minimum size of mapped features was one-half to one-quarter acre or 40' in width, respectively. NWI designations were included in the GIS coverage under the item "ATTRIBUTE", for both polygons and lines. Another attribute, "CLASS", was added to both polygon and linear wetland features. The appropriate category designation was entered (flats, salt marshes, etc.) based on the original NWI coding; the relationship to NWI type is detailed in Table 5, below.

MAPPING OF WETLANDS: The 18 quads were appended to form one large coverage of the study area. To make these coverages more useful for regulatory or management purposes we determined the combined acreages for aggregations of adjacent wetlands. These are provided under the items "NWIACRES" and "FRESHACRES". The former represents the combined acreage of contiguous polygons having the same freshwater NWI designation. Such contiguous polygons are separated only by a line feature, such as a narrow strand of another wetland type up to 40' in width, and thus may be considered as one larger wetland area for certain habitat purposes. Similarly, we computed the acreage of contiguous freshwater wetland features of any type, including acreage of contiguous ponds and major rivers and streams. These values are indicated under the item "FRESHACRES".

Table 5. Assignment of NWI Designations to "Class"

Class	NWI designation
Flats -	(M2US2-4; M2RF; M2AB; E2US2-4; E2RF; E2AB; R1US2-5)
Saltmarshes -	(E2EM)
Subtidal waters -	(M1 and E1)
Deep Freshwater -	(R1,2,3,5 that are UB or RB; L1 - except L1AB)
Coastal Islands -	(Upland on islands with Maine Coastal Island Registry number)
Freshwater wetlands -	(all other Riverine, Lacustrine, and Palustrine)
Mainland -	(All other U)
Rocky Shore -	(M2RS; M2US1; E2RS; E2US1)

COVERAGE (Appendix A: Figure 2).

NWI18_4 arc and polygon coverage of NWI wetlands

ATTRIBUTES:

- AREA (polygon features) area of polygons, m sq
- PERIMETER (polygon features) perimeter of polygons, m
- NWI18_4#, -ID polygon identification numbers
- LENGTH (for arc features) length of arc, m
- ATTRIBUTE (arc and polygon features) NWI designation (see above)
- CLASS (arc and polygon features) cover type (see above)
- FRESHACRES (polygon features) acreage of contiguous freshwater wetland features of any type
- NWIACRES (polygon features) combined acreage of contiguous polygons having the same freshwater NWI designation

Special notes:

We found that some of the wetlands of Merrymeeting Bay mapped by NWI as estuarine actually were impounded and now are freshwater; these were recoded as "PEMnew" in the coverage FRESHBUF.

NWI maps are prepared primarily by stereoscopic analysis of high altitude aerial photographs. Wetlands are identified on the photographs based on vegetation, visible hydrology, and geography in accordance with **Classification of Wetlands and Deepwater Habitats of the United States** (FWS/OBS - 79/31 December 1979). The aerial photographs typically reflect conditions during the specific year and season when they were taken. In addition, there is a margin of error inherent in the use of the aerial photographs. Thus, a detailed on the ground and historical analysis of a single site may result in a revision of the wetland boundaries established through photographic interpretation. In addition, some small wetlands and those obscured by dense forest cover may not be included in these coverages.

Federal, State and local regulatory agencies with jurisdiction over wetlands may define and describe wetlands in a different manner than that used in this inventory. There is no attempt, in either the design or products of this inventory, to define the limits of proprietary jurisdiction of any Federal, State or local government or to establish the geographical scope of the regulatory programs of government agencies. **Persons intending to engage in activities involving modifications within or adjacent to wetland areas should seek the advice of appropriate Federal, State and local agencies concerning specified agency regulatory programs and proprietary jurisdictions that may effect such activities.**

Data Restrictions: There are no restrictions on redistribution of this data set, however, secondary distribution must include this documentation. Credit should always be given to the source and automation agency when the data is transferred or printed.

Chapter 4. Landcover of Casco Bay

GENERAL: Landcover information was initially developed from a June 6, 1991 Landsat TM scene provided by the Maine Office of GIS and processed by Earthsat Corporation, Rockville, MD. The intended classification included: two intensities of development (residential and commercial, or transportation landuse), beach or dune, rock outcrop or bare ground, intensive agriculture (row crops), orchards, improved pasture or grasslands, old fields, clear cut, deciduous upland shrubs or regrowth, deciduous upland forest, evergreen upland shrub or regrowth, evergreen upland forest, mixed upland shrub or regrowth, mixed upland forest, open water, sparse emergent (marsh) vegetation, dense emergent vegetation, submerged vegetation, scrub-shrub wetlands, forested wetlands, and mudflats.

SOURCES OF DATA: Draft landcover products were received from Earthsat (via CBEP). Earthsat had aggregated a number of the classes which could not be distinguished with confidence; these were either dropped or were placed into the nearest related classes. We tested accuracy of the draft classification by comparing the interpretation to landcover information from other sources. The sources included 1) a 1972 polygon coverage encompassing about 35% of the study area (we used only polygons which had not changed according to 1991 aerial photography obtained from the Greater Portland Council of Governments), and 2) 1991 landcovers of Freeport and Brunswick, made from aerial photography by J.W. Sewell company. We examined the Earthsat interpretation within polygons selected from these two sources for covertypes of interest. The proportion of agreement was only 40 to 70%, depending on class.

MAPPING OF LANDCOVER: Jed Wright (FWS) then created additional grids using ERDAS software and the same 1991 imagery. Difficulties again were found in distinguishing certain important landcover types. Accordingly, we combined three of the interpreted images, using the most accurate features of each. Accuracy of the landcover was incrementally improved by 1) dropping all wetland interpretation from the image processing, and using wetland data from National Wetland Inventory digital maps; 2) aggregating classes in which confusion remained excessive and which did not need to be distinguished for the current project; 3) replacing or augmenting coastal upland and intertidal features with overlays derived from CMGE, and 4) directly editing certain features which were clearly distinguishable on aerial photos, but confused in the digital processing. The final classes were: developed/transportation, grass/pasture, rowcrop (agriculture), upland forested, upland rock outcrop, beach/dune, open water, submerged vegetation, emergent vegetation, wetland forested, and intertidal.

Upland classes of the final products were examined with reference to the aerial photographs, and tested for accuracy using field ground-truthing sites initially collected for the use of Earthsat in image processing. Since we did not use them for classifying the image, they still served as independent data.

Table 6. Results of Comparison Between Upland Classes in Final Grid LCNEW17 and Actual Field Sites.

Ground-Truth Site Type	Number Correct*	Number Wrong	Erroneous Class
developed/residential	13	0	
rock	1	1	developed (on coast)
crop	3	0	
grass/pasture/hay	3	0	
oldfield (grass)	6	1	crop
upland forested (all)	18	4	grass

* number of instances in which the classified image agreed with the ground-truth determination.

Since the locations of most of the wildlife habitats were mapped from other information sources (e.g., NWI, CMGE, bathymetry), our primary use of this landcover was in relating the proximity of habitats to development. The accuracy of the development signatures was generally quite good (see above). However, the high reflectance of coastal ledge caused it to be erroneously classed as developed; this formed an intermittent line along some shorelines. A portion of this error was corrected by reclassifying "developed" landcover cells falling within the areas CMGE designated as "ledge".

The processing required development of 17 grids, plus many other intermediate steps, all of which FWS retains, archived on tape.

COVERAGE (Appendix A: Figure 3).

LCNEW17 grid of landcover
ATTRIBUTES:
COUNT Number of 30 m square cells at each value
VALUE Cover type of cells:
- 3 beach, dune
- 4 inland rock outcrop, ledge
- 8 open water
- 9 submerged aquatic vegetation
- 10 emergent (marsh) vegetation
- 11 forested wetlands
- 12 intertidal flats
- 21 developed
- 22 grass, pasture
- 23 crops, bare earth
- 24 forested uplands

Grid Origin (x, y): 346755.000, 4804748.363
Grid Size (nrows, ncolumns): 4193,4047

Chapter 5. Eelgrass, Cordgrass Habitats

GENERAL: Eelgrass (*Zostera marina*) and smooth cordgrass (*Spartina alterniflora)* are highly ranked species on the Gulf of Maine Council's Species List for Identifying Regionally Significant Habitats. Both are of major ecological importance as structure for marine and estuarine vertebrates and invertebrates, and as primary producers of organic matter for coastal food chains. In the current context their habitats are appraised in purely horticultural terms, their suitability for growth of these plants; other aspects are considered in the analyses for fish and wildlife species which share their "community". Accordingly, the greatest observed density of plant growth is regarded as indicating the highest value habitat for that species.

SOURCES OF BIOLOGICAL AND SPATIAL DATA: The analysis relies on NWI maps for cordgrass and maps of eelgrass created by Seth Barker (DMR). Eelgrass beds had been identified from true color 1:12,000 aerial photos, field verified, and digitized from mylar overlays produced from the photos. Areal coverage of eelgrass (crown densities) were estimated and assigned to four classes: 0-10%, 10-40%, 40-70%, and 70-100%.

MAPPING OF HABITATS: The cordgrass coverage (CRDGRS4) was created by selecting all areas from NWI digital maps designated estuarine intertidal emergent and converting them to grid cell format. Corrections were made as noted in Chapter 3. We also found that most of the tidal marshes had pronounced zonation. In marshes having freshwater tributaries the lowest band was smooth cordgrass, the next higher a band of saltmeadow hay (*Spartina patens*), and the highest was cattail. When such areas of mixed vegetation were dominated by *S. alterniflora*, we included the entire NWI polygon in our coverage.

In lieu of information on vigor or biomass, as indicating relative habitat quality, all areas of cordgrass were assigned an "intermediate" score of 4 (out of a possible 8, before adjustments for species rank, habitat abundance, etc.). We did not establish a sensitivity or buffer zone for this coverage.

The DMR eelgrass coverage was converted to grid cell format (CASEELG6). Cells having eelgrass were scored 2 to 8 for habitat quality, corresponding to the density classes originally assigned by Seth Barker.

COVERAGES (Appendix A: Figures 4, 5).

CRDGRS4, CASEELG6 grids of cordgrass, eelgrass

ATTRIBUTES

COUNT Number of 30 m square cells at each value.

VALUE Relative habitat scores (adjusted for abundance).

Quality	As adjusted for abundance (from Table 1, both rounded to 2x)
CRDGRS4: (cordgrass)	
0 (not present)	0
4 (present)	8
CASEELG6: (eelgrass)	
0 (not present)	0
2 (0 - 10% crown cover)	4
4 (10 - 40% crown cover)	8
6 (40 - 70% crown cover)	12
8 (70 - 100% crown cover)	16

Grid Origin (x, y): 346755.000, 4804748.363
Grid Size (nrows, ncolumns): 4193,4047

Chapter 6. Shellfish, Marine Worm Habitats

GENERAL: A number of species of shellfish and marine worms are on the Gulf of Maine Council's Species List for Identifying Regionally Significant Habitats. Among the shellfish are softshell clams (*Mya arenaria*), blue mussels (*Mytilus edulis*), northern quahogs (*Mercenaria mercenaria*), and sea scallops (*Placopecten magellanicus*). Marine worms on that list include bloodworms (*Glycera dibranchiata*) and sandworms (*Nereis virens*). All species are of recreational and/or commercial importance, and also are important prey of other vertebrate and invertebrate marine wildlife.

SOURCES OF BIOLOGICAL AND SPATIAL DATA: The analysis relies on GIS coverages digitized by Seth Barker (DMR). These represent areas which have been commercially harvested; therefore, they do not portray all suitable habitats in Casco Bay. NOAA and FWS are in the process of modeling softshell clam habitat in Casco Bay; suitability of habitats will be based on salinity, temperature, substrate, and water depth.

MAPPING OF HABITATS: The shellfish coverage includes areas from the DMR shellfish coverage having any of the 4 species of bivalves listed above. The marine worm coverage includes all original marine worm polygons from the DMR worm coverage. The coverages are not intended to depict the limits of areas being managed or under regulatory control.

Grids were created from both of these coverages, and scores assigned to the habitats for use when combining coverages for all evaluation species. Because habitat quality could not be inferred from the data, all harvested areas were scored at an intermediate value (4 out of a possible 8, before adjustments).

COVERAGES (Appendix A: Figures 6, 7).

SHELL3G, WORM4G grids of shellfish and worm habitats, respectively

ATTRIBUTES:

COUNT Number of 30 m square cells at each value.
VALUE Relative habitat score (adjusted for abundance).

	Quality	As adjusted for abundance
		(from Table 1, rounded to 1x)
SHELL3G: (shellfish)		
	0 (not harvested)	0
	4 (harvested)	4
		(from Table 1, rounded to 2x)
WORM4G: (marine worms)		

0 (not harvested)	0
4 (harvested)	8

Grid Origin (x, y): 346755.000, 4804748.363
Grid Size (nrows, ncolumns): 4193,4047

Chapter 7. Waterbird Habitats: Common Loon

Habitats of three species of waterbirds, common loon, black duck, and Canada goose, were identified individually, then combined into a single coverage.

GENERAL: The common loon (*Gavia immer*) is a highly regarded waterbird characteristic of relatively pristine lakes and coastal waters of Casco Bay.

SOURCES OF BIOLOGICAL AND SPATIAL DATA: Data for occurrences of the common loon were obtained from the MDIF&W GIS coverage of Coastal Wildlife Concentration Areas (CWCA). The CWCA's are polygons drawn around areas in which relatively high numbers of marine birds and seals were observed during aerial survey flights made along the Maine coast from 1979 through 1982. Survey data were combined into five "seasons"; winter, spring, nesting, post-nesting, and fall. Maine Audubon Society provided a database of loon use of Maine lakes, and additional information on habitat preferences. Additional spatial information included eelgrass locations and densities (DMR), coastal shoreline (OGIS) and bathymetry (MGS).

HABITAT CONSIDERATIONS

Breeding habitats: Although there is no documentation of common loons nesting in the lower 15 towns, the loon does breed in the Casco Bay watershed (Maine Audubon Annual Loon Census 1994). Loons breed on freshwater lakes as small as two acres in open or densely forested areas. Nest sites are commonly located on the ground near the water's edge, usually on sand, rocks, or other firm substrate. Loons prefer to nest on small islands to minimize possibility of disturbance and reduce predation by mammals (Stockwell and Jacobs 1992).

Coastal habitats: Loons are found on Casco Bay primarily during the winter season with the population reaching 500 birds (Hutchinson and Ferrero 1980). Important coastal habitats include bays, coves, channels, inlets, and other shallow areas (McIntyre 1986). Shallow inshore waters are utilized more frequently than deeper offshore waters, although some loons will use continental shelf waters up to 100 m deep and 100 km from shore.

While primarily piscivorous, loons are opportunistic and will eat any suitable prey they can see and capture (McIntyre 1986). Foods include fish (staple), amphibians, insects, aquatic plants, crustaceans, mollusks, and leeches. Winter foods include flounder (*Pseudopleuronectes americanus*), rock cod (*Gadus morhua*), menhaden (*Brevoortia partronus*), salmonids, sculpin (*Leptocottus armatus*), and crabs (Schneider and Pence 1992). Feeding typically occurs in water < 5.5 m deep (McIntyre 1986, Daub 1989) with maintenance activities (preening, drifting) usually taking place in deeper water. Common prey species of loons often are concentrated in eelgrass beds, making these important foraging sites.

MANAGEMENT CONCERNS: Loon nesting may be reduced from historic levels by lakeside development in southern Maine (Stockwell and Jacobs 1992). In Ontario, Canada, hatching success decreased as the number of cottages within 150 meters of loon nests increased (Heimberger et al. 1983). Disturbance in the form of boating activity at crucial times during the breeding/nesting season can have detrimental effects on nesting success by reducing the number of territorial pairs per lake and by exposing the nest to predation and/or cooling of the eggs.

Oil spills pose a serious threat. Loons wintering in coastal waters are subject to oiling of feathers and entanglement in fishing gear (Palmer 1962, Vermeer 1973). Detailed information on the wintering distribution and ecology of common loons is lacking (Rimmer 1992).

MAPPING OF HABITATS: Waters less than 6 meters deep, particularly over eelgrass beds, were regarded as preferred coastal foraging habitat for the common loon. We did not have information on the proximity of foraging sites to development. Accordingly, we accepted MDIF&W disturbance buffers as sensitivity zones in which development activities would likely affect the value of neighboring habitats (Jones et al. 1988). We used a 30 m sensitivity zone for relatively low value foraging habitats, and a 90 m zone for moderate or high value foraging habitats. These distances also were used for identification of "impact zones", disturbed areas dominated by paved surfaces or buildings. Otherwise suitable habitats within these impact zones were reduced in score by half. Existing development was not given a habitat score.

Steps involved in mapping of seasonal habitats:

1) Select polygons from Coastal Wildlife Concentration Areas (CWCA) with loon counts > 1% of the study area population for each of the 5 seasonal surveys. The 1% criterion reduces the scope of the analysis to habitats likely to be significant from a population standpoint.

2) Select from resulting CWCA polygons areas where the depth is < -6 m; assign relative score = 4.

3) Select areas meeting conditions from step 2 and where eelgrass beds are present; assign these a relative score = 8.

4) Select all other areas in Casco Bay having eelgrass beds and depths < -6 meters; assign these a relative score = 4.

5) Identify a 30 m sensitivity zone around areas scored 4, and 90 m around areas scored 8.

6) Reduce habitat values by half if within impact zones around existing development: impact zones are 30 m buffers for habitats scored 4, 90 m for areas scored 8. Areas currently developed were scored 0.

Waterbird Habitats: Black duck

GENERAL: Waterfowl are important in Casco Bay from recreational (hunting, viewing) and ecological perspectives. One of the species on the Gulf of Maine Council's Species List for Identifying Regionally Significant Habitats, the American black duck (*Anas rubripes*), is of special interest, because of an historical decline in population.

This analysis attempts to identify both marine (winter foraging) and freshwater (foraging, nesting, brood-rearing and post-fledging) habitats for black ducks, and sensitivity zones in which development may degrade the adjacent habitats. These coverages are not intended to depict the limits of areas being managed or those areas already under regulatory control.

SOURCES OF BIOLOGICAL AND SPATIAL DATA: Biological data included the CWCA's (MDIF&W), eelgrass, shellfish beds and marine worm harvest areas (DMR), and wetlands (NWI). MDIF&W identified Moderate and High Value Wetlands for waterfowl from surveys made in 1974; we digitized these wetlands by identifying the corresponding NWI polygons, transferring them to a coverage, and assigning them the appropriate MDIF&W scores. Landcover was developed as part of this study (Chapter 4). Additional spatial information included the coastal shoreline (OGIS) and bathymetry (MGS).

HABITAT CONSIDERATIONS

Wintering: Black duck wintering populations in the Atlantic Flyway are concentrated in marine, estuarine, and riverine wetlands extending from the Canadian Maritimes through South Carolina. Rocky shoreline and large tidal amplitudes are typical of marine wintering habitat northeast of Cape Elizabeth, Maine. Black ducks loaf and feed on the southeast side of islands and peninsulas, where there is maximum sunlight and protection from wind (Longcore and Gibbs 1988). Black ducks also frequent ice-free salt marshes, small tidal bays, and open waters of dynamic ecosystems such as rivers and tidal inlets. Since black ducks are "dabblers", food sources must be near the surface or just buried in the substrate (Lewis and Garrison 1984).

Black ducks wintering in coastal habitats feed mostly on invertebrates living in rockweed or in shellfish beds on tidal flats (Jorde and Owen 1989). Diets differ due to habitat diversity, nutritional value of foods, and different foraging patterns.

Other seasons: Freshwater wetlands are used during the reproductive period (courtship through post-fledging) and for general foraging or cover. Black ducks generally prefer palustrine emergent wetlands for several functions (Frazer 1988), but habitat selection also depends on season. In the fall, palustrine scrub-shrub and forested wetlands receive more use. Riverine wetlands become more important as ice forms on lentic habitats. Less used, but still having functional value, are lacustrine and estuarine wetlands.

Black duck preferences for nesting habitat vary widely. They may nest in upland areas near an ephemeral pool or other wetland, or up to 1.5 km from a water source (Jerry Longcore, FWS, pers. com.). Due to this variability no attempt was made to map nesting habitats; it is assumed that some nesting habitat will fall within areas mapped for other functions, or within the sensitivity zones for those habitats (see below).

Brood-rearing ducks consistently select habitats that will meet the energy requirements of their growing young. Appropriate wetlands include those with active beaver colonies, impoundment ponds, and open water within palustrine emergent wetlands. Black ducks apparently prefer small wetland areas for pair-bonding (USFWS 1988). They also utilize small (< 0.5 ha) ephemeral pools and small permanent ponds intensively during the nesting season, as well as for stop-over points during overland movements with broods (Ringelman and Longcore 1982).

MAPPING OF HABITATS

We used the above understanding of the requirements or preferences of black ducks to characterize the habitat values of potential wintering, foraging, brood-rearing, and post-fledging areas for black ducks. NWI wetland classes and other environmental themes were used to assign relative scores for each of these life stages. Wintering areas were further defined from CWCA polygons in which the population exceeded 1% of the seasonal total count. The 1% criterion reduced the scope of the analysis to habitats likely to be significant from a population standpoint. Inland habitats which were within MHVW polygons were regarded as more likely to be suitable, and so were given a higher score. Habitat characterization and the resulting scores or values are shown below. These scores were used when combining coverages for various species.

A protective or "sensitivity zone" was identified around black duck habitats to indicate areas in which development and associated domestic activities would be expected to degrade those designated habitats. Zone widths (30 to 90 m) were based on MDIF&W wetland buffers (Jones et al. 1988). The final black duck coverage was adjusted to account for the effects from existing development in the watershed. Habitats within the sensitivity zone distances of existing development were reduced to one-half the score of pristine habitats.

The steps in mapping habitats were:

WINTERING COMPONENT:

1) select those CWCA polygons hosting => 1% of the Casco Bay total black duck count.

2) select areas within these polygons that are <= 1 m deep. Assign these a relative score of 4. This depth includes foraging areas accessible to this species.

3) select areas resulting from step (2) which also have eelgrass, shellfish, or are intertidal. Assign these a relative score of 8.

4) select areas <u>outside</u> the CWCA's, but which have eelgrass or shellfish and are <= 1 m deep, or are intertidal. Assign these a score of 4. While black ducks were not observed in these areas during the MDIF&W surveys, they were scored for the presence of suitable food resources.

BROODREARING AND POST-FLEDGING COMPONENTS:

1) Select NWI polygons designated palustrine emergent. Where these overlap a MHVW rated 2 or 3 assign these a score of 8, otherwise score as 6.

2) Select NWI polygons designated palustrine forested, scrub shrub, or aquatic bed. Assign these a score of 4.

INLAND FORAGING:

1) Select NWI polygons designated palustrine emergent, forested, scrub shrub, or aquatic bed. Where these overlap a MHVW rated 2 or 3 assign these a score of 8, otherwise score as 4.

2) Select NWI polygons designated riverine emergent or aquatic bed, or lacustrine emergent or aquatic bed. Assign these a score of 4.

COMBINATION OF HABITAT SCORES:

1) Identify sensitivity zones for the above; use a distance of 30 m for areas scored 4 and 90 m for areas scored 8. Reduce scores for habitat within this distance of existing development to one-half the score of pristine habitats of that type. Areas which are currently developed are scored 0.

2) Scores for the above habitat components were combined so that the output at each locality was the maximum of the scores for these functions.

Waterbird Habitats: Canada goose

GENERAL: The Canada goose, *Branta canadensis*, is a large and abundant waterbird of the Atlantic coastal flyway, and one of the species from the Gulf of Maine Council's Species List for Identifying Regionally Significant Habitats. Although resident populations have been increasing in the Northeast, habitat use in the Casco Bay study area still is dominated by migratory birds of the Atlantic flyway. The analysis identifies aquatic (foraging and probably resting) habitats and some upland foraging areas for Canada geese, and sensitivity zones in which development may degrade adjacent habitats. These coverages are <u>not</u> intended to depict the limits of areas being managed or under regulatory control.

SOURCES OF BIOLOGICAL AND SPATIAL DATA: Biological data included the CWCA's (MDIF&W), eelgrass (DMR), and wetlands (NWI). We also utilized MDIF&W MHVW's for assigning habitat scores. Landcover was developed as part of this study (Chapter 4). Additional spatial information included the coastal shoreline (OGIS) and bathymetry (MGS).

HABITAT CONSIDERATIONS

The Atlantic coast migratory population of the Canada goose breeds from Labrador and Newfoundland to Quebec. It now winters largely in the mid-Atlantic states and the Carolinas; those migrating further south have been reduced to 10% of the pre- 1960's levels (Malecki et al. 1988). Changes in agricultural practices (larger fields, more corn fields), milder winters, and creation of new wildlife refuges have encouraged the altered migration patterns. The extreme form of this "shortstopping" behavior is the development of resident (non-migratory) populations. In Canada's St. Lawrence valley, goose numbers and length of stay during spring and fall "staging" also has increased with the introduction of corn culture and heavy spring flooding (Reed et al. 1977).

Resident populations (those breeding south of 47 degrees latitude) have been increasing as migratory flocks decline, leading to management concerns over damage to crops and nuisance conditions (Foss 1994). In New Hampshire and Massachusetts resident Canada goose populations readily adapt to suburban situations, nesting around artificial ponds or reservoirs and grazing on adjacent lawns. Preferred habitats include beaver ponds and ponds near pastures, preferably having small islands. Resident birds overwinter on open water near the coast. There is not a large breeding population in Maine (Sheaffer and Malecki, ms.).

In addition to the geographic shift, Canada geese now feed more commonly on uplands than occurred historically (Malecki et al. 1988). Previous to the 1960's Canada geese were known to feed on moist soil and aquatic plants; this now is supplemented with corn and other upland grains, and pasture plants (Harvey et al 1988). Geese feed in marshes and fields up to 13 km from water, foraging first in fields adjacent to water

(Reed et al. 1977). They eat farmland grasses/grains (leaves, roots, seeds), sedge tubers, or marsh grass seeds and roost on flooded grasslands, marshes, or open water. Migrating Canada geese are common in Maine in winter; they use ice-free fresh water and coastal marshes for resting and feeding, and agricultural land for grazing (grasses, corn stubble). Canada geese also feed heavily on eelgrass in shallow offshore waters (Thayer et al. 1984), and on marine algae (Whitlatch 1982).

MAPPING OF HABITATS

We developed a coverage of Canada goose foraging habitats in the Casco Bay study area, and sensitivity zones in which development may degrade adjacent habitats. Suitable conditions included shallow waters with an abundance of plant foods, or agricultural fields suitable for gleaning or grazing. We selected the following cover types: mud flats, grain fields, salt marshes, and shallow protected waters.

In lieu of information on minimum distances between foraging sites and development we used the MDIF&W disturbance buffers for wetlands (Jones et al. 1988). These were applied as a 30 m sensitivity zone for "low value" foraging habitats, and a 90 m zone for "moderate" or "high" value foraging habitats. Upland habitats were not assigned a sensitivity zone.

The steps in mapping habitats were:

1) select polygons from the MDIF&W CWCA's hosting =>1% of the Casco Bay total Canada goose count, for <u>any one of the seasons</u> surveyed. The 1% criterion reduces the scope of the analysis to habitats likely to be significant from a population standpoint.

> a) select areas within these polygons that are <= 1 m deep. Assign these a relative score of 4. The scores are used when combining coverages for various species.
>
> b) select areas within the polygons from step (2) having eelgrass beds, estuarine emergent vegetation, or other aquatic vegetation. Assign these a relative score of 8.

2) select polygons from the MDIF&W CWCA's that were used by 1% or more of the Casco Bay total Canada goose count <u>for more than one season</u>. Select areas within these polygons that are <= 1 m deep and; score these as 8.

3) select all other estuarine/marine aquatic beds or estuarine emergent vegetation <= 1 m deep, freshwater aquatic beds and palustrine emergent; score these as 4.

4) select the agriculture class from the satellite landcover (this is based largely on signatures from corn fields) that are =>5 acres; score these 4.

5) select MDIF&W inland MHVW rated 2 or 3; where these overlay palustrine emergent or aquatic beds assign these a score of 8, otherwise score as 4.

6) select estuarine, riverine, lacustrine, palustrine open water within 90 m of wetlands of step (4) above, score as 4.

7) identify sensitivity zones for above (except agriculture fields); use a distance of 30 m for areas scored 4 and 90 m for areas scored 8. Assign habitats within the sensitivity zone distance of existing development one-half the score of pristine habitats.

COVERAGE (Appendix A: Figure 8).

WATERB is a grid of the maximum of the scores for black duck, Canada goose, or common loon habitats, adjusted for impacts from existing development.

ATTRIBUTES:

COUNT number of 30 m square cells at each value.
VALUE cell values, adjusted for relative abundance.

Quality	**As adjusted for abundance** (from Table 1, all 1x)
0 (not suitable)	0
4 (suitable foraging habitat for loons, black ducks, or Canada goose)	4
4 - 6 (suitable brood-rearing or post-fledging habitat for black duck)	6
8 (preferred reproductive or foraging habitat for loons, black ducks, or Canada goose)	8

Grid Origin (x, y): 346755.000, 4804748.363
Grid Size (nrows, ncolumns): 4193,4047

Chapter 8. Bald Eagle Essential Habitats

GENERAL: The Casco Bay study area includes several bald eagle (*Haliaeetus leucocephalus*) nests. We lacked information on parameters to define the associated foraging habitat. Therefore, for this analysis, we included only nest site zones consisting of uplands within areas designated by MDIF&W as Essential Habitats.

DATA SOURCES: Data for the bald eagle coverage were obtained from the MDIF&W 1994 Atlas of Essential Wildlife Habitats for Maine's Endangered and Threatened Species. This source includes both active nest sites and currently inactive sites which were used within the last 5 years.

MAPPING OF HABITATS: Essential Habitats include the area within 1320' (402 m) of each nest (MDIF&W 1995). Upland areas within this zone were scored 8 as suitable habitat; inclusions which are currently developed were scored 0.

COVERAGE (Appendix A: Figure 9).

EAGBUFG2: gridcell coverage of current Eagle Nesting Habitats in Casco Bay, adjusted for development.

ATTRIBUTES:

COUNT: Number of cells for each value
VALUE: Cell values, adjusted for relative abundance.

Quality	**As adjusted for abundance** (from Table 1, rounded to 8x)
0	0
8 (Uplands within Essential Habitats)	64

Grid Origin (x,y): 346755.000, 4804748.363
Grid Size (nrows, ncolumns): 4193, 4047

Chapter 9. Roseate Tern Habitats

GENERAL: Roseate terns (*Sterna dougallii dougallii*), a state and federally listed endangered species, utilize certain coastal islands and inshore waters of Casco Bay. The two most important nesting islands for roseates in Maine are Eastern Egg Rock and Petit Manan Island, although the Sugarloaf Islands (at the eastern edge of our study area) were important sites historically and "could be the site of a restoration project" (Stephen Kress, Nat. Audubon Soc., pers. com.). Limited information from banding recoveries indicates that these roseate terns winter along the north coast of South America, and may remain there for the first and even second year of life (Ralph Andrews pers. com.). In Maine, roseates nest with the more aggressive common terns (which assists in nest defense) and also with arctic terns. Suitability of nesting sites is limited by many factors. These include appropriate vegetation, proximity of feeding areas, and absence of nesting gulls, humans, and predatory mammals and birds (Ralph Andrews, Steve Kress, pers. coms.). Jeff Spendelow (Patuxent Res. Center, pers. com.) stated that "good foraging sites for prey to feed the young" may be a major or limiting factor in maintenance of colonies.

SOURCES OF BIOLOGICAL AND SPATIAL DATA : Data for the tern coverages were obtained from the MDIF&W 1994 Essential Habitat maps, CWCA coverage, MDIF&W Seabird Island Database, and Andrews (1990). The federal Recovery Plan for the roseate tern (Andrews et al. 1989) contains data summaries and extensive discussion of management needs and actions. Biological sensitivity and requirements were derived from reports of Nisbet (1989), Shealer and Kress (1994), and Heinemann (1992). Additional spatial information included the coastal shoreline (OGIS) and bathymetry (MGS).

HABITAT CONSIDERATIONS

While records are available of roseate tern nesting in Casco Bay, we were not able to locate information on roseate tern foraging locations. Our primary data source for occurrence of marine wildlife, the CWCA coverage, does not list terns by species. Therefore, we developed a GIS coverage of potential roseate tern foraging habitats from surrogate information, taking into account the roseate tern's preferences. The following factors were considered:

Feeding range: Roseate terns may fly considerable distances from nesting or roosting sites to feed. Heinemann (1992) observed 11 and 16 km flight distances between a major roseate tern nesting colony at Bird Island, Massachusetts and its two primary feeding sites. Jeff Spendelow (pers. com.) noted that foraging excursions may, on occasion, be up to 50 km round trip. This information suggests that foraging areas located within 15 km of nesting islands may be suitable.

Feeding site fidelity: Ann Kilpatrick, (McKinney NWR, pers. com.) noted that the same sites off the north shore of Long Island were used day after day by birds from Faulkner Island, Connecticut. Nisbet (1989) noted that feeding by roseate terns around Buzzards Bay, Massachusetts, was generally restricted to a few specific areas; these did not change over a span of 10 years or more. At Petit Manan Island (Maine) roseates were observed to feed exclusively over a shallow bar between Petit Manan Point and Green Island (Nisbet 1989). Accordingly, specific foraging areas may be used persistently, and may be mapped for protection and management.

Feeding associates: Ann Kilpatrick, Shealer and Kress, and Andrews et al., observe that feeding flocks often are dominated by the far more abundant common terns. Heinemann described four types of roseate tern foraging behavior: shoal feeding - (in less than 3 m depth, but adjacent to deep water), feeding over shallow flats - (in less than 2 m depth), school feeding - (predator fishes driving forage fishes to surface along deep edges of shoals), and over feeding cormorants - (terns follow cormorants and capture fishes driven to the surface).

Feeding environment/prey: Jeff Spendelow commented that foraging frequently occurs at tide rips (typically where current flows over shallow bars), in relatively sheltered areas. Ann Kilpatrick found that the major prey at Long Island Sound sites was sand lance situated over shoals. Tom Halavik (FWS, pers. com.) notes that sand lance commonly are found at river mouth sandbars and shoals, and also as migrating pods. Young of the year summer in the surf zone, then settle a few hundred yards offshore. Heinemann (1992), working in Buzzards Bay, Massachusetts, reported that 95% of roseate's prey was sand lance in early summer, and herring (3 species), mackerel, and bluefish later in late summer. Nisbet (1989) also found that feeding was mostly on sand lance, but also on anchovy. Shealer and Kress (1994) observed foraging by roseates during the post breeding and pre-migration period (late July and August) at Stratton Island, Maine. At this time roseate terns fed almost exclusively on sand lance in Saco Bay (just south of Casco Bay), although other prey were available and were taken by common terns. Feeding typically occurred in < 10 m depths, over sand. Andrews (pers. com.) and Kress (1993) identified young white hake, pollack and herring as important foods for mid-coast and northeast Maine colonies.

MAPPING OF HABITATS

Nesting Islands: These were mapped directly from MDIF&W roseate tern Essential Habitats and the MDIF&W Seabird Island Database. Jane Arbuckle (pers. com.) submitted that persistent nesting by common terns may indicate suitable roseate nesting habitat. Three islands in Casco Bay supported common terns during both 1976 and 1984 surveys. Two of these were already Essential Habitats; Grassy Ledge (the third island) was added to our nesting island coverage. Outer and Inner Green, East Brown Cow, and White Bull Islands also were important nesting islands for common terns, historically (Stephen Kress, pers. com.). While these are not currently suitable for roseate terns, these islands are recogized as valuable habitats for other seabirds (see Chapter 10).

Foraging Habitats: A GIS coverage of potential roseate tern foraging habitats was developed from the CWCA coverage, based upon 3 attributes: proximity of polygons to roseate tern nesting islands, suitability of water depth, and foraging by species that feed in association with roseate terns (based on Heinemann 1992). In Maine Cormorants and common terns are far more abundant than roseate terns. Therefore, mapping the distribution of areas used by feeding associates is likely to be conservative (include or overestimate roseate tern feeding areas).

The steps were:

1) select polygons from the CWCA coverage which were within foraging range of known and potential nesting colonies (15 km).

2) from the above set we selected polygons used by foraging associates (terns and cormorants). CWCA polygon attributes include average count by season for each species. During the nesting and post-nesting season (May 1 to August 31, inclusive) the average count per observation for all terns (species not identified) was 7; for cormorants the average was 42. We selected polygons within foraging range for which there were:

> a) an average count > 6 terns for any season and there was not a contiguous tern nesting island or a beach on which least terns nest. This requirement reduced inappropriate identification of foraging areas when birds really were present only because they were nesting nearby. Score = 4.
>
> b) alternatively, polygons were selected which had an average count of > 41 cormorants for either the nesting or post-nesting season, and there was not a contiguous cormorant nesting island. Score = 4.
>
> c) if both terns and cormorants were feeding in an area score = 8.
>
> d) additional CWCA polygons were included, based on observations of roseate tern feeding by Jane Arbuckle (pers. com.); score = 8.

3) from the above set we retained areas < 10 m deep.

4) portions of nesting islands and feeding areas which are currently developed were scored 0.

The resulting GIS coverages are intended as representations of environmentally suitable land and water areas for roseate terns but are not intended to depict areas being managed or under regulatory control.

COVERAGE (Appendix A: Figure 10).

ROSEATE6 grid of roseate tern nesting islands and areas which are likely to be used for feeding by roseate terns.

ATTRIBUTES:

COUNT: number of 30 m sq cells having a particular value

VALUE: cell values, adjusted for relative abundance.

Quality	**As adjusted for abundance** (from Table 1, foraging rounded to 2x; nesting rounded to 7x)
0 (not suitable)	0
4 (suitable depth and in area used by cormorant <u>or</u> terns)	8
8 (suitable depth and in area used by cormorant <u>and</u> terns	16
8 (nesting island)	56

Grid Origin (x,y): 346755.000, 4804748.363

Grid Size (nrows, ncolumns): 4193, 4047

Chapter 10. Seabird Habitats

GENERAL: In addition to wading birds and the roseate tern (analyzed separately), seven seabird species were common to the Gulf of Maine Council's list of species for designating Regionally Significant Habitats, and the MDIF&W Seabird Nesting Island Database (the primary data source for this theme). However, only two of the seven (common eiders, *Somateria mollissima*, and common terns, *Sterna hirundo*) nest on Casco Bay islands. MDIF&W uses seabird nesting as a basis for designation of "Significant Wildlife Habitats;" islands proposed for such designation (draft NRPA islands) were added to the coverage even if none of the constituent species were on the Gulf of Maine Council's list.

In addition to nesting habitat, this analysis identifies aquatic habitats (foraging and probably resting) for eiders and terns, and sensitivity zones in which development can be expected to degrade the adjacent habitats. These coverages are <u>not</u> intended to depict the limits of areas being managed or under regulatory control.

SOURCES OF BIOLOGICAL AND SPATIAL DATA : Data for all islands within or bordering Casco Bay were obtained from the MDIF&W Seabird Nesting Island Database. Foraging and resting areas were determined from MDIF&W's CWCA coverage. Additional spatial information included the coastal shoreline (OGIS), bathymetry (MGS), and shellfish and eelgrass beds (DMR).

HABITAT CONSIDERATIONS

<u>Eider:</u> The common eider is a large, social sea duck with circumpolar distribution (Blumton et al. 1988). It breeds on small coastal islands in the Gulf of Maine. Guillemette et al (1993) noted that common eiders feed along rocky shores, diving for blue mussels, urchins, and crabs. They prefer shallow waters over kelp beds where their prey is most abundant; in the Gulf of St. Lawrence these areas occur at depths of 0 -6 m. Goudie and Ankney (1988), however, note that apparent interspecific competition between 4 species of wintering sea ducks displaced eiders from some shallow foraging areas. They characterize eider foraging depths in the presence of other sea ducks as -3 m down to -10 m.

<u>Tern:</u> Common terns also nest on small coastal islands, and also on islands in some large lakes (Veit and Petersen 1993). Nesting terns often are displaced by gulls from the most favorable insular sites. Terns feed on small fishes, often over tide rips (typically where current flows over shallow bars), in relatively sheltered areas. Prey items include young herring (*Clupea*), mackerel, bluefish, sand lance, and anchovy (Heinemann 1992).

MANAGEMENT CONCERNS

Human disturbance can be a problem for either species, reducing availability of foraging areas or driving birds from nests and thus increasing exposure of young and eggs to predators. Therefore, we mapped zones within which development would likely degrade value of the adjacent habitat.

Nesting: We used the literature and available data sets to assign sensitivity distances for individually for terns and eider nesting islands; we did not assign a sensitivity distance specifically for draft NRPA islands. Erwin (1989) found that nesting common terns and black skimmers flushed when approached within 200 - 400 m. He recommended that a 200 m buffer be established for human intrusion near colonies. While a 200 m zone may be sufficient as a human approach- distance for common terns, development is likely to prolong and increase the types of disturbance. We used GIS to examine distances between developed lands and seabird colonies along the New Hampshire, Massachusetts, and Maine coast. We found the closest that common terns nested to an industrial site was 260 m, while the minimum distance between residential land uses and nesting birds was 480 m (45 colonies examined). We selected a 300 m sensitivity zone for sites on which common terns nested. None of the common tern nesting sites in Casco Bay occur this close to development.

Blumton et al., (1988) developed a nesting habitat model for the eider which included sensitivity to human disturbance as a factor. Their optimal distance from permanent human settlement was 2 km or more. The minimum distances observed between eider colonies and development in Casco Bay are 580 m (Crow Island-Great Diamond), 410 m (Pinkham Island-South Harpswell), and 490 m (Seal Island-Small Point). Because the minimum distances still may be relatively stressful, we rounded the minimum up to 500 m for sensitivity zones around nesting islands for eiders.

Feeding: available data did not allow us to examine proximity of foraging sites and development. One can argue that birds can more readily abandon foraging areas than nest sites, since the former involve less of an "investment". We generally accepted the MDIF&W disturbance distances (Jones et al. 1988), using a 30 m sensitivity zone for relatively low value foraging habitats, and a 90 m zone for moderate or high value foraging habitats.

MAPPING OF HABITATS

The steps in mapping habitats were:

EIDER FORAGING:

1) Select polygons from the MDIF&W CWCA's hosting 1% or more of the total eider count for the study area, for any of the survey intervals. The 1% criterion reduces the scope of the analysis to habitats likely to be significant from a population standpoint.

2) Select areas within these polygons that are <= 10 m deep. Assign these a relative score of 4.

3) Select areas having mussel beds, eelgrass beds, or other submerged vegetation within the polygons from step (2). Assign these a relative score of 8.

4) Select areas outside the CWCA's that are <= 10 m and have mussel beds, eelgrass beds, or other submerged vegetation. Assign these a relative score of 4.

EIDER NESTING:

1) Identify islands with 1% or more of the Casco Bay total eider nest count. Assign these a relative score of 8.

COMMON TERN FORAGING:

1) Select polygons from the CWCA coverage hosting 1% or more of the study area total tern count, for any of the 3 seasons during which they occurred there. It was assumed that the unidentified terns counted in this coverage were predominantly common terns. Assign these polygons a relative score of 4.

COMMON TERN NESTING:

1) Identify islands with 1% or more of the Casco Bay total tern nest count. Assign these a relative score of 8.

OTHER SEABIRD NESTING ISLANDS:

Assign draft NRPA islands a score of 8.

ADJUST FOR IMPACTS FROM EXISTING DEVELOPMENT:

Reduce the foraging habitat values by half if within impact zone around existing development: zones are 30 m for habitats scored 4, 90 m for areas scored 8. Areas which are currently developed were scored 0.

COVERAGE (Appendix A: Figure 11).

SEABHAB2 grid of foraging and nesting habitats for eiders and terns, and draft NRPA seabird nesting islands; habitat scores adjusted for effects from existing development.

ATTRIBUTES:

COUNT: number of 30 m square cells at each value.
VALUE: habitat scores, adjusted for relative abundance.

Quality	**As adjusted for abundance** (from Table 1,foraging rounded to 1x; nesting rounded to 3x)
0 (not suitable)	0
4 (suitable foraging habitat for eiders or terns)	4
8 (preferred foraging habitat for eiders or terns)	8
8 (nesting island)	24

Grid Origin (x, y): 346755.000, 4804748.363
Grid Size (nrows, ncolumns): 4193,4047

Chapter 11. Shorebird Habitats

GENERAL: Piping plovers (*Charadrius melodus*) and least terns (*Sterna albifrons*) nest on dunes and beaches, and forage on flats and in nearshore waters of Casco Bay. The plover is listed as endangered by Maine and threatened by federal authorities; least terns are listed as endangered by Maine.

SOURCES OF BIOLOGICAL AND SPATIAL DATA: Data for the least tern and piping plover coverages were obtained from Brad Allen and Lindsay Tudor (MDIF&W), and Jody Jones of the Maine Audubon Society (Audubon). MDIF&W shorebird foraging and roosting surveys date back to 1979. Audubon has conducted nesting surveys of piping plovers since 1981, and least terns since 1977. The federal Recovery Plan (1987) for the piping plover contains data summaries and extensive discussion of management needs and actions; an updated revised plan is in draft.

Plover and tern nest locations depicted in Jones and Camuso (1994) were traced onto USGS 7.5' topographic quads, then digitized as point coverages. CMGE digital quads for Small Point, Cape Elizabeth, and Prouts Neck provided beach, intertidal and subtidal polygons which were interpreted as nesting and foraging habitats (see below); NWI maps were used to identify some intertidal foraging habitats. MDIF&W supplied coverages of plover and tern Essential Habitats; these were used in establishing boundaries for sensitivity zones. A digital representation of the Casco Bay coastline was obtained from OGIS.

HABITAT CONSIDERATIONS

Least tern nesting: Although tern nesting beaches are relatively dynamic, site fidelity is indicated by consistency of nesting efforts. Atwood and Massey (1988) show that least terns in California are prone to return to previous year colony sites, or move only short distances. This implies conservation benefits from identifying and protecting long term nesting areas and associated requisites, such as foraging habitats.

Least tern foraging: Least tern foraging habitats around nesting areas were identified from figures in Jones and Camuso (1994). The areas identified were well within the distances stated by Atwood and Minsky (1983). The latter described foraging distances for breeding colonies of least terns in California as "90-95% within 1 mile of shore in water less than 60 feet in depth." Typical foraging habitat is within 2 miles of colony sites in "relatively shallow nearshore ocean waters in the vicinity of major river mouths...". Jones and Camuso observed the relative distributions of terns feeding in the marsh behind the nesting area and the ocean in front of it. They noted 93 of 468 feeding episodes in the marsh versus 375 over the ocean. Birds feeding in the marsh tended to stay relatively near the nest area, but range more widely when feeding over the ocean.

Piping plover nesting: Piping plovers nest on dynamic coastal beaches and sand spits above the high tide line. Nesting substrate consists of sand and gravel or shells, in which the birds excavate a shallow depression. Nests are typically situated in open sand, but can also be found in sparse or moderately dense beach grass. Nesting occurs from April through late July. Chicks are mobile shortly after hatching and fledge by the end of August.

Piping plover foraging: Piping plover adults and chicks feed on invertebrates on intertidal beaches and flats, and on organisms associated with beach wrack. During the reproductive season, feeding areas generally are contiguous with nesting and brood rearing areas. Jones and Camuso observed 65 of 453 feeding events over the marsh behind nesting beaches versus 388 on the ocean side.

MANAGEMENT CONCERNS

Most Maine piping plover nests are now individually protected by fencing to exclude predators and pedestrian or vehicular traffic (Jones 1993); these efforts enhance nesting success even within relatively developed locations. Such intensive persistent management to some degree substitutes for imposition of large passive natural protective buffer zones, which are infeasible due to the high level of recreational use and development of southern Maine beach sites. Least terns nest colonially, so protection of their nests from predators has been far less effective than for plovers (Jones 1993). For this reason more remote (island) beaches should be examined for possible establishment or natural maintenance of tern and plover populations. This was the purpose for our identification of potential nesting habitat (see below).

We attempted to map sensitivity zones in which development may degrade the adjacent habitats. This was set at 90 m (295') for nesting, potential nesting, and feeding habitats, based on information collected by Robert Buchsbaum (ms.) His distances for shorebird tolerances, 180' to 300', agree with MDIF&W buffer zones for riparian habitats (Jones et. al. 1988).

Finally, we overlaid our coverage onto the MDIF&W designated piping plover and least tern Essential Habitats. Any Essential Habitat areas not already within our coverage were then included as an additional sensitivity zone.

MAPPING OF HABITATS

Observed nesting areas: Least tern and piping plover nesting areas for the lower 15 towns in the lower Casco Bay watershed were identified from Maine Audubon's 1994 Piping Plover and Least Tern Project Report (Jones and Camuso 1994). Nesting areas were overlaid on CMGE digital quads, and the corresponding CMGE beach polygons were selected for our shorebird coverage. Known nesting areas were scored 8.

Potential nesting areas: The CMGE maps displayed many beach areas on the mainland and islands which might offer additional or alternative nesting habitat for terns and plovers. Polygons with suitable designations were selected (Table 7), the characteristics examined further on USGS quads and black and white aerial photos, then placed into the coverage if deemed to be similar to areas used by these birds. Next we eliminated potential nesting areas smaller than smallest beach area in use (11,000 sq m, about 2.7 acres), based on comments by John Atwood (Manomet Observatory, pers. com.). Potential nesting areas were scored 4.

Table 7. Polygon Types Included as Suitable Nesting or Foraging Habitats for Least Terns and Piping Plovers.

Tern Foraging:

Coastal Marine Geologic Environment Categories

B1: intertidal sand beach
C2: medium velocity tidal channel
C7: Inlet channel
F1: Coarse grained flat
Me: ebb tidal delta
Mf: flood tidal delta
Mp: point or lateral bar

National Wetland Inventory Categories

E2US3N: estuarine intertidal, unconsolidated mud shore
M2US3N: marine intertidal, unconsolidated mud shore

Plover Foraging:

Coastal Marine Geologic Environment Categories

M1: High salt marsh
B1: sand beach
Mp: point or lateral bar

National Wetland Inventory Categories

E2US3N: estuarine intertidal, unconsolidated mud shore
M2US3N: marine intertidal, unconsolidated mud shore
E2EM1P: estuarine intertidal, emergent vegetated

Tern and Plover Nesting:

Coastal Marine Geologic Environment Categories

Sd: dunes, vegetated beach ridge

Feeding areas: Foraging habitats were added to our coverage by selecting CMGE polygons having the appropriate tidal and substrate characteristics (Table 7) and located within the areas most frequently used, based on depictions in Jones and Camuso. Additional foraging areas were selected from the CMGE and from National Wetland Inventory (NWI) digital maps, based on correspondence with the MDIF&W shorebird database. Known feeding areas were scored 8 for habitat quality.

Essential Habitats: areas which were outside the above habitats and sensitivity zones, and within the piping plover and least tern Essential Habitats were scored 4.

Adjustment for impacts from existing development: The above habitat values were reduced by half if within a 90 m wide "impact" zone around existing development. Areas which are currently developed were scored 0.

The coverages are intended as representations of environmentally suitable land and water areas for the two species but are not intended to depict areas being managed or under regulatory control, such as Maine Essential Habitats, or federal Critical Habitats.

COVERAGE (Appendix A: Figure 12).

SHORBG6 grid coverage of nesting and foraging areas, including effects from existing development.

ATTRIBUTES:

COUNT: number of 30 m square cells at each value.
VALUE: habitat scores, adjusted for relative abundance.

Quality	**As adjusted for abundance** (from Table 1, foraging rounded to 2x; nesting to 4x)
0 (not suitable)	0
4 (potential nesting habitat for plovers or terns)	16
8 (known foraging habitats for plovers or terns)	16
8 (known nesting habitats for plovers or terns)	32

Grid Origin (x, y): 346755.000, 4804748.363
Grid Size (nrows, ncolumns): 4193,4047

Chapter 12. Wading Bird Habitats

General: Wading birds are conspicuous wildlife of Casco Bay coastal and inland wetlands, and long have been regarded as biological indicators of environmental quality. While several species of egrets and herons nest in Maine, only the great blue heron (*Ardea herodias*) is on the Gulf of Maine Council's list of species for designating Regionally Significant Habitats. However, we used data regarding nesting colonies including the other species also, since these sites are likely to be suitable for all wading birds. The other species were: snowy egret (*Egretta thula*), black crown night heron (*Nycticorax nycticorax*), yellow crown night heron (*N. nyctanassa*), glossy ibis (*Plegadis falcinellus*), little blue heron (*E. caerulea*), and cattle egret (*Bubulcus ibis*).

SOURCES OF BIOLOGICAL AND SPATIAL DATA : Data on Maine wading bird colonies and coastal foraging areas were obtained from Brad Allen (MDIF&W), Andrews 1990, Gibbs and Woodward 1984, Tyler 1977, and Hutchinson and Ferrero 1980. A June 24, 1992 memo from Kyle Stockwell also was used to update colony distribution; locations of two inland colonies were provided by P. Bozenhart (MDIF&W). Additional information on biological tolerances and requirements were taken from Short and Cooper 1985, Chapman and Howard 1984, Tyler 1977, Gibbs and Woodward 1984, and from Gibbs et al. 1991.

Biological coverages included the CWCA's (MDIF&W), eelgrass (DMR), and wetlands (NWI). We also utilized MDIF&W MHVW's for assigning habitat scores. Landcover was developed as part of this study (Chapter 4). Additional spatial information included the coastal shoreline (OGIS), CMGE, and bathymetry (both from MGS).

HABITAT CONSIDERATIONS

The importance of foraging habitat is related to intrinsic characteristics (abundance of prey, accessibility of prey) and, for colonial nesting birds, distance from roosts or colony sites. Accordingly, scores were assigned in two phases: (a) by cover type, as indicative of foraging conditions, and then (b) based on distance from known colony sites (Erwin et al., 1993). The latter valuation method was supplemented by (c) "high" and "medium" value wading bird habitat areas as assessed by the MDIF&W (MHVW), and coastal areas in which wading birds were observed feeding (Hutchinson and Ferrero 1980).

A. Use of cover characteristics as an indicator of foraging value: The MDIF&W (agency memo of 12-22-93) used three variables (percentage of open water, wetland area, and diversity of wetland types) to rate particular wetlands as important to waterfowl and wading birds. However, criteria for wading birds may differ somewhat from those for waterfowl. Also, findings of Gibbs et al. (1991) suggest that these variables are not consistently associated with habitat use by wading birds (see Table 8). Accordingly, size and configuration of wetlands was only taken into account by giving special emphasis to the "moderate" and "high" value wetlands so identified by MDIF&W (see below).

As an alternative, the foraging value of wetlands were derived from NWI types, and from available occurrence data. Certain ecological systems were regarded as particularly productive or likely to host concentrations of forage organisms on a cyclic (tidal or seasonal) basis. Thus intertidal estuarine, palustrine, tidal riverine and littoral habitats were scored relatively high, while intertidal marine and limnetic areas were accorded intermediate scores. Emergent or aquatic vegetation (e.g., E2EM or E2AB) also indicated highly productive conditions; unconsolidated shore or reef offered moderate productivity but good exposure of prey, while scrub/shrub, rocky shore, forested, or unconsolidated bottom were regarded as less suitable from the standpoint of structure. The assignments of habitat foraging values for wading birds, interpolated from these factors and adapting the comments of Chapman and Howard and Gibbs et al., is shown in Table 9.

B. Distance from colony sites as a factor in foraging value of wetlands: Wading bird colonies are located at sites remote from predators and disturbance, yet within range of wetland foraging areas (Gibbs and Woodward 1984). These distance factors were considered as a sequence of zones around known colony sites. Habitat within the zone closest to the colony ("colony zone") was rated high both to protect the colony, and because use of nearby wetlands for foraging would minimize energy expenditure for the birds. More distant habitats were assigned to "primary" and "secondary" foraging zones, having correspondingly lower relative values.

Wading bird colonies within 30 km of the study area were mapped as a GIS coverage; all relevant colonies were on islands in Casco Bay.

Table 8. COMPARISON OF OBSERVED WADING BIRD USE OF INLAND WETLANDS AND WETLAND RANKING CRITERIA

Data from Gibbs, J.P., J.R. Longcore, D.G. McAuley and J.K. Ringelman. 1991. Use of Wetland Habitats by Selected Nongame Water Birds in Maine.
U.S. Fish Wildl. Serv., Fish Wildl. Res. 9. 57pp. 87 Maine wetlands, 20 variables, 1501 visits.

VARIABLES => (from Gibbs et al)	PERCENTAGE OPEN WATER			WETLAND AREA (HECTARES)			LIFE FORM DIVERSITY			nwi types * most used by waders (examined only l,pab,pem,pf,pss,pub)	nwi types rarely used by waders
SPECIES	signif.	preferred	not preferred	signif.	preferred	not preferred	signif.	preferred	not preferred		
Amer. bittern	0.01	28.8	54	ns			0.05	1.8	1.3	pss,pf,pem,pab	pub
great blue heron	0.05	35	54	0.01	10	4	ns			pss,pf,pem,pab,l	pub
green-bk. heron	ns			0.05	3	8	ns			pss	pab,l,pf,pub
Virginia rail	ns			0.05	17.8	7	ns			pss,pf	pab,l,pub
sora rail	0.05	19.8	46	ns			ns			pss,pem,pf	l,pub
Condition for preferred WWH ranking =>		35 to 65			medium to large			3 or more wetl. types		TYPE	RANKING
										l	5
										pab	4
										pem	3
										pf	2
Species' preference compared to WWH criteria =>		1 of 5 agree			2 of 5 agree			1 of 5 agree		pss	1
										pub	6

* National Wetland Inventory Types

pab	Palustrine aquatic bed
pem	Palustrine emergent
pf	Palustrine forested
pss	Palustrine scrub shrub
pub	Palustrine unconsolidated bottom

Table 9. Wetland Types found in Casco Bay and Their Suitability for Wading Birds Based on National Wetlands Inventory Attributes

NWI abbreviation	Description	Relative foraging suitability for wading birds** (0 to 4)	Adapted from Gibbs et al. 1991	Adapted from Chapman and Howard, 1984 (* = 'of value')
M1UB -	Marine, Subtidal, Unconsolidated Bottom	0		
M2AB -	Marine, Intertidal, Aquatic Bed	3		
M2RF -	Marine, Intertidal, Reef	2		
M2RS -	Marine, Intertidal, Rocky Shore	1		
M2US -	Marine, Intertidal, Unconsolidated Shore	2		
E1UB -	Estuarine, Subtidal, Unconsolidated Bottom	0		
E2AB -	Estuarine, Intertidal, Aquatic Bed	4		*
E2RS -	Estuarine, Intertidal, Rocky Shore	2		
E2US -	Estuarine, Intertidal, Unconsolidated Shore	4		*
E2EM -	Estuarine, Intertidal, Emergent	4		*
R1UB -	Riverine, Tidal, Unconsolidated Bottom	0		*
R1AB -	Riverine, Tidal, Aquatic Bed	4		*
R1RS -	Riverine, Tidal, Rocky Shore	2		
R1US -	Riverine, Tidal, Unconsolidated Shore	4		*
R2UB -	Riverine, Lower Perennial, Unconsolidated Bottom	0		*
R2RS -	Riverine, Lower Perennial, Rocky Shore	1		
R2US -	Riverine, Lower Perennial, Unconsolidated Shore	2		*
R3RB -	Riverine, Upper Perennial, Rock	0		
L1UB -	Lacustrine, Limnetic, Unconsolidated Bottom	0	1	
PUB -	Palustrine, Unconsolidated Bottom	2	0	*
PAB -	Palustrine, Aquatic Bed	3	2	*
PEM -	Palustrine, Emergent	4	3	*
PSS -	Palustrine, Scrub-Shrub	4	4	*
PFO -	Palustrine, Forested	3	3	*
U -	Upland	0		

Gibbs, J.P., J.R. Longcore, D.G. McAuley and J.K. Ringelman. 1991. Use of Wetland Habitats by Selected Nongame Water Birds in Maine. U.S. Fish Wildl. Serv., Fish Wildl. Res. 9. 57pp.

Chapman, B.R. and R.J. Howard. 1984. Habitat suitability index models: great egret. Biol. Rept. 82(10.78), U.S. Fish and Wildlife Service

** Suitability based upon literature, and higher anticipated productivity in wetlands with aquatic macro-vegetation and in tidal waters, and by greater accessibility to forage in wetlands offering limited obstructions.

The colony was then circumscribed by a primary foraging zone, characterizing a "home range" for most of these species. Foraging distances were estimated from discussions in Erwin et al., 1987. The cited flight distances were generally (50-70%) less than 5 km; mean travel distances for 4 species of egrets and herons "were all well below 5 km". Frederick and Collopy (1988) also found daily travel distances of 5 km or less. Short and Cooper (1985) rated foraging areas at 5 km at 1/2 the value of those within 1 km, and at 10 km at 0.1 of the base value. Figures in Gibbs and Woodward were considerably greater; from a mean of 6 km to a maximum of over 30 km. They found a significant linear relationship between the quantity of "marsh" within 25 km and colony size.

Home range was further estimated by overlaying a GIS coverage of colony sites on polygons from Hutchinson and Ferrero (1980) in which one percent or more of the population of any wading bird species' was observed foraging during the nesting season. A 10000 m (radius) buffer around all colony sites was found to include these polygons, and this was used as the primary foraging zone. All of the rest of the watershed within the lower 14 towns lies within 25 km of island colonies (considered the secondary foraging zone). Foraging habitats within the primary zone were scored higher than those within the secondary zone.

C. <u>Further identification of foraging areas from aerial survey and expert appraisal</u>: Two supplementary measures of wading bird usage were adapted from MDIF&W products. Coastal concentration areas (from Hutchinson and Ferrero 1980) used by wading birds were assigned scores based on number of wading bird species seen and number of seasons they were present. The basic unit was occurrence of 1% or more of the Casco Bay population of a species during any of six seasons of the surveys.
MDIF&W Moderate and High Value Wetlands also were assigned scores indicating an increased likelihood of use of these habitats.

MAPPING OF HABITATS

The final coverage was a composite of the values from the three data sources from (B) and (C) above (location with respect to the colonies, CWCA, and MHVW) and the "intrinsic" wetland scores from (A). For each wetland site, the overall score for wading bird foraging was the <u>maximum</u> from (B) or (C) times the "intrinsic" score based on NWI type. Nesting islands then were included, yielding a range of habitat quality scores from 8 to 4.

Colony disturbance or sensitivity zones were established as a buffer around the nesting islands; the appropriate protective buffer distance for colonies was estimated from the following. Watts and Bradshaw (1994) observed that Chesapeake Bay wading bird colonies were located about 790 m from buildings, significantly different from the average of 460 m for random points. Rodgers and Smith (in press) conducted flushing response experiments and found that humans and boats could approach to within 125 m of wading bird colonies without overtly disturbing nesting birds. Management guidelines from John Ogden, (ms.) recommend an 800 m buffer around woodstork colonies. We also examined proximity of residential and commercial landuse to seabird colonies along the Massachusetts coast. We measured distances between colony sites and land use mapped at 1:24000, using GIS. Among the 45 colonies including species other than cormorants and gulls, the minimum distance to development was 700 to 1000 m. Based on this, we established a colony sensitivity zone of 800 m.

Bird use of foraging areas depends to some degree on isolation from disturbance and maintenance of environmental factors such as water quality. Short and Cooper (1985), in a habitat suitability model for great blue herons, recommend buffering feeding areas at 100 m. Robert Buchsbaum (Massachusetts Audubon Society, pers. com.), reviewing literature and his field observations, offered tolerance distances ranging from 60 feet for great egrets to 300 feet for great blue herons. Bratton (1990) conducted a series of boat intrusion experiments. She observed that egrets and herons were likely to flush and leave foraging areas when a boat approached to within 60 m. Chapman and Howard (1984) noted that boating and other water activities within 50 m are adverse for great egret nesting colonies. The development of neighborhoods around foraging or nesting habitats may increase vehicular traffic, and also offer a base for secondary disturbances from domestic animals or recreational activities. Therefore, the sensitivity zone distance should be larger than the minimum at which birds flush. MDIF&W buffers moderate and high value riparian and wetland habitats at 250' (Jones et al. 1988). We used a 30 m sensitivity zone for habitats which scored lowest, and a 90 m zone (about 295') for the higher scored foraging habitats. In all cases, the scores of foraging habitats within the sensitivity zone distances of existing development were reduced to one-half the score of pristine habitat. Areas which are currently developed were scored 0.

COVERAGE (Appendix A: Figure 13).

WADEHAB2 grid of foraging and nesting habitats for wading birds, including effects from existing development.

ATTRIBUTES:

COUNT: number of 30 m square cells at each value.
VALUE: habitat scores, adjusted for relative abundance.

Quality	**As adjusted for abundance** (from Table 1, foraging rounded to 1x; nesting to 4x)
0 (not suitable)	0
4 (suitable foraging habitat)	4
8 (preferred foraging habitats near to nesting colonies	8
8 (nesting habitats)	32

Grid Origin (x, y): 346755.000, 4804748.363
Grid Size (nrows, ncolumns): 4193,4047

Chapter 13. Freshwater and Anadromous Fish Habitats

GENERAL: Lake and stream fisheries are ecologically important in the Casco Bay watershed and serve as significant recreational assets. MDIF&W developed a fisheries habitat appraisal method (MDIF&W 1989) which combines environmental characteristics, recreational values, and relative abundance of fish species to yield a numerical estimate of fisheries value. These numerical scores were regarded as the primary measure of value for resident fishes; other data were used as surrogates, as described below.

Our evaluation also considered anadromous and catadromous fishes species, those dependent on both fresh waters and the ocean. Nine species were common to the available databases and the Gulf of Maine Council's Species List for Identifying Regionally Significant Habitats. These were: alewife (*Alosa pseudoharengus*), American eel (*Anguilla rostrata*), American shad (*Alosa sapidissima*), American smelt (*Osmerus mordax*), Atlantic salmon (*Salmo salar*), Atlantic tomcod (*Microgadus tomcod*), brook trout (*Salvelinus fontinalis*), redbreast sunfish (*Lepomis auritus*) and shortnose sturgeon (*Acipenser brevirostrum*). Anadromous and resident species were given approximately equal weighting in the overall stream habitat ratings.

SOURCES OF BIOLOGICAL AND SPATIAL DATA

General: Most of the fisheries assessments and the basic sampling data on Casco Bay stream and lake fishes were obtained from Owen Fenderson and Richard Arsenault of MDIF&W. Information on anadromous fishes was digitized from Eipper et al. 1982. This publication did not consider striped bass, (*Morone saxatilis*) another important anadromous species which occurs in coastal inshore waters and downstream of dams in the Kennebec and Androscoggin rivers (Flagg 1994, Flagg and Squiers 1995). Casco Bay, and the Kennebec River in particular, supports a highly significant striped bass recreational fishery. The omission of this species did not affect the outcome of the analysis, however, since both rivers were regarded as highly important fisheries habitats based on their value to other species.

Landcover was developed as part of this study (Chapter 4). Digital representations of the Casco Bay coastline, ponds, lakes, streams and rivers were obtained from OGIS. NWI and CMGE were used to identify intertidal and subtidal areas within the lower reaches of major rivers.

Stream fisheries: Biological and ecological data on streams in the lower 15 towns of the Casco Bay watershed were obtained from MDIF&W records held at Gray, Maine; we entered these into a digital database. Most of this information is based on surveys carried out in 1986/87, which documented biota, water chemistry, and stream structure at one or more characteristic sites along most of the major streams and rivers in the watershed. Data from each sample site was applied to upstream and downstream reaches having the same name, or down to tidal waters. Attributes included: date of collection, stream name, MDIF&W number, town, sampling location, length and width of sample area, substrate, temperature, pH, conductivity, alkalinity, riparian cover, and numbers of fishes, invertebrates, and reptiles collected.

Several digital databases were provided by Owen Fenderson, MDIF&W, Bangor, Maine. These listed names and locations of most of the permanent streams and characterized sport fisheries of the major streams, rivers and lakes. These databases and information from more extensive local MDIF&W records were combined to form attributes for an overall stream fish GIS coverage. Stream use by anadromous fishes was added from Eipper at al. 1982, and Card et al. 1981.

Lake fisheries: Data were obtained from the MDIF&W Lake Inventory (1993 Format), a statewide database containing fields for water chemistry, recreational characteristics, and fish species. Each of 60 species was rated as either not known to be present (0), present (1), present as a significant fishery (2), or being stocked (3). The Inventory was supplemented by a fisheries database, focussed on recreationally important species ("Occurrence of Fishable Populations"; data set FISH.FISHERY, supplied by O. Fenderson). The databases were combined by assuming that each species from the latter was "present as a significant fishery". Overall, data was available for 16 lakes and ponds in the study area.

HABITAT CONSIDERATIONS

Stream habitat valuation: Habitat scores from MDIF&W were available for most of the streams in the study area. For streams without MDIF&W scores we developed a surrogate measure from the electrofishing data set, based on counts of sport fish species. We first verified that a positive and significant correlation existed between the MDIF&W scores and sport fish counts for the 84 streams where both measures were available. The score based on counts of species was indexed to match MDIF&W range, and was used to complement the absent MDIF&W scores.

To either of the above habitat scores we added a value for present or anticipated use by anadromous fishes. Nine species of anadromous fish were documented from the Casco Bay watershed; the number of species per stream was indexed to match MDIF&W range.

Lake habitat valuation: As with the streams coverage, the MDIF&W habitat rating was used where available for lakes in this watershed. Where not available, we substituted scores from another database ("FISH.LKVALUES" supplied by Owen Fenderson, MDIF&W) which listed intermediate values from the MDIF&W habitat appraisal process. Alternatively, to characterize lakes about which we had fisheries data but no appraisal from MDIF&W, we summed the number of species present by lake and indexed this to the maximum for any lake in the study area .

MAPPING OF HABITATS

Stream data: stream scores were the sum of the score from MDIF&W habitat evaluation or, alternatively, the surrogate score we developed from MDIF&W surveys, plus a score based on the relative number of anadromous species. The sum of resident and anadromous values was indexed on 0 to 8 basis. Stream boundaries were derived from stream and river coverages (from OGIS). In coastal reaches, riverine subtidal areas were assigned the full score, while adjacent intertidal flats were given half the score.

Lake data: lake habitat scores were derived either from (in order of availability) 1) the MDIF&W rating, 2) the MDIF&W rating intermediate values, or 3) the relative number of species present. These scores were indexed on 0 to 8 basis.

Sensitivity/protection zones: We mapped protection or sensitivity zones peripheral to these habitats in which development activities may be expected to affect fish habitat quality. We first attempted to identify effects of existing riparian development on fish communities by relating the fisheries data to the extent of development. Accordingly, we compared the proportion of each subwatershed that was determined to be developed or in agriculture (based on the landcover analysis), and the fishery scores or composition of the fish communities for the associated stream. We also compared the fisheries parameters for streams in relation to the proportions of land developed within 180 m and 480 m wide corridors. Neither analysis disclosed any significant relationship, probably because of data limitations. Also, most of our fisheries data were from the 1980's, while the landcover information is based on 1991 imagery. Finally, the precision of the landuse determinations may be inadequate for this purpose.

We finally adopted a rule-based approach based on MDIF&W riparian distances (Jones et al. 1988). Protection or sensitivity zones were based on the stream and lake scores; waters with MDIF&W ratings of F1 ("low value") or occurrence of 1 to 3 anadromous species were given a 30 m (~100 ') sensitivity zone. Higher rated waters were given a 90 m (295') zone. To account for impact from riparian development, we scored fisheries habitat within these distances from existing development one-half that for pristine habitat.

COVERAGE (Appendix A: Figure 14).

FISHHAB5 grid of lake and stream fish habitat scores, including effects from existing development. Cell values are the maxima from the stream and lake components.

ATTRIBUTES:

COUNT: number of 30 m square cells at each value.

VALUE: habitat scores, adjusted for relative abundance.

Quality	As adjusted for abundance (from Table 1, rounded to 2x)
0 (not suitable)	0
2 (suitable habitat, some fisheries value)	4
4 (intermediate fisheries value)	8
8 (high fisheries value)	16

Grid Origin (x, y): 346755.000, 4804748.363
Grid Size (nrows, ncolumns): 4193,4047

Chapter 14. Funding Opportunities for Habitat Protection

Conservation organizations and private landowners may be interested in using this report to identify important areas for habitat protection. Voluntary habitat protection strategies include conservation easements, land acquisition, restoration and management, agricultural incentives and conservation education. Conservation Options (Schauffler 1994) details other opportunities available for private landowners interested in land protection. The following cooperative initiatives and funding opportunities are currently available through the federal and state government to implement habitat protection measures:

The North American Waterfowl Management Plan is an international effort to conserve the continent's remaining wetlands and increase migratory bird populations. It is a matching partnership program that includes the governments of the United States, Canada, Mexico, states, provinces and over 200 private groups. More than $30 million in funding for the Plan has been funneled through the North American Wetlands Conservation Act for habitat protection. The Atlantic Coast Joint Venture, which includes coastal habitats in the Gulf of Maine, is one of nine Joint Ventures identified by the plan. Over 60,000 acres of wetlands will be protected on the Atlantic coast when this Joint Venture is completed.

The Partners for Wildlife Program improves and protects fish and wildlife habitat on private lands through alliances between the U.S. Fish and Wildlife Service and other organizations and individuals, while leaving the land in private ownership. Since its establishment, the program has restored thousands of acres of wetland habitat and associated uplands through habitat restoration and management programs that blend wildlife conservation with profitable land use. Besides habitat restoration and management activities, the program also establishes habitat protection programs, provides technical assistance with land management problems such as reducing pesticide use and managing water levels, and conducts demonstration projects to promote the importance of private lands for fish and wildlife resources.

In 1988, the **U.S. Fish and Wildlife Service** began the Challenge Grant program to restore living resources and habitats on National Wildlife Refuges, Fish Hatcheries, research facilities, and private lands. The program manages resources in partnership with non-federal public and private organizations and individuals. The U.S. Fish and Wildlife Service will provide up to 50% of the total project cost. Partners or cooperators provide the remainder -- in cash, material, equipment, land and/or services.

The **National Fish and Wildlife Foundation** is a non-profit organization established by Congress to award challenge grants for conservation activities on behalf of fish, wildlife and plant conservation. Programs include habitat protection and restoration, research, public awareness, education and management. Grants are awarded three times a year and are distributed among federal, state, and provincial agencies, colleges and universities, private corporations, and domestic and international conservation organizations. Grants are awarded on a 2:1 matching basis; for every dollar in federal funds awarded, two dollars in direct non-federal contributions must be provided.

The U.S. Fish and Wildlife Service's Northeast Region Wetland Concept Plan identified nearly 850 wetland sites that warrant consideration for acquisition within the 13 state region. The Plan was developed as part of the Emergency Wetlands Resources Act of 1986 that directed the Service to identify the location and types of wetlands that should receive priority attention for acquisition by federal and state agencies using **Land and Water Conservation Fund** appropriations.

This fund is used by the U.S. Department of the Interior to acquire lands. The fund is also available by allocation to states to provide outdoor recreational resources through their conservation, development and use. The fund receives surplus property taxes, motorboat fuel taxes, certain revenues from the Outer Continental Shelf Lands Act, and user fees collected at National Parks and other federal fee collection areas.

The **Coastal Wetlands Planning, Protection and Restoration Act** established a matching grant program for states requesting federal funds for coastal wetland restoration projects. Projects eligible for grant proposals include acquisition, restoration, enhancement or management of coastal wetland ecosystems. Coastal Wetland Grants must demonstrate quantifiable benefits to coastal wetland hydrology, water quality and/or fish and wildlife species.

For additional information on these and other cooperative habitat protection initiatives, contact the following offices of the Maine Dept. of Inland Fisheries and Wildlife and/or the U.S. Fish and Wildlife Service:

Ken Elowe, Director
Wildlife Division
Maine Dept. of Inland Fisheries & Wildlife
284 State St.
State House Station #41
Augusta, Maine 04333
(207) 287-5252

Stewart Fefer, Project Leader or Lois Winter, Outreach Specialist
Gulf of Maine Project
U.S. Fish & Wildlife Service
4R Fundy Rd.
Falmouth, ME 04105
(207) 781-8364

Literature Cited

Adamus, P.R. 1986. The cumulative impacts of development in southern Maine: Wetlands: Their locations, functions, and value. Augusta: Maine State Planning Office. 69p.

Andrews, R., G. Atwell, B.G. Blodget, I.C.T. Nisbet, and M. Scheibel. 1989. Recovery plan for roseate tern, Sterna dougallii, northeastern population. U.S. Fish and Wildlife Service, Region 5. 86 p.

Andrews, R. 1990. Coastal waterbird colonies: Maine to Virginia 1984-85; Part 1. Maine to Connecticut. U.S. Fish and Wildlife Service, MA. 429 p.

Atwood, J.L. and D.E.Minsky. 1983. Least tern foraging ecology at three major California breeding colonies. Western Birds 14:57-72.

Atwood, J.L. and B.W. Massey. 1988. Site fidelity of least terns in California. The Condor 90:389-394.

Bilby, R.E. 1984. Characteristics and frequency of cool-water areas in a western Washington stream. J. Freshw. Ecol. 2:593-602.

Blumton, A.K., R.B. Owen, Jr., and W.B. Krohn. 1988. Habitat suitability index models: American eider (breeding). U.S. Fish and Wildlife Service, Biological Report 82(10.149). 24 p.

Bratton, S.P. 1990. Boat disturbance of Ciconiiformes in Georgia estuaries. Colonial Waterbirds 13(2): 122-128.

Buchsbaum, R. Unpub. Disturbance tolerance distances for various New England vertebrates. Massachusetts Audubon Soc.. Wenham MA.

Calhoun, A.J.K., J.E. Cormier, R.B. Owen, Jr., A.F. O'Connell, Jr., C.T. Roman, and R.W. Tiner, Jr . 1995. The wetlands of Acadia National Park and vicinity. Technical Report prepared for Maine Agricultural and Forest Experiment Station. Miscellaneous Publication 721. 108 p.

Chapman, B.R. and R.J. Howard. 1984. Habitat suitability index models: great egret. Biol. Rept. 82(10.78), US Fish. Wildl. Serv. 23 p.

Chescheir, G.M., J.W. Gilliam, R.W. Skaggs, and R.G. Broadhead. 1991. Nutrient and sediment removal in forested wetlands receiving pumped agricultural drainage water. Wetlands 11:87-172.

Correll, D.L. and D.E. Weller. 1989. Pages 9-23 in Sharitz, R.R. and J.W. Gibbons (eds.) Freshwater wetlands and wildlife. Proceedings of a symposium held at Charleson, SC., March 24-27, 1986. U.S. Department of Energy.

Cowardin, L.W., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish Wildl. Serv. 103 p.

D.J. Card, R.A. Aho, and L.M. Gillespie. 1981. Casco Bay marine resources inventory. Maine DMR.

Daub, Betsy C. 1989. Behavior of common loons in winter. J. Field Ornithol. 60(3):305-311.

Eipper, A., W. Knapp, and C. Laffin. 1982. Anadromous fish streams of New England: upstream migratory routes. Portfolio NE-1. U.S.D.I. Fish and Wildlife Service.

Erwin, M.R. 1989. Responses to human intruders by birds nesting in colonies: experimental results and management guidelines. Colonial Waterbirds 12(1): 104-108.

Erwin, M.E., G.M. Haramis, D.G. Krementz and S.L. Funderburk. 1993. Resource protection for waterbirds in Chesapeake Bay. Envir. Manag. 17(5): 613-619.

Erwin, M.E., J.E. Spendelow, P.H. Geissler and B.K. WIlliams. 1987. Relationships between nesting populations of wading birds and habitat features along the Atlantic coast. In W.R. Whitman and W.H. Meredith (eds): Waterfowl and wetlands symposium; proceedings of a symposium on waterfowl and wetland management in the coastal zone of the Atlantic flyway. Delaware Depart. of Nat. Res. and Environm. Control, Dover DE. 552 p.

Flagg, L.N. and T.S. Squiers. 1994. Restoration of striped bass in the state of Maine. Anadromous Fish Div., Maine DMR, Augusta. 7 p.

Flagg, L.N. and T.S. Squiers. 1995. State of Maine 1994 striped bass fishery and monitoring report. Maine DMR, Augusta. 8 p.

Foss, C. R. (ed.). 1994. Atlas of breeding birds in New Hampshire. Audubon Society of New Hampshire; Arcadia Publishers, Dover. 414 p.

Frayer, W.E., T.J. Monahan, D.C. Bowden, and F.A. Graybill. 1983. Status and trends of wetlands and deepwater habitats in the conterminous United States, 1950's to 1970's. Colo. State Univ. 32 p.

Frazer, C. 1988. The Ecology of post-fledging american black ducks in eastern Maine. M.S. Thesis, University of Maine at Orono. Orono, Maine. 90 p.

Frederick, P.C. and M.W. Collopy. 1988. Reproductive ecology of wading birds in relation to water conditions in the Florida Everglades. Florida Coop. Fish and Wildl. Res. Unit, Sch. For. Res. and Conserv. Univ. of Florida. Tech Rept. No. 30.

Gibbs, J. and S. Woodward. 1984. Breeding colonies of great blue herons on Maine coastal islands. Maine Chapt. The Nature Conservancy. 24 p.

Gibbs, J.P., J.R. Longcore, D.G. McAuley and J.K. Ringelman. 1991. Use of Wetland Habitats by Selected Nongame Water Birds in Maine. U.S. Fish Wildl. Serv., Fish Wildl. Res. 9. 57p.

Goudie, R. I. and C. D. Ankney. 1988. Patterns of habitat use by sea ducks wintering in southeastern Newfoundland. Ornis Scandinavica 19: 249-256.

Guillemette, M., J.H. Himmelman, C. Barette and A. Reed. 1993. Habitat selection by common eiders in winter and its interaction with flock size. Can. J. Zool. 71: 1259-1266.

Harvey, W.F., R.A. Malecki, and E.C. Soutiere. 1988. Habitat use by foraging Canada Geese in Kent County, Maryland. Trans. NE Sect. WIldl. Soc. 45:1-7.

Heimberger, M., D. Euler, and J. Barr. 1983. The impact of cottage development on common loon reproductive success in central Ontario. Wilson Bull 95:431-439.

Heinemann, D. 1992. Foraging ecology of roseate terns breeding on Bird Island, Buzzards Bay, Massachusetts. Report to USFWS, Newton Corner, MA. 54 p.

Hutchinson, A.L. and R.C. Ferrero. 1980. An assessment of the impacts of oil pollution on the marine wildlife of Casco Bay, Maine. Maine Dept. of Inland Fisheries and WIldlife, Augusta, ME. 137 p.

Jacobs, T.C., and J.W. Gilliam. 1985. Riparian losses of nitrate from agricultural drainage water. J. Environ. Qual. 14:472-478.

Jacobson, H.A., Jacobson, G.L., Jr., and Kelley, J.T. 1987. Distribution and abundance of tidal marshes along the coast of Maine. Estuaries, 10:126-131.

Jones, J. 1993. Recommendations for managing least terns and piping plovers in Maine. Maine Audubon Society, Falmouth ME. 14 p.

Jones, J.J., J.P. Lortie and U. D. Pierce, Jr. 1988. The Identification and Management of Significant Fish and Wildlife Resources in Southern Coastal Maine. Maine Dept. Inl. Fish. and Wildl., Augusta, Maine. 140 p.

Jones, J.J. and J. Camuso. 1994. 1994 Piping Plover and Least Tern Project Report. Maine Audubon Society, Falmouth ME. 40 p.

Jorde, D. G. and R. B. Owen, Jr. 1989. Foods of Black Ducks, *Anas rubripes*, Wintering in Marine Habitats of Maine. The Canadian Field-Naturalist. 104:300-302.

Keller, C.M.E., C.S. Robbins, and J.S. Hatfield. 1993. Avian communities in riparian forests of different widths in Maryland and Delaware. Wetlands 13(2): 137-144.

Kress, Stephen W. 1993. Roseate tern chick provisioning at a restored Maine Coast (USA) colony. Poster, Colonial Waterbird Soc. Mtg., Oct 6-10, 1993.

Kundt, J.F., T. Hall, V.D. Stiles, S. Funderburk, and D. McDonald. 1988. Streamside forests: the vital, beneficial resource. Univ. Maryland Coop. Ext. Serv., College Park, MD.

Lewis, J.C., and R.L. Garrison. 1984. Habitat suitability index model: American black duck (wintering). U.S. Fish WIldl. Serv. FWS/OBS-82/10.68 16 p.

Longcore, J.R. and J.P. Gibbs. 1988. Distribution and numbers of American black ducks along the Maine coast during the severe winter of 1980-81. Waterfowl in Winter. Univ. of Minnesota, Minneapolis MN 377-389.

Malecki, R.A., S.E. Sheaffer, and J.W. Enck. 1988. Influence of agricultural land use changes on wintering Canada Geese in the Atlantic flyway. Trans. NE Sect. Wildl. Soc. 45: 8-15.

McIntyre, Judith W. 1986. Common Loon - species description and natural history. Audubon Wildlife Report. pp. 679-695.

MDIF&W. 1989. Significant fish and wildlife resources of coastal York County, Maine. Maine Dept. Inland Fisheries and WIldlife, Augusta. 151 p.

MDIF&W. 1995. Atlas of essential wildlife habitats for Maine's endangered and threatened species. Maine Dept. of Inland Fish. and Wildl., Augusta ME. 21 p. plus maps.

Newberry, D.G.S. 1992. Management of urban riparian systems for nitrate reduction. U.S. Env. Prot. Agency, Region 5, Chicago, IL.

Nisbet, I.C.T. 1989. Status and biology of the northeastern population of the roseate tern *Sterna dougallii*. Lit. Survey for USFWS, Newton Corner, MA. 74 p.

Nixon, S.W. and V. Lee. 1986. Wetlands and water quality: A regional review of recent research in the United States on the role of freshwater and saltwater wetlands as sources, sinks, and transformers of nitrogen, phosphorus, and various heavy metals. U.S. Army Eng. Waterways Exp. Stn. Tech. Rep. Y-86-2. 229 p.

Odum, E.P. 1989. Pages 1-8 in Sharitz, R.R. and J.W. Gibbons (eds.) Freshwater wetlands and wildlife. Proceedings of a symposium held at Charleson, SC., March 24-27, 1986. U.S. Department of Energy.

Ogden, J.C. Unpub. Habitat management guidelines for the wood stork in the Southeast Region. U.S. Fish and Wildlife Service, Region 4, Atlanta, GA.

Palmer, R. S. 1962. Handbook of North American birds. Yale Univ. Press, New Haven, Connecticut. 567 p.

Peterjohn, W.T., and D.L. Correll. 1984. Nutrient dynamics in an agricultural watershed. Observations on the role of a riparian forest. Ecology 65:1466-1475.

Reed, A., G. Chapdelaine and P. Dupuis. 1977. Use of farmland in Spring by migrating Canada geese in the St. Lawrence valley, Quebec. J. Appl. Ecol. 14: 667-680.

Rimmer, Christopher C. 1992. Common Loon in Schneider, K.J. and D.M. Pence (eds.) Migratory nongame birds of management concern in the Northeast. U.S. Fish and Wildlife Service, Newton Corner, Massachusetts. 400p.

Ringelman, J.K. and J.R. Longcore. 1982. Movements and wetland selection by brood-rearing black ducks. J. Wildl. Manage. 46(3):615-621.

Rodgers, J.A.,Jr. and H.T. Smith. In press. Set-back distances to protect nesting bird colonies from human disturbances in Florida. Conservation Biology.

Scarnecchia, D.L. 1981. Effects of streamflow and upwelling on yield of wild coho salmon. Can. J. Fish. Aquat. Sci. 38:471-475.

Schauffler, F.M. 1994. Conservation options. A guide for Maine landowners. Maine Coast Heritage Trust, Brunswick ME. 30 p.

Sheaffer, S.E. and R.A. Malecki. In Press. Status of Atlantic flyway resident nesting Canada geese. Proc. Int. Canada Goose Symp. Milwaukee, WI. 5p.

Shealer, D.A. and S.W. Kress. 1994. Post-breeding movements and prey selection of roseate terns at Stratton Island, Maine. J. Field Ornithol. 65(3): 349-362.

Short, H.L. and R.J. Cooper. 1985. Habitat suitability index models: great blue heron. Biol. Rept. 82(10.99), U.S. Fish and Wildlife Service. 23 p.

Simmons, R.C., A.G. Gold, and P.M. Groffman. 1992. Nitrate dynamics in riparian forests: groundwater studies J. Environ. Qual. 21:659-665.

Stockwell, S.S. and J. Jacobs. 1992. Effects of Lakeshore development and recreational activity on the reproductive success of common loons in southern maine. Proc. American Loon Conference. Bar Harbor ME. pp. 222-234.

Thayer, G.W., W.J. Kenworthy, and M.S. Fonseca. 1984. The ecology of eelgrass meadows of the Atlantic coast: a community profile. U.S. Fish Wildl. Serv. FWS/OBS-84/02. 147 p.

Tyler, H.R. 1977. Wading birds in Maine and their relevance to the Critical Areas Program. Planning Rept. No. 26. 51 p.

USFWS. 1980. Habitat Evaluation Procedures (HEP). U.S.D.I. Fish and Wildlife Service. Division of Ecological Services. ESM 102.

USFWS. 1988. American Black duck breeding habitat enhancement in the Northeastern United States: A Review and Synthesis. U. S. Fish Wildl. Serv. FWS/OBS-88/49.89. 48 p.

Veit, R.R. and W.R. Petersen. 1993. Birds of Massachusetts. Massachusetts Audubon Society. 514 p.

Vermeer, K. 1973. Some aspects of the breeding and mortality of Common Loons in east central Alberta. Can. Field Nat. 87:403-408.

Vos, D.K., R.A. Ryder, and W.D. Graul. 1985. Response of breeding great blue herons to human disturbance in northcentral Colorado. Colonial Waterbirds 8(1): 13-22.

Watts, B.D and D.S.Bradshaw. 1994. The influence of human disturbance on the location of great blue heron colonies in the lower Chesapeake Bay. Colonial Waterbirds 17(2):184-186.

Whitlatch, R.B. 1982. The ecology of New England tidal flats: a community profile. U.S. Fish Wildl. Serv. FWS/OBS-81/01. 125 pp.

Williams, J.D., and C.K. Dodd, Jr. 1979. Importance of wetlands to endangered and threatened species. Pages 565-575 in P.E. Gresson et al. (eds.), Wetland functions and values: The state of our understanding. Tech. Publ. 79-2. Am. Water Resour. Assoc., Minneapolis, MN.

Winger, P. 1986. Forested wetlands of the Southeast: review of major characteristics and role in maintaining water quality. U.S. Fish and Wildlife Service. Publ. 163. 16p.

Appendix A: Figures

Appendix B: Identification of Species for Priority Habitats

(Gulf of Maine Council Ranked List of Evaluation Species)

Identification of Species for Priority Habitats

U.S. Fish & Wildlife Service, Gulf of Maine Project
Gulf of Maine Council on the Marine Environment

In 1990, the Gulf of Maine Council on the Marine Environment (Council) was established as an effort to address transboundary issues related to Gulf resources. The Council is organized by the governors of Massachusetts, New Hampshire and Maine, and the Premiers of Nova Scotia and New Brunswick, under the international *Agreement on the Conservation of the Marine Environment of the Gulf of Maine*. The Council and its Working Group, representing a partnership of several federal, state, and local agencies and private organizations, in 1991 adopted a Gulf Action Plan, outlining priorities on which to focus collective efforts.

The Action Plan's mission is "to maintain and enhance environmental quality in the Gulf of Maine and to allow for sustainable use by existing and future generations." The Plan identifies seven high priority objectives, among which are protection, restoration, and enhancement of fish and wildlife habitat within the Gulf region. This includes the development of a systematic approach for identifying, classifying and protecting regionally significant habitats. As a participant in the Plan's implementation, the Gulf of Maine Project of the U.S. Fish and Wildlife Service is coordinating an international, multi-state, and non-governmental organizational effort to design and implement such an approach.

Fig. 1. PRIORITY SPECIES DESIGNATION PROCESS

1. Establish Habitat Panel of resource agencies and non-governmental organizations
2. Determine species ranking criteria
3. Establish relative weights among criteria
4. Accumulate candidate species list
5. Score candidates using weighted criteria
6. Select top increment of ranked list as priority species

HABITAT IDENTIFICATION APPROACH

During October 1992, the Gulf of Maine Project, in association with the Gulf of Maine Council, convened a workshop in St. Andrews, New Brunswick to begin implementation of the Habitat Protection goals in the Action Plan. Participants included marine, wildlife, and other natural resource agencies from the states and provinces, as well as federal agencies and non-governmental organizations. One of the goals of the workshop was to initiate a coordinated, comprehensive, systematic approach for identifying priority fish and wildlife habitats in the Gulf of Maine region.

At the workshop, the Gulf of Maine Project proposed using a step-wise approach to the task (Fig. 1), in which responsible agencies from each state or province, federal agencies, and representative non-governmental organizations would work together to develop criteria for ranking species, and then apply these criteria to develop a list of priority fish, wildlife and plants for the region. Since habitats are the places where species live, the nomination and ranking of important species is an effective means of identifying such regionally significant habitats.

HABITAT PANEL

Subsequent to the habitat workshop, the Gulf of Maine Council's Working Group nominated individuals in the representative agencies and non-governmental organizations to serve on a Habitat Panel to implement priority habitat identification. Expertise, data, and opinions from agencies and organizations familiar with marine, freshwater, and terrestrial life of the Gulf of Maine and its watershed would be vital for constructing the species list. Moreover, the criteria for rating species would reflect the mandates and interests of these agencies and groups. It was recommended that a representative from the wildlife/freshwater fish and the marine resource agencies of each federal, state and provincial entity and up to two non-governmental organizations per state or province be appointed as a participant on the Habitat Panel. Members are listed in Fig. 2.

SPECIES RANKING CRITERIA

At the heart of the species ranking process were criteria that could be applied to any group of species. These criteria were developed incrementally, including input from representatives of concerned agencies and groups and their colleagues, with opportunities to revise positions during several iterations. The iterative process was devised as a way of gaining consensus on the relative value of resources.

The first step identified criteria (see table) that represent the social, economic, and environmental reasons behind the preferences or mandates of the public, private interests, and governmental agencies. Next, these criteria were assigned weights. Candidate species were then nominated, and were scored by participants according to the criteria. A species' total score was determined by both the number of applicable criteria and the weight assigned to each of these criteria. This sequence allowed a great deal of input, while at the same time limited the effects of unconscious biases of agency or group representatives. The rationally-derived criteria melded the diverse interests of agencies and organizations, and their disparate views on priority species, into a list with a regional perspective.

SPECIES LIST

The resulting ranked species list (see table) was accepted by the Committee as the product of a consensus approach to species identification. The species themselves, and their rankings, are not the ultimate focus of this effort, but were chosen as a means to select regionally significant habitats, the task specified by the Council. The list is inclusive of all categories of species in the region, with a focus on coastal species that rely on the Gulf. A great variety of species and taxonomic categories emerged as of interest to participants, and all will be important in locating priority habitats.

WHERE WE GO FROM HERE

The species list will next be used as a focus for identifying habitats. For each area, scores for each species can be added, accounting for both the numbers of species using the area and the weight accorded each species. Protecting habitats for the top-ranked species will also tend to protect habitats for lower-ranked species in the same area.

With the active support of agencies and organizations on the Committee, habitat models will be developed from information about each species' distribution, habitat characteristics, and needs and tolerances during various life history stages. Ecological data such as upland, wetland, or water cover types, bathymetry, soil/substrate, salinity/hydrology, and other types of data will be used to locate and display habitats, using a GIS. Known species distribution data will be used to test and verify predicted habitats.

Fig. 2. HABITAT PANEL MEMBERS
(As of 3/15/94)

Jurisdiction	Agency
Canada	Canadian Wildlife Service (Atlantic Regional Habitat Program) Department of Fisheries and Oceans
New Brunswick	Department of Natural Resources (Fish & Wildlife Branch) New Brunswick Museum New Brunswick Federation of Naturalists New Brunswick Nature Trust
Nova Scotia	Department of Natural Resources (Wildlife Resources, Waterfowl, and Wetlands) Nova Scotia Museum (Natural History Museum/Marine Studies) Acadia Center for Estuarine Research Federation of Nova Scotia Naturalists
United States	U.S. Fish and Wildlife Service (Gulf of Maine Project) National Marine Fisheries Service (Northeast Fisheries Center)
Maine	Department of Inland Fisheries and Wildlife (Wildlife Resource Assessment) Department of Marine Resources College of the Atlantic The Nature Conservancy (Maine Chapter)
Massachusetts	Department of Environmental Protection (Marine Program) Division of Marine Fisheries Division of Fisheries and Wildlife (Non-Game Programs) Cetacean Research Unit
New Hampshire	Fish & Game Department Division of Marine Fisheries (Fish & Game Department) Audubon Society of New Hampshire The Nature Conservancy Natural Heritage Inventory (Department of Resources and Economic Development)

Once the habitats have been identified, the protection status of these habitats and threats to them will be determined. Working with the wide variety of habitat protection measures available in each jurisdiction, watershed management plans will be developed that identify long-term management and restoration needs, and projects will be implemented to protect and restore priority habitats throughout the Gulf of Maine.

Produced by Carol J. Boggis, cjb productions, for:
U.S. Fish and Wildlife Service, Gulf of Maine Project
4R Fundy Road, Falmouth, ME 04105
For more information, contact Arnold Banner, Senior Staff Biologist, at (207) 781-8364

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SPECIES LIST

SPECIES RANKING CRITERIA

A. Importance to environmental, scientific, commercial or other special interest groups (species sought out or portrayed for consumptive or non-consumptive purposes). Total of up to 16 points.
B. Species listed as endangered, threatened (U.S. designation), vulnerable (designation of Committee on the Status of Endangered Wildlife in Canada), or special concern (designation of some states). Total of up to 10 points.
C. Limits/controls on take/harvest of species (state/provincial or federal regulation on numbers/season; listed species (B, above) automatically qualify here also). Total of up to 5 points.
D. Significant decline of population is anticipated (based on trends or expected events). Total of up to 11 points.
E. Strictly tied to specific habitat, locality, or association of cover types, for at least one critical part of its life cycle ("bio-indicator"). Total of up to 9 points.
F. Species dependent on marine or estuarine system for at least part of life cycle. Total of up to 8 points.
G. Abundance has been significantly reduced throughout species' range. Total of up to 9 points.
H. Important predator, prey, or primary producer in terms of energy transfer or controlling populations of other species within the Gulf of Maine. Total of up to 16 points.
I. Species plays a major role in succession or maintenance of community by physically or chemically modifying habitat. Total of up to 11 points.
J. Species occurs in Gulf of Maine year round. Total of 5 points.

SPECIES	SCIENTIFIC NAME	RANK	RANKING CRITERIA										CHARACTERISTICS
alewife	*Alosa pseudoharengus*	31	A		C	D	E	F	G	H		J	Labr.-Carolinas; common anad. fish; feed on zooplankton; imp. prey; commercial; decline in catch; managed
alpine woodfern	*Woodsia alpina*	145	A	B	C	D	E		G	H	I	J	Vascular plant, circumbor., New Engl., Greenland, Alaska, Nfld., rare; high altitudes, crevices in limestone, moist, cool
American beach grass	*Ammophila breviqulata*	44	A		C	D	E	F	G	H	I	J	Temperate, e. & w. Atl.; throughout GOM; sandy beaches/dunes; few protected locales; stabilizes substrate; reduced
American eel	*Anguilla rostrata*	138	A		C	D	E	F	G	H		J	Catadromous fish; lakes, rivers, coastal waters, winter in mud, commercial
American lobster	*Homarus americanus*	26	A		C	D	E	F	G	H	I	J	Labr.-Cape Hatt.; omnivorous crustacean; coastal-deep water, commercial, size limits; catch stable
American plaice	*Hippoglossoides platessoides*	33	A		C	D	E	F	G	H		J	N. Atl.; large-mouth flatfish; deep water sand/mud, circumboreal, commercial; overfished; managed
American sand lance	*Ammodytes americanus*	92	A			D	E	F	G	H		J	Common fish of surf off sandy shores, prey of fish, birds, whales, n. e. seaboard
American shad	*Alosa sapidissima*	21	A		C	D	E	F	G	H		J	Labr.-FL; anad. fish; feed on zooplankton, commercial and recreational, depleted, some recovery; managed
American smelt	*Osmerus mordax*	57	A		C	D	E	F	G	H		J	E. coast N. Amer.; anad./coastal fish; feed on macroinverts. and fishes; commercial and rec., abundant
American woodcock	*Philohela minor*	109	A		C	D	E		G	H			Breed e. and central N. Amer.; winter s. of GOM; eat earthworms, insects; common in ME
amphipod	*Corophium volutator*	98	A			D	E	F	G	H	I	J	Tube dwelling, muddy shores; widespread, e. and w. n. Atl., common in GOM; imp. to upper Bay of Fundy
arctic tern	*Sterna paradisaea*	42	A	B	C	D	E	F	G	H			Arctic to Cape Cod, Pacific; abundant offshore, pop. declines, GOM important breeding; pred. on fishes
aschelminthean worm	*Priapulus caudatus*	160	A			D	E	F		H		J	Subtidal to 500m; mud or gravel, Mass. to Arctic
aster	*Aster anticostensis*	80	A	B		D	E		G	H	I	J	Vasc. plant; rare, endemic, vulnerable to damming river
Atlantic cod	*Gadus morhua*	13	A		C	D	E	F	G	H		J	NW Atl.; resident fish, benthic feeder, major pop. decline; commercial, recreational, managed
Atlantic mackerel	*Scomber scombrus*	25	A		C	D	E	F	G	H		J	NW Atl.-Carolinas; imp. commercial, recr. fish; resident to GOM; managed, stable; important prey
Atlantic puffin	*Fratercula arctica*	39	A	B	C	D	E	F	G	H		J	Arctic to mid n. Atl; w. Atl. to Delaware, winter offshore; few sensitive colonies, reduced pop.; pred. on fishes
Atlantic ridley turtle	*Lepidochelys kempii*	18	A	B	C	D	E	F	G				Oceanic, rare summer visitor; nest Texas, Mexico
Atlantic salmon	*Salmo salar*	5	A	B	C	D	E	F	G	H		J	N. Atl., recr. and commercial fish; decline due to harvest/habitat; expect decline in Canada; managed
Atlantic tomcod	*Microgadus tomcod*	107	A			D	E	F	G	H		J	GOM resident, common in estuaries, benthic feeder; ecologically important (prey of eagles, seabirds)
Atlantic whitefish	*Coregonus huntsmani*	17	A	B	C	D	E	F	G	H		J	Rare (2 pops., Tusket and Petite Riviere); semi-anadromous

SPECIES	SCIENTIFIC NAME	RANK	RANKING CRITERIA										CHARACTERISTICS
bald eagle	*Haliaeetus leucocephalus*	35	A	B	C	D	E	F	G	H		J	N. Amer.; resident in GOM; eat fish, carrion; coastal; ME has >90% of northeast breeding sites.
banded bog skimmer	*Williamsonia lintneri*	66	A	B	C	D	E		G	H		J	Dragonfly; NH-NY range; inland and coastal wooded areas, bogs, sedge meadows
bay scallop	*Aequipecten irradians*	27	A		C	D	E	F	G	H	I	J	Gulf of Mexico to Cape Cod, reported to Nova Scotia; subtidal, assoc. w/eelgrass; commercial
beach senecio	*Senecio pseudo-arnica*	104	A			D	E	F	G	H	I	J	Circumpolar, coastal; vascular plant; sandy/gravel sea beaches, rare (in GOM Grand Manan archipelago); outlying pop., vulnerable
beggartick	*Bidens eatonii*	62	A	B		D	E	F	G	H	I	J	Vasc. plant of estuar.; Hudson, Conn., Kennebec, St. Lawrence; uncommon; danger from nonpt. pollution
birdseye primrose	*Primula laurentiana*	108	A	B		D	E	F	G	H	I	J	Subarctic to ME, coastal rocky headlands; vascular plant; rare; protected in Fundy Nat. Park and ME
black bear	*Ursus americanus*	78	A		C	D	E		G	H		J	N. Amer., but patchy; require large forested areas; omnivorous
black duck	*Anas rubripes*	58	A		C	D	E	F	G	H		J	Surface feeder, resident, sought by hunters, gradual decline, need open water in winter
black-legged kittiwake	*Rissa tridactyla*	100	A		C	D	E	F	G	H		J	Migratory, Arctic to mid-Atl.; breed colonies on coastal cliffs; winter offshore; eat fishes, crustaceans, abundant
black racer	*Coluber constrictor*	120	A	B	C	D	E		G	H		J	Most of continental US, xeric/mesic forests, rocky areas; terrestrial, feed on mice, rats, lizards, frogs
Blanding's turtle	*Emys blandingi*	88	A	B	C	D	E		G	H		J	ME, s. VT, NH, w. to MN; aquatic-terrestrial; omnivorous, uncommon
blinks	*Montia fontana*	79	A	B		D	E	F	G	H	I	J	Vascular plant; circumboreal, s. to GOM; NB, ME; wet, brackish shores; reduced
bloodworm	*Glycera dibranchiata*	34	A		C	D	E	F	G	H	I	J	Atl. coast N. Amer.; intertidal muds; estuarine; commercial bait; prey of shorebirds, fishes; swarm
blue mussel	*Mytilus edulis*	14	A		C	D	E	F	G	H	I	J	Circumpolar; inter/subtidal; estuarine/coastal; prey of birds, fishes, inverts.; commercial; form reefs; managed
bluefin tuna	*Thunnus thynnus*	49	A	B	C	D	E	F	G	H			Migr., all oceans; GOM summers; estuaries to offshore; important predator on fishes, squid; commercial, rec.
bluefish	*Pomatomus saltatrix*	69	A		C	D	E	F	G	H			Atl., seasonally Nova Scotia to Argentina; oceanic to estuaries; predator, cyclic pop.; managed
bottle brush grass	*Hystrix patula bigeloviana*	115	A	B		D	E		G	H	I	J	Vascular plant; endemic, may be extirpated
box turtle	*Terrapene carolina*	86	A	B	C	D	E	F	G	H		J	E. half of US, declining; always uncommon in NE, fields, bogs; omnivorous
brittlestar	*Ophiura sarsi*	103	A			D	E	F		H	I	J	Boreal; 9-3000m; omnivore (small prey); incidental catch in shrimp fishery
brook trout (anadromous)	*Salvelinus fontinalis*	41	A		C	D	E	F	G	H		J	Native stream/river fish, Canada to GA; pred. on inverts., fishes; occasional estuaries, important recreationally
Canada goose	*Branta canadensis*	65	A		C	D	E	F	G	H		J	N. Amer.; breed Arctic-G. St. Lawrence, winter GOM s. to Mex.; herbivore, prey of eagles; migr. pop. decreas.
Cetrariastrum catawbiense	*Cetrariastrum catawbiense*	153	A			D	E		G	H	I	J	Lichen; s. Appal. Mtns., mtns. of Cent., S. Amer., New Guinea, Uganda; GOM - moist old coastal forests NB, NS
Cladina terrae-novae	*Cladina terrae-novae*	130	A			D	E	F	G	H	I	J	Lichens of coastal peat bogs; Nfld.-NJ; GOM - NB, e. ME; dominant of 6 caribou lichens
common dolphin	*Delphinus delphis*	55	A		C	D	E	F	G	H		J	All seas; predator on squid, fish; usually oceanic, enters estuaries; abundant
common eider	*Somateria mollissima*	46	A		C	D	E	F	G	H		J	Circumboreal; common, pop. increase in coastal GOM; breed tundra, islands; eat molluscs, crustaceans
common loon	*Gavia immer*	16	A	B	C	D	E	F	G	H		J	Circumboreal; summer on protected lakes; winter in protected coastal waters US and Can.; stable pop.
common murre	*Uria aalge*	75	A		C	D	E	F	G	H		J	Arctic-Nova Scotia; only few vulnerable col. s. (coastal cliffs, islands); reduced pop.; harvested in Nfld., Lab.
common tern	*Sterna hirundo*	47	A	B	C	D	E	F	G	H			Breed N. Amer., winter S. Amer.; common coastal, lakes; decline in GOM numbers, eat fish, insects
copepod	*Eurytemora herdmani*	128	A				E	F		H		J	Estuarine species, important prey in upper Bay of Fundy; pelagic; resident

SPECIES	SCIENTIFIC NAME	RANK	RANKING CRITERIA										CHARACTERISTICS
copepod	*Calanus glacialis*	124	A				E	F		H		J	NW Atl.-Arctic, deep basins; planktonic; widespread in GOM; indicator of Gulf of St. Lawrence water; important prey; resident
copepod	*Calanus finmarchicus*	129	A				E	F		H	I	J	Form 80% of GOM zooplankton; Eastport ME to Cape Hatteras; seasonal peaks
copepod "bluefeed"	*Anomalocera patersoni*	136	A			D	E	F		H		J	Small zooplankter, oceanic, wide range; swarm at surface; important fish food, resident, inshore w/warm water intrusion
cordgrass	*Spartina alterniflora*	22	A			D	E	F	G	H	I	J	N. Atl. coasts; estuaries, mud/sandy embayments in GOM (abundant Fundy); vast stands to s., important cover, producer
curlygrass fern	*Schizaea pusilla*	114	A			D	E		G	H	I	J	Nova Scotia-NJ; wetlands, pine barrens; rare
diamondback terrapin	*Malaclemys terrapin*	24	A	B	C	D	E	F	G	H		J	Live in salt marshes; were popular as food, populations recovering
diatom	*Nitzschia sp.*	140	A				E	F		H		J	Small planktonic; locally imp. over Georges Bank
diatom	*Gyrosigma sp.*	143	A				E	F		H	I	J	Important to upper Bay of Fundy; benthic muds, sand; large; resident
dinoflagellate	*Gonyaulax sp.*	139	A				E	F		H	I	J	Planktonic, diurnal migrations; local importance in Georges Bank
dulse	*Palmaria palmata*	54	A		C	D	E	F	G	H	I	J	E. & w. N. Atl; on rock, wood, other algae; intertidal-20m; commercial
eelgrass	*Zostera marina*	12	A			D	E	F	G	H	I	J	Arctic to S. Carolina, Pacific; perennial; form beds; import. substrate, food for ducks; period. disease
euphausiid	*Meganyctiphanes norvegica*	117	A				E	F		H		J	Fundy to Delaware; "krill shrimp"; common inshore summer-fall; prey for whales, birds
finback whale	*Balaenoptera physalus*	20	A	B	C	D	E	F	G	H		J	All oceans; most common whale in GOM (present all year); coastal/pelagic; eat small fish, krill; stable
flying squid	*Illex illecebrosus*	71	A		C	D	E	F	G	H		J	Arctic to Cape Hatt.; inshore summers; pred. on fishes, krill; mod. commercial, cyclic; common; managed; resid.
foraminifera	*Globulimina auriculata*	150	A				E	F		H	I	J	N. Atl. and n. Pac.; benthic; depths 100-300m; throughout GOM; typical of basins w/high salinity & organics, low oxygen
foraminifera	*Ammotium cassis*	156	A				E	F		H	I	J	N. & s. Atl., n. Pac.; benthic; throughout GOM, lower estuaries; low pH, high particulates/turbidities (tolerant); resident
Furbish lousewort	*Pedicularis furbishiae*	63	A	B	C	D	E		G	H	I	J	Vascular plant; St. Johns floodplain ME & NB, wet woods, endemic
golden eagle	*Aquila chrysaetos*	83	A	B	C	D	E		G	H		J	N. Amer., remote forests, cliffs; rare, feed on rodents
goldenrod	*Solidago multiradiata*	135	A			D	E		G	H	I	J	Vascular plant; subarctic s. to NS; rocky calcareous & peaty soil
grass shrimp	*Palaeomonetes pugio*	113	A		C	D	E	F		H		J	New England/Fundy; common; deposit feeder, scavenger, predator on small inverts.
grasshopper sparrow	*Ammodramus savannarum*	87	A	B	C	D	E		G	H			SW ME-Brit. Columbia, Central Amer.; seasonal migrant; eat seeds, insects; pop. reduced, in hayfields, fallow fields w/o shrubs
gray-cheeked thrush	*Catharus minimus bicknelli*	127	A	B	C	D	E		G	H			Boreal; N. Amer. s. to Mass.; migrate through GOM; uncommon; coniferous/deciduous forests
gray seal	*Halichoerus grypus*	106	A		C	D	E	F	G	H		J	G. of St. Lawrence to Mass.; uncommon, coastal and offshore; dispersed; remote ledges, shoals
great blue heron	*Ardea herodias*	81	A		C	D	E	F	G	H	I		N. and S. Amer.; lakes, rivers, coastal; common colony nesting in GOM; eat fishes, herps, inverts.
great cormorant	*Phalacrocorax carbo*	64	A	B	C	D	E	F	G	H	I	J	N. Atl. Arctic - mid Atl. coast; coastal islands and cliffs; fish eaters; pop. increasing
greater shearwater	*Puffinus gravis*	90	A		C	D	E	F	G	H			Atl. ocean; pelagic GOM in spring; breed s. Atl., heavy harvest there, vulnerable; eat pelagic crustaceans
green crab	*Carcinas maenas*	141	A				E	F		H	I	J	Atl. and Pac.; rocky shores, sheltered bays, tolerate low salinity, omnivore; introduced, still spreading, abundant GOM

SPECIES	SCIENTIFIC NAME	RANK	RANKING CRITERIA										CHARACTERISTICS
green sea urchin	*Strongylocentrotus droehbachiensis*	10	A		C	D	E	F	G	H	I	J	Circumboreal, n. of Cape Cod, intertidal-1200m; protected rocky habitat; eat kelp, but omnivorous; commercial, managed; important prey
haddock	*Melanogrammus aeglefinis*	19	A		C	D	E	F	G	H		J	N. Atl.; GOM resident, commercial benthic fish; stocks depleted; managed
harbor porpoise	*Phocoena phocoena*	6	A	B	C	D	E	F	G	H		J	Estuarine/coastal; Atl. and Pac.; GOM important, common; eat benthic fishes inshore; year-round; risk from pollution, fishing
harlequin duck	*Histrionicus histrionicus*	50	A	B	C	D	E	F	G	H			E. & w. coasts N. Amer.; sea duck, islands; >50% of Atl. pop. winters GOM; eat amphi-isopods; may be at risk
herring	*Clupea harengus*	15	A	B	C	D	E	F	G	H		J	Labr.-Cape Hatt.; most important commercial finfish in GOM; important prey; spawning area closures; stable
horseshoe crab	*Limulus polyphemus*	70	A			D	E	F	G	H		J	Midcoast ME to G. of Mex.; intertidal to 25m; eat worms, molluscs; minor commercial; stable; shorebirds eat eggs; resident
horsetail kelp	*Laminaria digitata*	45	A			D	E	F	G	H	I	J	Arctic to NY; exposed inter/subtidal rocks; substrate for epifauna; eaten by urchins
humpback whale	*Megaptera novaeangliae*	30	A	B	C	D	E	F	G	H	I	J	All oceans; coastal/pelagic; rel. common GOM spring, summer only; feed small fish, krill; stable
Irish moss	*Chondrus crispus*	1	A		C	D	E	F	G	H	I	J	Labr.-L.I. Sound; perennial algae; lower intertidal; important food plant (commercial harvest)
Karner blue butterfly	*Lycaeides melissa samuelis*	37	A	B	C	D	E		G	H		J	New Hampshire, NY, WI; pine barrens
landlocked Arctic char	*Salvelinus alpinus*	91	A	B	C	D	E		G	H		J	NB, ME, VT; few oligotrophic lakes; intolerant of competition; no major historic pop. decline; managed, stable
Leach's storm-petrel	*Oceanodroma leucorhoa*	84	A	B	C	D	E	F	G	H	I	J	Both N. Amer. coasts; uncomm., breed Nfld.-MA; comm. Pac. coast; pelagic, eat small fish, inverts; harvested
least tern	*Sterna albifrons*	56	A	B	C	D	E	F	G	H			ME to S. Amer.; common/declining, nest pebble/sand beaches; nest spring; loss of beach habitat, nest predation; protected
leatherback turtle	*Dermochelys coriacea*	60	A	B	C	D	E	F	G	H			Oceanic; feed on jellyfish; occasional summer visitor to GOM, very wide ranging
lion's mane	*Cyanea capillata*	159	A				E	F		H	I	J	Large jellyfish; n. Atl.; swarm, bays, sounds, open sea; drift n. as mature, seasonally; shelter fishes
little skate	*Raja erinacea*	131	A			D	E	F		H	I	J	Nova Scotia to VA; abundant subtidal to 100m; sand/ pebble bottom; predator on crabs, worms, fish
longhorn sculpin	*Myoxocephalus octodecimspinosus*	148	A			D	E	F		H		J	Nova Scotia to VA; common subtidal to 100m; estuary/ offshore; resident; omnivorous
Long's bittercrest	*Cardaminae longii*	72	A	B		D	E	F	G	H	I	J	Estuaries of VA, MA, NJ, to ME; uncommon; danger from nonpoint pollution; little on public land
maidenhair spleenwort	*Asplenium trichomanes*	149	A			D	E		G	H	I	J	Vascular plant; circumboreal, very rare in GOM
marsh felwort	*Lomatogonium rotatum*	121	A			D	E	F	G	H	I	J	Circumbor., s. to GOM, vasc. plant of coastal shores, bogs, saltmarsh; large range, rare (6 ME sites, 1 NB)
mountain mint	*Pycnanthemum virginianum*	155	A			D	E		G	H	I	J	Vascular plant; rare in GOM, widespread to south
mummichog	*Fundulus heteroclitus*	82	A			D	E	F	G	H		J	Atl. coast N. Amer.; common in estuarine marshes/ seagrass; coastal; omnivorous; prey of birds, fishes; harvest, no regulation
mysid	*Neomysis americana*	126	A				E	F		H		J	G. of St. Lawrence-VA; very common shallow, brackish water; epibenthic/water column; important prey of fishes, eat detritus
narrow-leaf arnica	*Arnica augustifolia lonchophylla*	134	A			D	E		G	H	I	J	Vascular plant rare in GOM (may be extirpated); Alaska through Canada
New England cottontail	*Sylvilagus transitionalis*	94	A	B	C	D	E		G	H		J	Atl. coast: s. ME-s. NJ, NY, PA, Appalach. to s. GA; forests; eat grasses, flowers, berries
northern comandra	*Geocaulon lividum*	116	A	B		D	E		G	H	I	J	Boreal N. Amer., into New Engl. mtns.; vascular plant; peat bogs/conif. woods; GOM-NB, e. ME; reduced
northern harrier	*Circus cyaneus*	119	A	B	C	D	E	F	G	H			Amer. hawk; grasslands, marshes; migrate; feed on rodents, birds, amphibians; stable overall

SPECIES	SCIENTIFIC NAME	RANK	RANKING CRITERIA										CHARACTERISTICS
northern phalarope	*Lobipes lobatus*	95	A	B	C	D	E	F	G	H			Circumpolar; moderate migratory concentrations; eat zooplankton
osprey	*Pandion haliaetus*	73	A	B	C	D	E	F	G	H			N. and S. Amer.; common GOM migrant/breeding; coastal islands, headlands, lakes; eat fish
Oxytropis deflexa foliolosa	*Oxytropis deflexa foliolosa*	158	A	B		D	E		G	H	I	J	Vascular plant; widely distributed but rare; GOM site protected
pearl mussel	*Marguaritifera margaritifera*	101	A			D	E	F	G	H	I	J	N. Atl.; freshwater streams draining into Atl. (incl GOM); suspension feeder, symbiont w/trout; threat by harvest, pollution
peat moss	*Sphagnum flavicomans*	93	A			D	E		G	H	I	J	Nfld.-NJ; coastal peat bogs; GOM - NB, e. ME, 1 of 20 peat mosses
peregrine falcon	*Falco perigrinus*	61	A	B	C	D	E	F	G	H			Worldwide; migrate through GOM, uncommon; nest in cliffs; forage over shores, islands; eat birds
periwinkles	*Littorina littorea*	32	A		C	D	E	F	G	H	I	J	N. Atl. coasts; intertidal-high salt zone; rock substrate; graze algae; commercial in Europe, prey of fish, birds
piping plover	*Charadrius melodus*	40	A	B	C	D	E	F	G	H			Migrate Nfld. s. to Mexico; sandy beaches; also Canada e. of Rockies, Great Lakes; decline from habitat loss
pogy	*Brevoortia tyrannus*	77	A		C	D	E	F	G	H		J	Atl., seasonal Fundy to Argentina; feed on small plankton; prey of fish, mammals, birds
pollock	*Pollachius virens*	23	A		C	D	E	F	G	H		J	N. Atl.; resident in GOM; coastal-offshore; predator on fishes; krill; commercial; overfished, managed
Pterospora andromedea	*Pterospora andromedea*	122	A			D	E		G	H	I	J	Vascular plant, saprophyte, rare and at risk in N. Amer.
quahog	*Mercenaria mercenaria*	28	A		C	D	E	F	G	H	I	J	G. of St. Lawrence to G. of Mexico; intertidal warm waters (local pops. in GOM); mud/sand; commercial
Rand's eyebright	*Euphrasia randii*	118	A			D	E	F	G	H	I	J	Labr.-Nfld., Quebec, midcoast ME; turf slopes/knolls, peat, brackish shores; not rare in ME
razorbill	*Alca torda*	74	A	B	C	D	E	F	G	H	I	J	NE N. Amer., GOM resident; historic decline, some recovery; few sensitive colonies, coastal cliffs, islands
red knot	*Calidris canutus*	96	A		C	D	E	F	G	H			Tundra-S. Amer.; GOM migratory stopover sites sodbanks (most MA); some decline after recovery from 1800's
red phalarope	*Phalaropus fulicarius*	123	A		C	D	E	F	G	H			Wide range, uncommon; pelagic; nest in coastal sedge, tundra w/ponds; GOM important staging
red spruce	*Picea rubens*	67	A			D	E		G	H	I	J	E. N. Amer.; Quebec-Tenn.; boreal/temperate; GOM - common coastal coniferous/mixed forests; old growth rare; sensitive to pollution
redbreast sunfish	*Lepomis auritus*	152	A		C	D	E		G	H		J	New Brunswick to FL, w.; recr., common, stable; shallow warm lakes, streams; omnivorous, no limits
redfish	*Sebastes marinus*	52	A		C	D	E	F	G	H		J	N. Atl.; imp. comm. finfish in ME; overfished; managed
ribbon snake	*Thamnophis sauritus*	146	A	B	C	D	E		G	H		J	S. Nova Scotia to GA; semi-aquatic, marshes, lakes
right whale	*Eubalaena glacialis*	9	A	B	C	D	E	F	G	H		J	N. Atl.; coastal/offshore; rare; GOM critical, far below historic abundance, slowly increasing, filter feeder, at risk, year-round
river otter	*Lutra canadensis*	85	A		C	D	E	F	G	H		J	N. Amer. lakes, rivers; eat inverts, fishes; taken commercially/recreationally
rockweed	*Ascophylum nodusum*	4	A		C	D	E	F	G	H	I	J	Arctic to L.I. Sound; on intertidal rocks; perennial; producer, substrate for epifauna/epiphytes; commercial as packing
roseate tern	*Sterna dougallii dougallii*	43	A	B	C	D	E	F	G	H			NE coast N. Amer., FL; breeds GOM islands w/sand, boulders, grass; pop. threatened by gull encroachment, pollution
sand worm	*Nereis virens*	59	A		C	D	E	F	G	H	I	J	Atl. coast N. Amer.; inter/subtidal sands; common; estuarine/marine; commercial bait; prey of fishes
saxifrage	*Saxifraga aizoon*	105	A	B		D	E	F	G	H	I	J	Arctic-Fundy; alpine, only coastal cliffs in Fundy; disjunct, rare; historic Mt. Washington
screwstem	*Bartonia paniculata*	110	A	B		D	E		G	H	I	J	Nfld.-FL; vasc. plant; some decline; rare GOM (3 NB, 3ME sites); coastal wet, peatlands; some public; vulnerable

SPECIES	SCIENTIFIC NAME	RANK	RANKING CRITERIA										CHARACTERISTICS
sea anemone	*Cerianthus borealis*	102	A			D	E	F		H	I	J	Fundy-Cape Cod; sandy bottoms, 50-500m deep; very abundant in GOM; eat plankton, fishes; offer habitat/ structure
sea lamprey	*Petromyzon marinus*	161	A			D	E	F	G	H		J	E. & w. N. Atl., Great Lakes; anadromous; predator/ parasite on fishes; uncommon in oceans
sea lavender	*Limonium cardinianum*	99	A			D	E	F	G	H	I	J	Widespread; upper salt marshes, rocky shores; harvested (flower arrangements), no limits
sea pen	*Pennatula aculeata*	151	A				E	F		H		J	Nfld.-Carolinas; octocoral; 100m and deeper sand/mud bottom; very abundant in GOM
sea scallop	*Placopecten magellanicus*	11	A		C	D	E	F	G	H	I	J	Labrador to Cape Hatt.; subtidal to 200m, sand, gravel, shell; abundant, commercial; overfished; managed
seaside sparrow	*Ammospiza maritima*	111	A		C	D	E	F	G	H			ME-Gulf Coast; indicator species of shortgrass tidal marsh; eat insects/crustaceans; secure
sedge	*Carex josselynii*	132	A			D	E		G	H	I	J	Vascular plant; endemic, vulnerable to damming river
sedge wren	*Cistothorus platensis*	76	A	B	C	D	E	F	G	H			Widely ranging (Canada-Chile); coastal/inland marshes; historic declines, uncommon
sei whale	*Balaenoptera borealis*	8	A	B	C	D	E	F	G	H		J	All oceans; uncommon in GOM; little pop. data; filter feeding; recovering/stable; GOM all year
semipalmated sandpiper	*Calidris pusilla*	97	A		C	D	E	F	G	H			Wide range; abundant beaches, mudflats, marsh, rocky shores; prey concentration important in GOM in spring/ fall; eat small inverts.
sharp-tailed sparrow	*Ammodramus caudacutus*	89	A	B	C	D	E	F	G	H		J	Salt marshes/dune grasses; Quebec-VA-Great Plains; common breeding GOM, winter south
shortnose sturgeon	*Acipenser brevirostrum*	48	A	B	C	D	E	F	G	H		J	NB-FL tidal rivers; anadromous; benthic feeder; never abundant in GOM; harvested in St. Johns
shrimp	*Pandalus borealis*	38	A		C	D	E	F	G	H		J	Circumboreal, s. to Cape Cod; to 100m depth; decline in commercial catches; managed
soft shelled clam	*Mya arenaria*	2	A		C	D	E	F	G	H	I	J	Subarctic to Cape Hatteras; tidal muds; filter feeder; prey of ducks, mammals, fishes; recreational/commercial
sperm whale	*Physeter catodon*	29	A	B	C	D	E	F	G	H			Large prey, all seas; occasional in GOM (deep water typically); somewhat below historic/stable; not winter
spiny dogfish	*Squalus acanthias*	137	A		C	D	E	F		H		J	N. Atl. & n. Pac.; widespread in GOM, becoming major predator, very common; seasonal
spotted turtle	*Clemmys guttata*	68	A	B	C	D	E		G	H		J	Quebec-FL; wetland-terrestrial, declining from take, dvp.
striped bass	*Morone saxatilus*	36	A		C	D	E	F	G	H		J	St. Lawrence-FL, Pac.; coastal rivers, anadromous, large prey, recreational importance; managed
threadleafed sundew	*Drosera filiformis*	51	A	B	C	D	E	F	G	H	I	J	Subarctic to G. of Mex. (abund. in s.); scattered in GOM; coastal bogs, predator; rare here (ME, NS)
trumpet worm	*Cysteneides gouldii*	144	A			D	E	F		H	I	J	Wide distrib., intertidal/subtidal, shallow sandy bottoms, common, imp. fish food
truncate angel wing	*Barnea truncata*	112	A			D	E	F		H	I	J	Disjunct, Minas Basin, generally MA to FL; intertidal mud and peat banks, rocky ledges
tufted red weed	*Gigartina stellata*	3	A		C	D	E	F		H	I	J	RI-Nfld.; perennial algae; pool edges, wave-beaten intertidal rocks between rockweeds and kelps
upland sandpiper	*Bartramia longicauda*	125	A	B	C	D	E		G	H			N. Amer., w. of Rockies, uncommon, large dry grassy fields; pop. declining in n.e. US, stable overall
water pipit	*Anthus spinoletta*	157	A	B	C	D	E		G	H			Bird common during migration on muddy shores and plowed fields
white rice grass	*Leersia virginica*	154	A			D	E		G	H	I	J	Ontario-TX, FL; swamps, forested wetlands; 4 ME cos.
Whitlow-grass	*Draba lanceolata*	142	A	B		D	E		G	H	I	J	Upland vascular plant, circumneutral cliff community; wide range, rare in GOM
willet	*Catoptrophorus semipalmatus*	147	A		C	D	E	F	G	H			Both coasts, midwest of N. Amer.; common shorebird, increasing; breed salt marsh, beaches, winter south
winter flounder	*Pseudopleuronectes americanus*	7	A		C	D	E	F	G	H		J	NW Atl.-GA; estuarine to offshore, small prey, rec./commercial importance; overfished; managed
witch flounder	*Glyptocephalus cynoglossus*	53	A		C	D	E	F	G	H		J	GOM-Cape Hatt.; deepwater, small prey, wide-ranging, commercial value; overfished; managed
yellow screwstem	*Bartonia virginica*	133	A			D	E	F	G	H	I	J	Vascular plant of bogs, saltmarsh; very rare in GOM; south to LA

GULF OF MAINE COUNCIL SPECIES LIST: NUMERICAL RATINGS FOR ALL CANDIDATE SPECIES

alewife	*Alosa pseudoharengus*	55	harlequin duck	*Histrionicus histrionicus*	51
alpine woodfern	*Woodsia alpina*	29	herring	*Clupea harengus*	58
American beach grass	*Ammophila brevigulata*	52	horseshoe crab	*Limulus polyphemus*	45
American eel	*Anguilla rostrata*	30	horsetail kelp	*Laminaria digitata*	52
American lobster	*Homarus americanus*	56	humpback whale	*Megaptera novaeangliae*	55
American plaice	*Hippoglossoides platessoides*	54	Irish moss	*Chondrus crispus*	66
American sand lance	*Ammodytes americanus*	40	Karner blue butterfly	*Lycaeides melissa samuelis*	53
American shad	*Alosa sapidissima*	57	landlocked Arctic char	*Salvelinus alpinus*	40
American smelt	*Osmerus mordax*	49	Leach's storm-petrel	*Oceanodroma leucorhoa*	42
American woodcock	*Philohela minor*	36	least tern	*Sterna albifrons*	50
amphipod	*Corophium volutator*	39	leatherback turtle	*Dermochelys coriacea*	48
arctic tern	*Sterna paradisaea*	53	lions mane	*Cyanea capillata*	22
aschelminthean worm	*Priapulus caudatus*	18	little skate	*Raja erinacea*	31
aster	*Aster anticostensis*	43	longhorn sculpin	*Myoxocephalus octodecimspinosus*	29
Atlantic cod	*Gadus morhua*	59	Long's bittercrest	*Cardaminae longii*	45
Atlantic mackerel	*Scomber scombrus*	56	maidenhair spleenwort	*Asplenium trichomanes*	28
Atlantic puffin	*Fratercula arctica*	53	marsh felwort	*Lomatogonium rotatum*	33
Atlantic Ridley turtle	*Lepidochelys kempii*	58	mountain mint	*Pycnanthemum virginianum*	25
Atlantic salmon	*Salmo salar*	61	mummichog	*Fundulus heteroclitus*	42
Atlantic tomcod	*Microgadus tomcod*	36	mysid	*Neomysis americana*	32
Atlantic whitefish	*Coregonus huntsmani*	58	narrow-leaf arnica	*Arnica augustifolia lonchophylla*	31
bald eagle	*Haliaeetus leucocephalus*	54	New England cottontail	*Sylvilagus transitionalis*	40
banded bog skimmer	*Williamsonia lintneri*	46	northern comandra	*Geocaulon lividum*	34
bay scallop	*Aequipecten irradians*	56	northern harrier	*Circus cyaneus*	33
beach senecio	*Senecio pseudo-arnica*	36	northern phalarope	*Lobipes lobatus*	40
beggartick	*Bidens eatonii*	47	osprey	*Pandion haliaetus*	45
birdseye primrose	*Primula laurentiana*	36	Oxytropis deflexa foliolosa	*Oxytropis deflexa foliolosa*	22
black bear	*Ursus americanus*	43	pearl mussel	*Marguaritifera margaritifera*	38
black duck	*Anas rubripes*	48	peat moss	*Sphagnum flavicomans*	40
black legged kittiwake	*Rissa tridactyla*	38	peregrine falcon	*Falco perigrinus*	48
black racer	*Coluber constrictor*	33	periwinkles	*Littorina littorea*	55
Blandings turtle	*Emys blandingi*	41	piping plover	*Charadrius melodus*	53
blinks	*Montia fontana*	43	pogy	*Brevoortia tyrannus*	43
bloodworm	*Glycera dibranchiata*	54	pollock	*Pollachius virens*	57
blue mussel	*Mytilus edulis*	59	Pterospora andromedea	*Pterospora andromedea*	33
bluefin tuna	*Thunnus thynnus*	51	quahog	*Mercenaria mercenaria*	56
bluefish	*Pomatomus saltatrix*	45	Rand's eyebright	*Euphrasia randii*	33
bottle brush grass	*Hystrix patula bigeloviana*	34	razorbill	*Alca torda*	44
box turtle	*Terrapene carolina*	41	red knot	*Calidris canutus*	40
brittlestar	*Ophiura sarsi*	37	red phalarope	*Phalaropus fulicarius*	33
brook trout (anadromous)	*Salvelinus fontinalis*	53	red spruce	*Picea rubens*	45
Canada goose	*Branta canadensis*	46	redbreast sunfish	*Lepomis auritus*	26
Cetrariastrum catawbiense	*Cetrariastrum catawbiense*	33	redfish	*Sebastes marinus*	51
Cladina terrae-novae	*Cladina terrae-novae*	32	ribbon snake	*Thamnophis sauritus*	29
common dolphin	*Delphinus delphis*	50	right whale	*Eubalaena glacialis*	60
common eider	*Somateria mollissima*	52	river otter	*Lutra canadensis*	41
common loon	*Gavia immer*	58	rockweed	*Ascophylum nodusum*	61
common murre	*Uria aalge*	44	roseate tern	*Sterna dougallii dougallii*	53
common tern	*Sterna hirundo*	51	sand worm	*Nereis virens*	48
copepod	*Calanus finmarchicus*	32	saxifrage	*Saxifraga aizoon*	36
copepod	*Calanus glacialis*	33	screwstem	*Bartonia paniculata*	35
copepod	*Eurytemora herdmani*	32	sea anemone	*Cerianthus borealis*	37
copepod "bluefeed"	*Anomalocera paterssoni*	31	sea lamprey	*Petromyzon marinus*	18
cordgrass	*Spartina alterniflora*	57	sea lavender	*Limonium cardinianum*	38
curlygrass fern	*Schizaea pusilla*	34	sea pen	*Pennatula aculeata*	27
diamondback terrapin	*Malaclemys terrapin*	56	sea scallop	*Placopecten magellanicus*	60
diatom	*Nitzschia sp.*	30	seaside sparrow	*Ammospiza maritima*	34
diatom	*Gyrosigma sp.*	30	sedge	*Carex josselynii*	31
dinoflagellate	*Gonyaulax sp.*	30	sedge wren	*Cistothorus platensis*	44
dulse	*Palmaria palmata*	50	sei whale	*Balaenoptera borealis*	60
eelgrass	*Zostera marina*	59	semipalmated sandpiper	*Calidris pusilla*	39
euphausiid	*Meganyctiphanes norvegica*	34	sharp-tailed sparrow	*Ammodramus caudacutus*	40
finback whale	*Balaenoptera physalus*	57	shortnose sturgeon	*Acipenser brevirostrum*	51
flying squid	*Illex illecebrosus*	45	shrimp	*Pandalus borealis*	53
foraminifera	*Globulimina auriculata*	27	soft shelled clam	*Mya arenaria*	66
foraminifera	*Ammotium cassis*	25	sperm whale	*Physeter catodon*	55
furbish lousewort	*Pedicularis furbishiae*	47	spiny dogfish	*Squalus acanthias*	30
golden eagle	*Aquila chrysaetos*	42	spotted turtle	*Clemmys guttata*	45
goldenrod	*Solidago multiradiata*	31	striped bass	*Morone saxatilus*	53
grass shrimp	*Palaeomonetes pugio*	34	threadleafed sundew	*Drosera filiformis*	51
grasshopper sparrow	*Ammodramus savannarum*	41	trumpet worm	*Cysteneides gouldii*	30
gray cheeked thrush	*Catharus minimus bicknelli*	32	truncate angel wing	*barnea truncata*	34
gray seal	*Halichoerus grypus*	36	tufted red weed	*Gigartina stellata*	62
great blue heron	*Ardea herodias*	42	upland sandpiper	*Bartramia longicauda*	33
great cormorant	*Phalacrocorax carbo*	46	water pipit	*Anthus spinoletta*	23
greater shearwater	*Puffinus gravis*	40	white rice grass	*Leersia virginica*	25
green crab	*Carcinas maenas*	30	Whitlow-grass	*Draba lanceolata*	30
green sea urchin	*Strongylocentrotus droehbachiensis*	60	willet	*Catoptrophorus semipalmatus*	29
haddock	*Melanogrammus aeglefinis*	57	winter flounder	*Pseudopleuronectes americanus*	60
harbor porpoise	*Phocoena phocoena*	60	witch flounder	*Glyptocephalus cynoglossus*	51
			yellow screwstem	*Bartonia virginica*	31

APPENDIX C: ACRONYMS USED IN THIS REPORT

CBEP	Casco Bay Estuary Project
CMGE	Coastal Marine Geologic Environments (MGS data set)
CWCA	Coastal Wildlife Concentration Areas (MDIF&W data set)
DMR	Maine Department of Marine Resources
FWS	U.S. Fish and WIldlife Service
GIS	Geographic Information System (hardware, software and data)
GOMC	Gulf of Maine Council
MDIF&W	Maine Department of Inland Fisheries and Wildlife
MGS	Maine Geological Survey
MHVW	Moderate and High Value Wetlands (MDIF&W data set)
mlw	Mean low water (average elevation of low tides over a 19 year interval)
NRPA	Maine Natural Resource Protection Act
NWI	National Wetland Inventory (U.S. Fish and WIldlife Service)
OGIS	Maine Office of GIS
USGS	U.S. Geological Survey

Appendix D: Estimate of Data Reliability

Theme	Primary Source	Reliability*
Hydrology, coastline	existing coverages	3
CMGE	existing coverages	2
Bathymetry	MGS coverage	2
NWI	existing coverages	3
Landcover	Landsat	2
Eelgrass	existing coverages	3
Cordgrass	NWI	2
Shellfish, Marine Worm Habitats	existing coverages	2
Waterbird habitats: coastal	CWCA	3
Waterbird habitats: inland	NWI	1
Bald eagle nesting habitats	Essential Habitats	2
Roseate tern habitats: nesting	MDIF&W database	2
Roseate tern habitats: feeding	CWCA	1
Seabird habitats: nesting	MDIF&W database	3
Seabird habitats: feeding	CWCA	2
Shorebird habitats: nesting	Audubon data	3
Shorebird habitats: feeding	Audubon data	3
Wading bird habitats: nesting	MDIF&W database	3
Wading bird habitats: nesting	CWCA	2
Freshwater and anadromous fish habitats	MDIF&W	2

*(1 less certain, 3 more certain)

Figure 1
Casco Bay Study Area

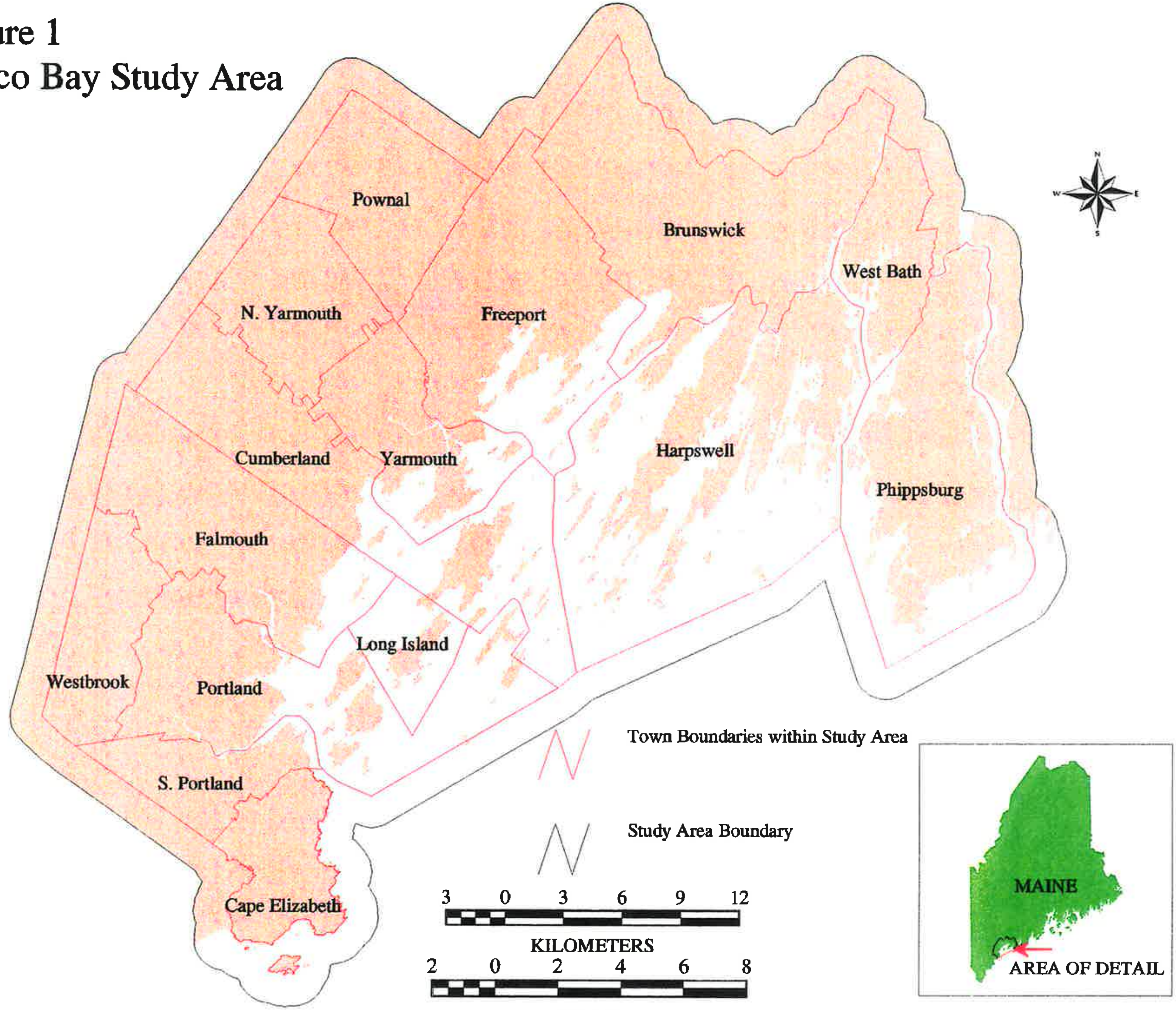


Figure 2
Casco Bay Wetlands and Coastal Islands

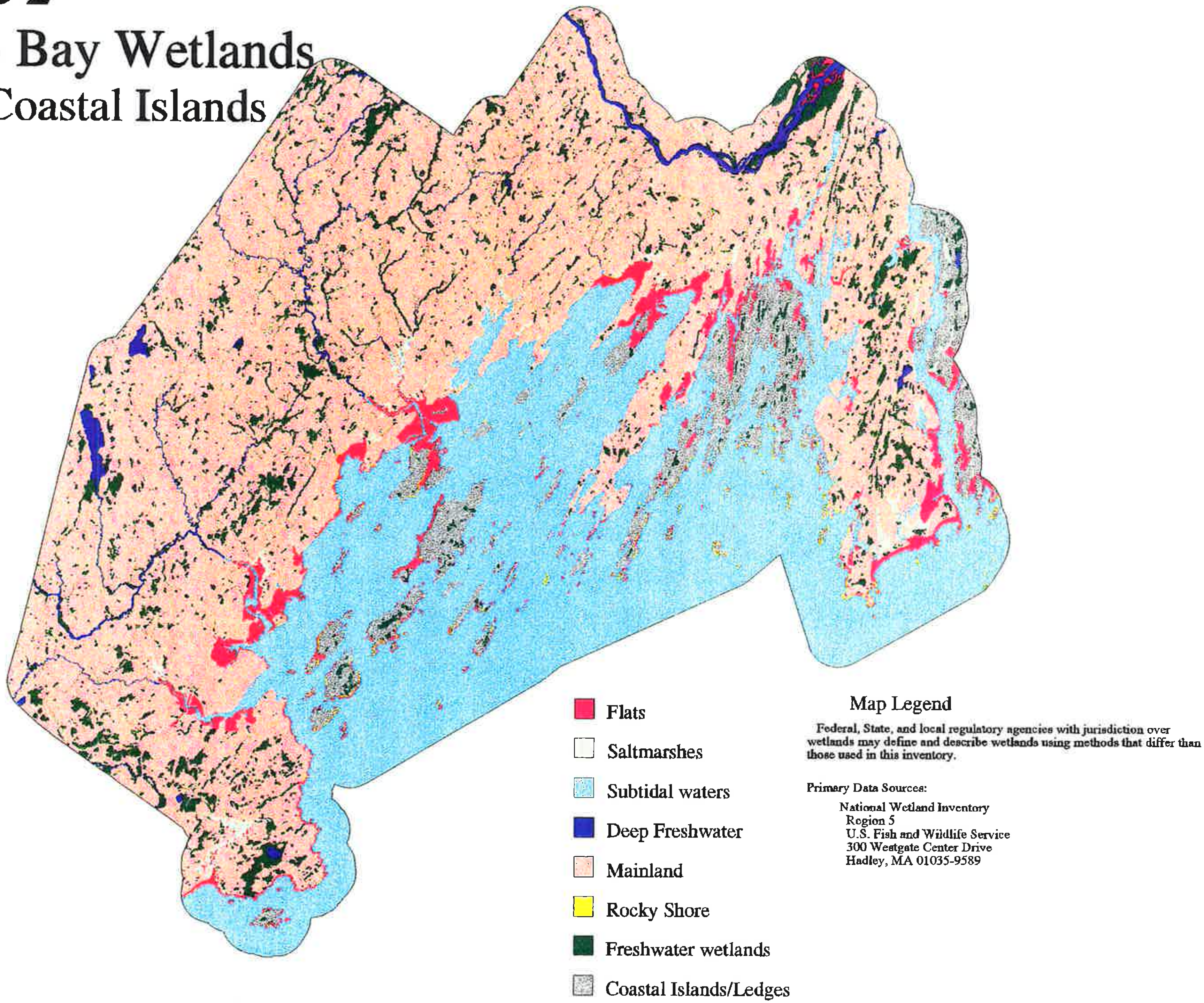


Figure 3
Casco Bay Landcover

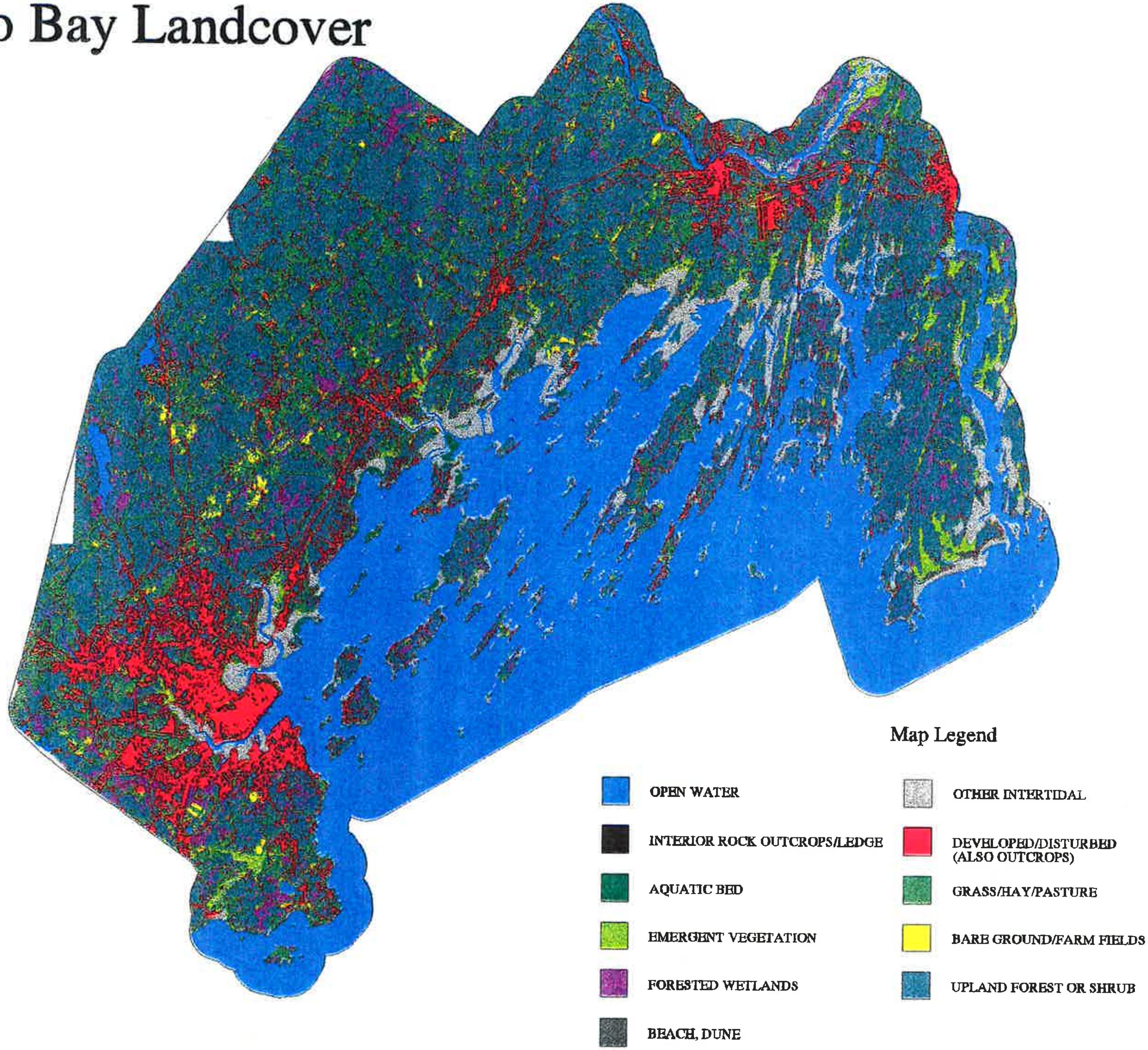
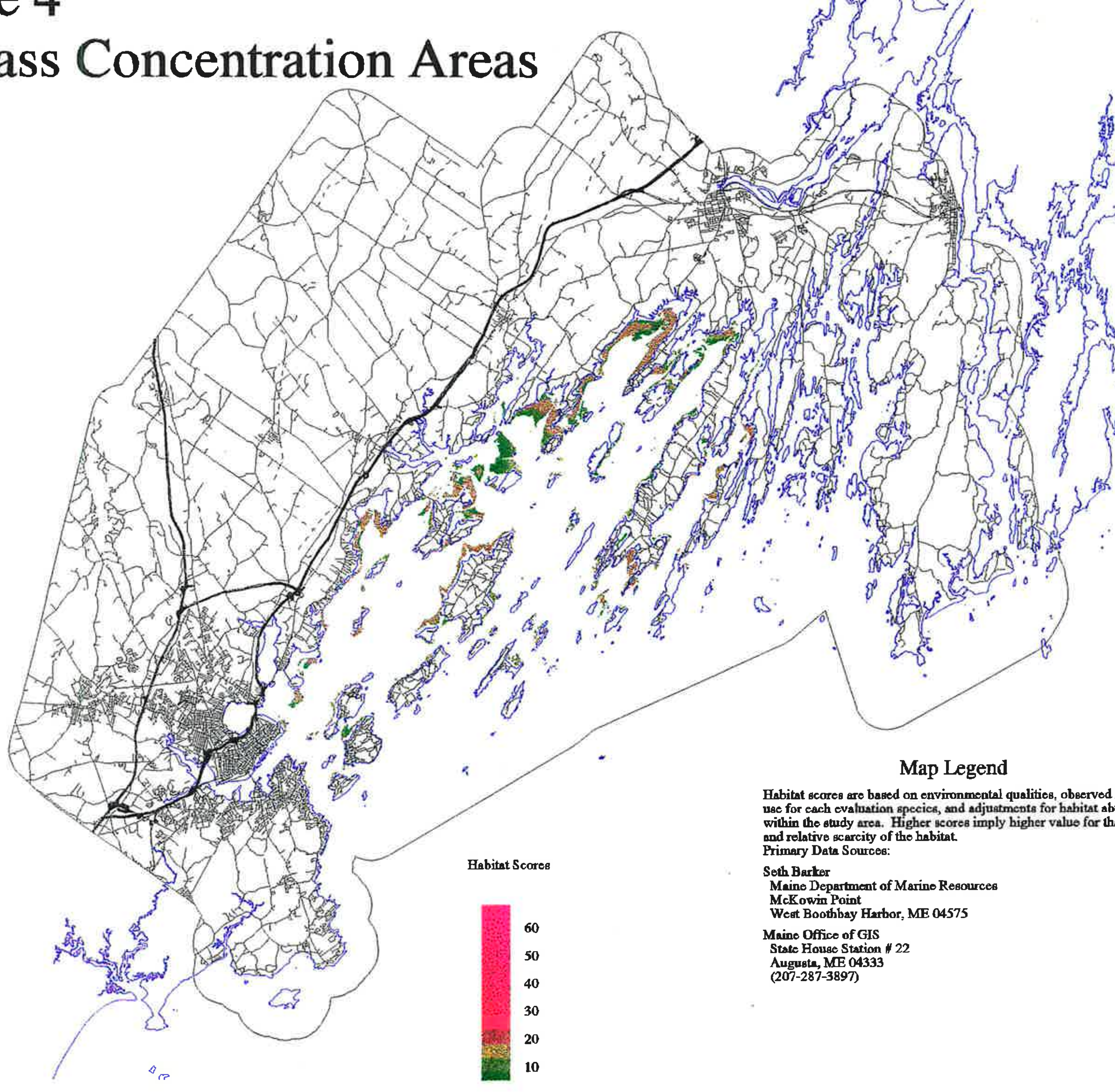


Figure 4
Eelgrass Concentration Areas



Map Legend

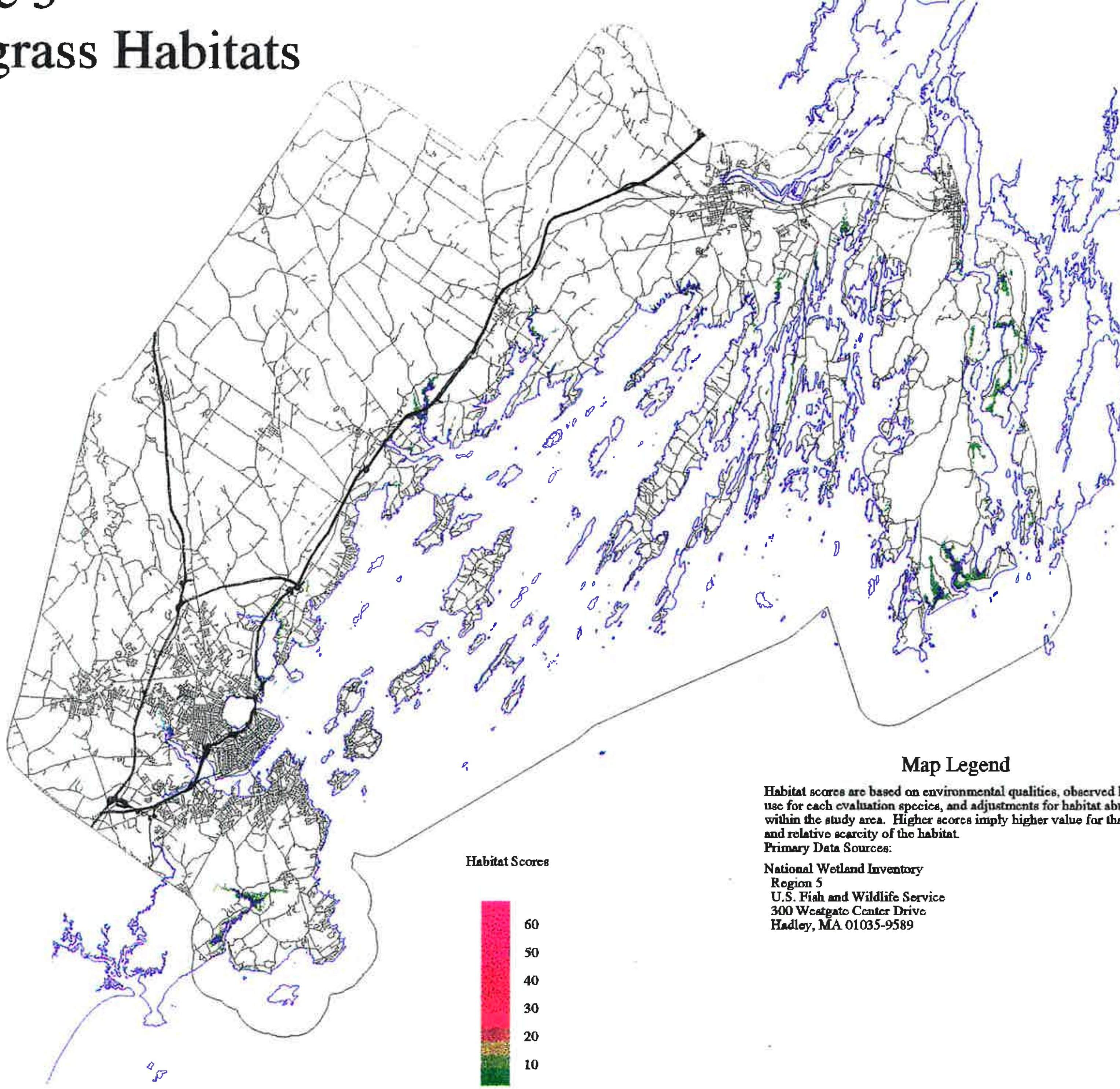
Habitat scores are based on environmental qualities, observed levels of use for each evaluation species, and adjustments for habitat abundance within the study area. Higher scores imply higher value for that species, and relative scarcity of the habitat.

Primary Data Sources:

Seth Barker
Maine Department of Marine Resources
McKowin Point
West Boothbay Harbor, ME 04575

Maine Office of GIS
State House Station # 22
Augusta, ME 04333
(207-287-3897)

Figure 5
Cordgrass Habitats

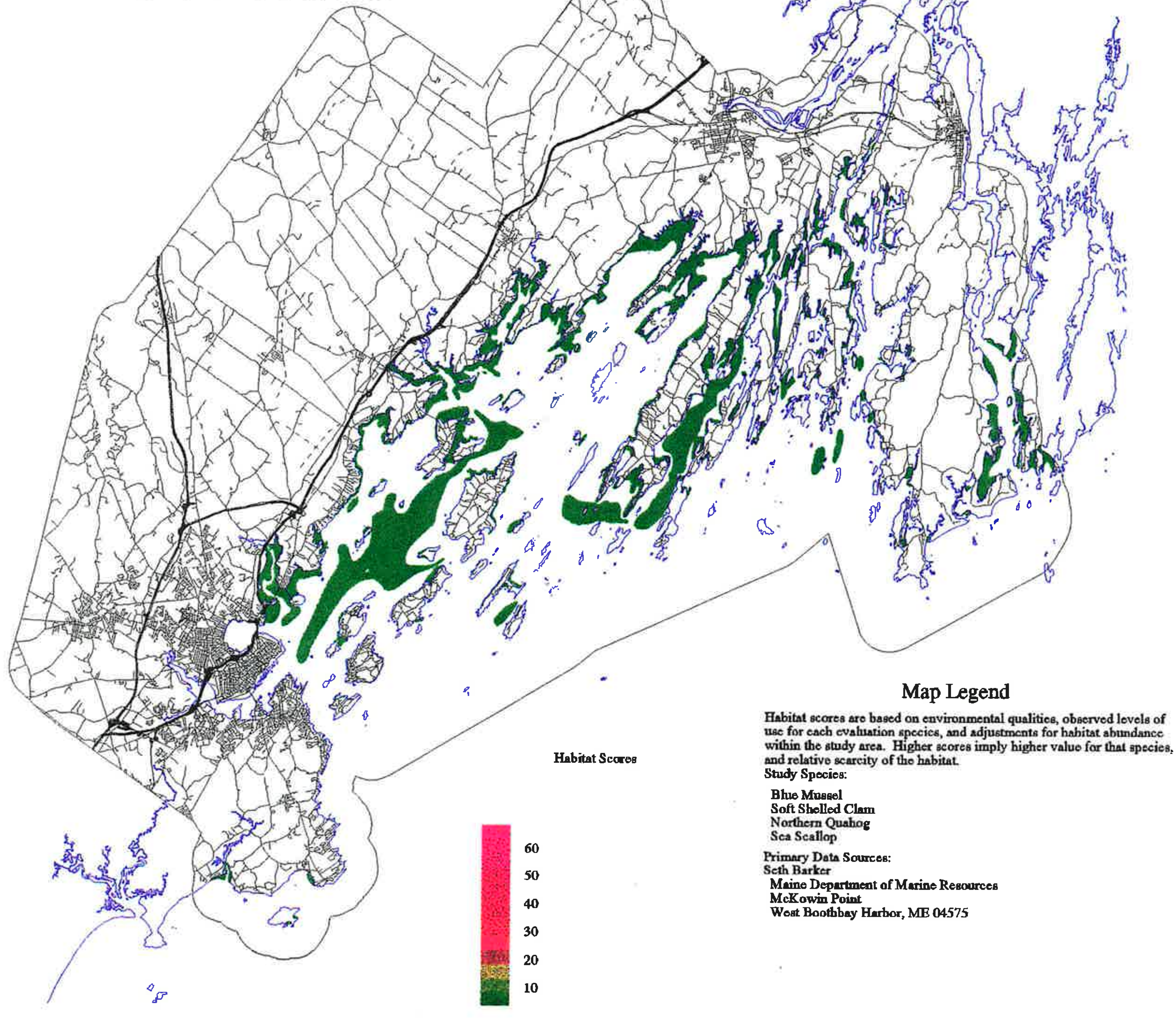


Map Legend

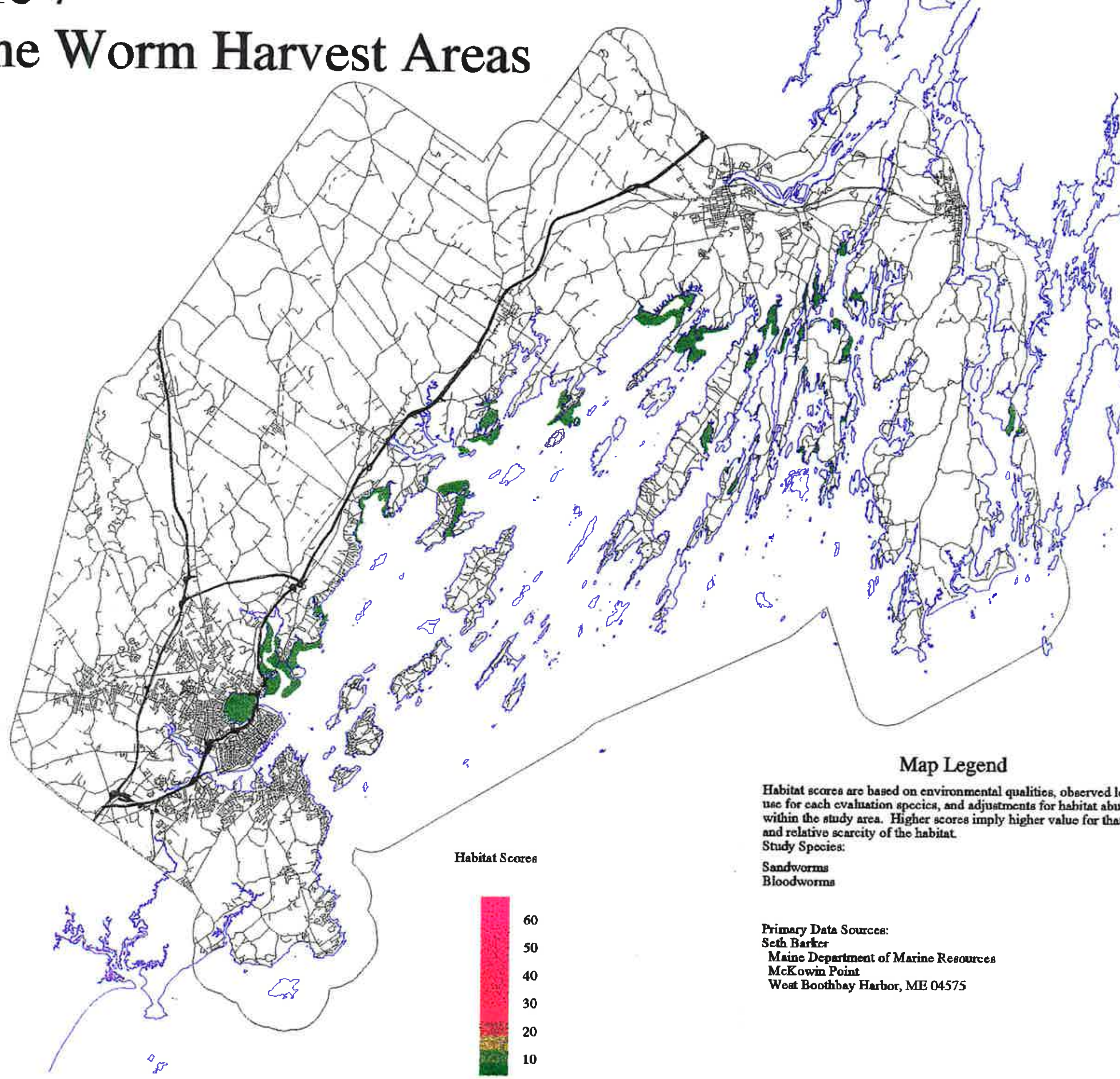
Habitat scores are based on environmental qualities, observed levels of use for each evaluation species, and adjustments for habitat abundance within the study area. Higher scores imply higher value for that species, and relative scarcity of the habitat.
Primary Data Sources:

National Wetland Inventory
Region 5
U.S. Fish and Wildlife Service
300 Westgate Center Drive
Hadley, MA 01035-9589

Figure 6
Shellfish Harvest Areas



Marine Worm Harvest Areas



Map Legend

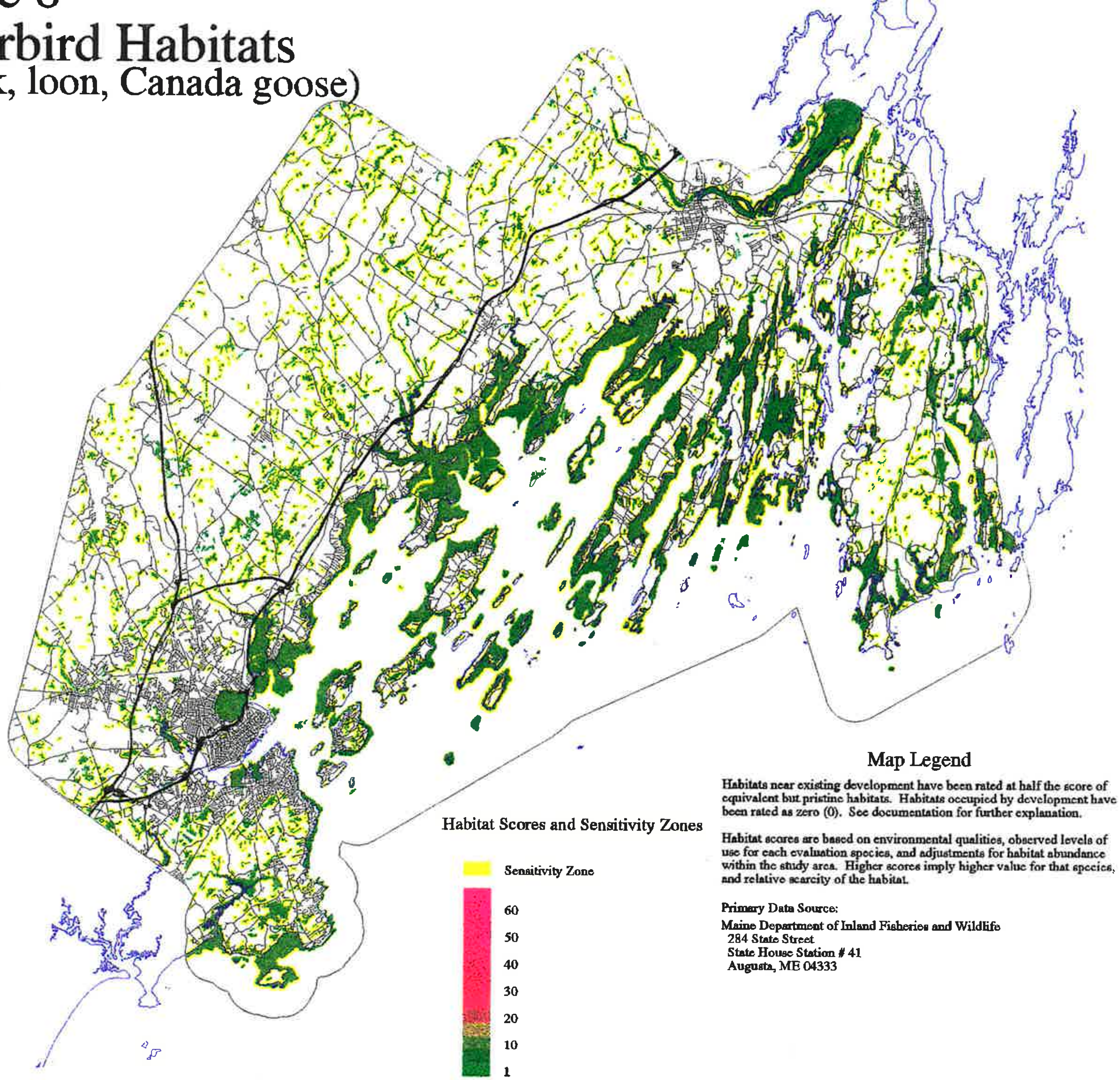
Habitat scores are based on environmental qualities, observed levels of use for each evaluation species, and adjustments for habitat abundance within the study area. Higher scores imply higher value for that species, and relative scarcity of the habitat.

Study Species:

Sandworms
Bloodworms

Primary Data Sources:
Seth Barker
Maine Department of Marine Resources
McKowin Point
West Boothbay Harbor, ME 04575

Figure
Waterbird Habitats
(black duck, loon, Canada goose)



Map Legend

Habitats near existing development have been rated at half the score of equivalent but pristine habitats. Habitats occupied by development have been rated as zero (0). See documentation for further explanation.

Habitat scores are based on environmental qualities, observed levels of use for each evaluation species, and adjustments for habitat abundance within the study area. Higher scores imply higher value for that species, and relative scarcity of the habitat.

Primary Data Source:
Maine Department of Inland Fisheries and Wildlife
284 State Street
State House Station # 41
Augusta, ME 04333

Figure 9
Bald Eagle Nesting Locations

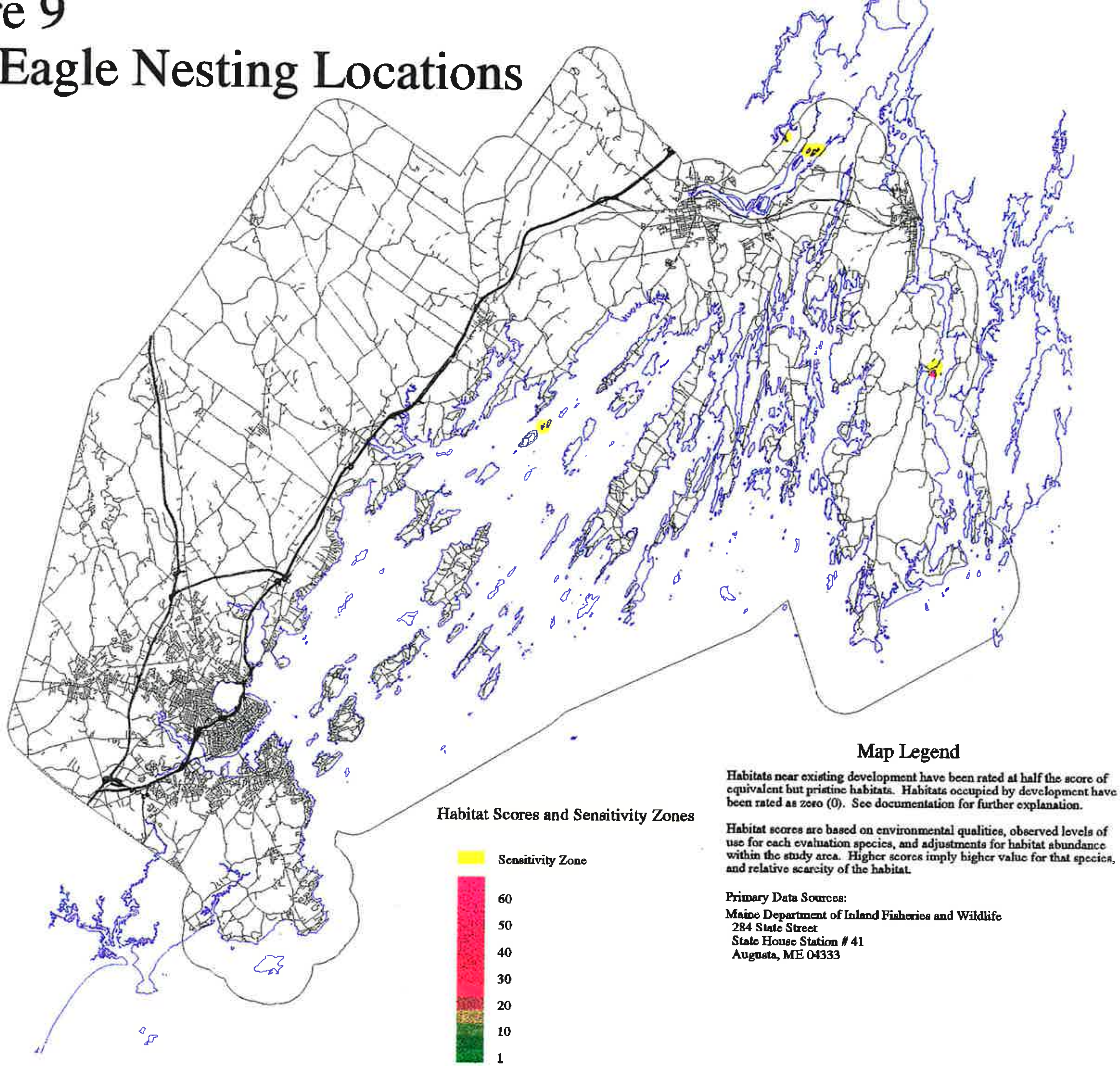


Figure 10
Roseate Tern Habitats

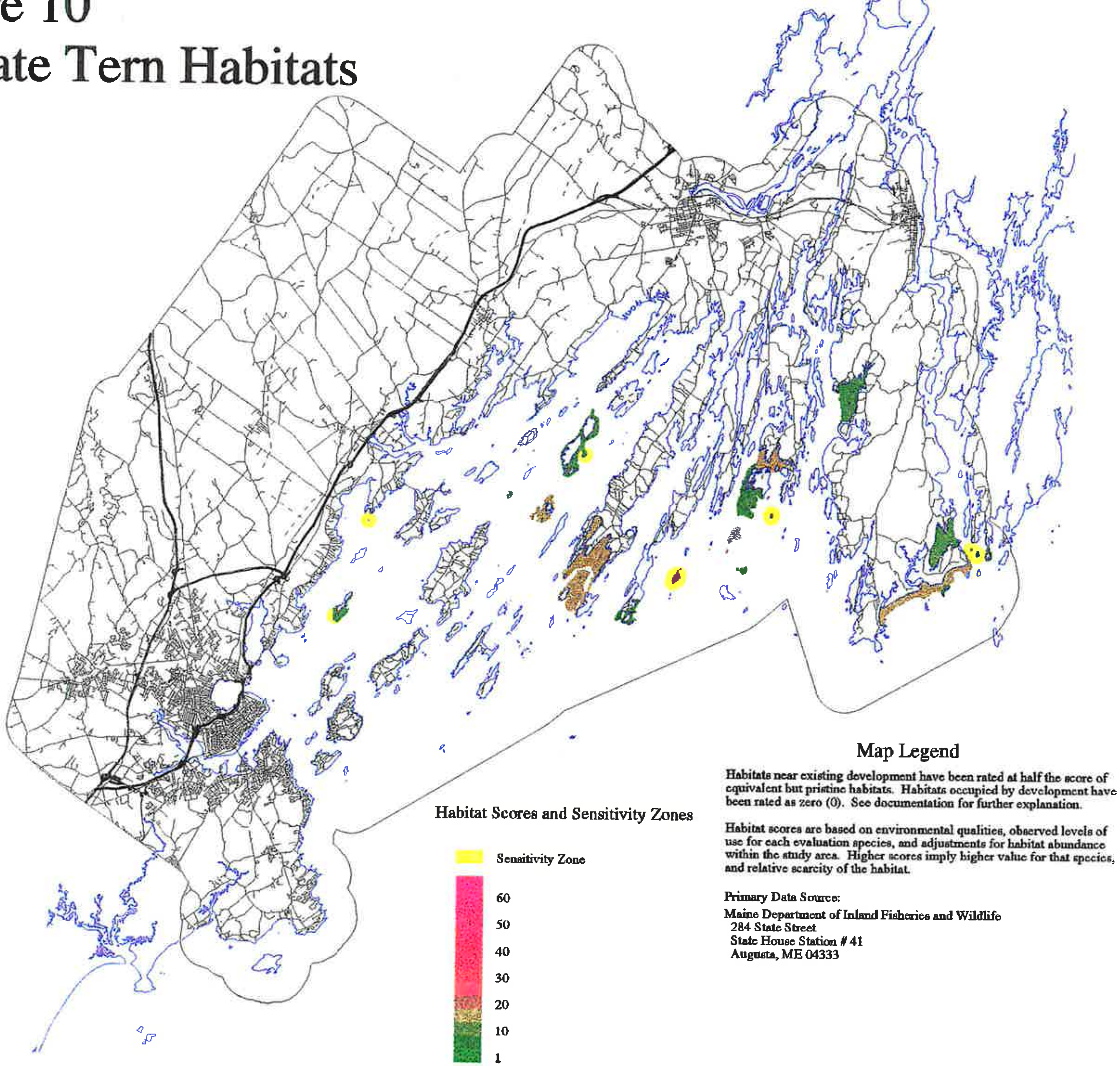


Figure 11 Seabird Habitats
(Common Eider, Common Tern)

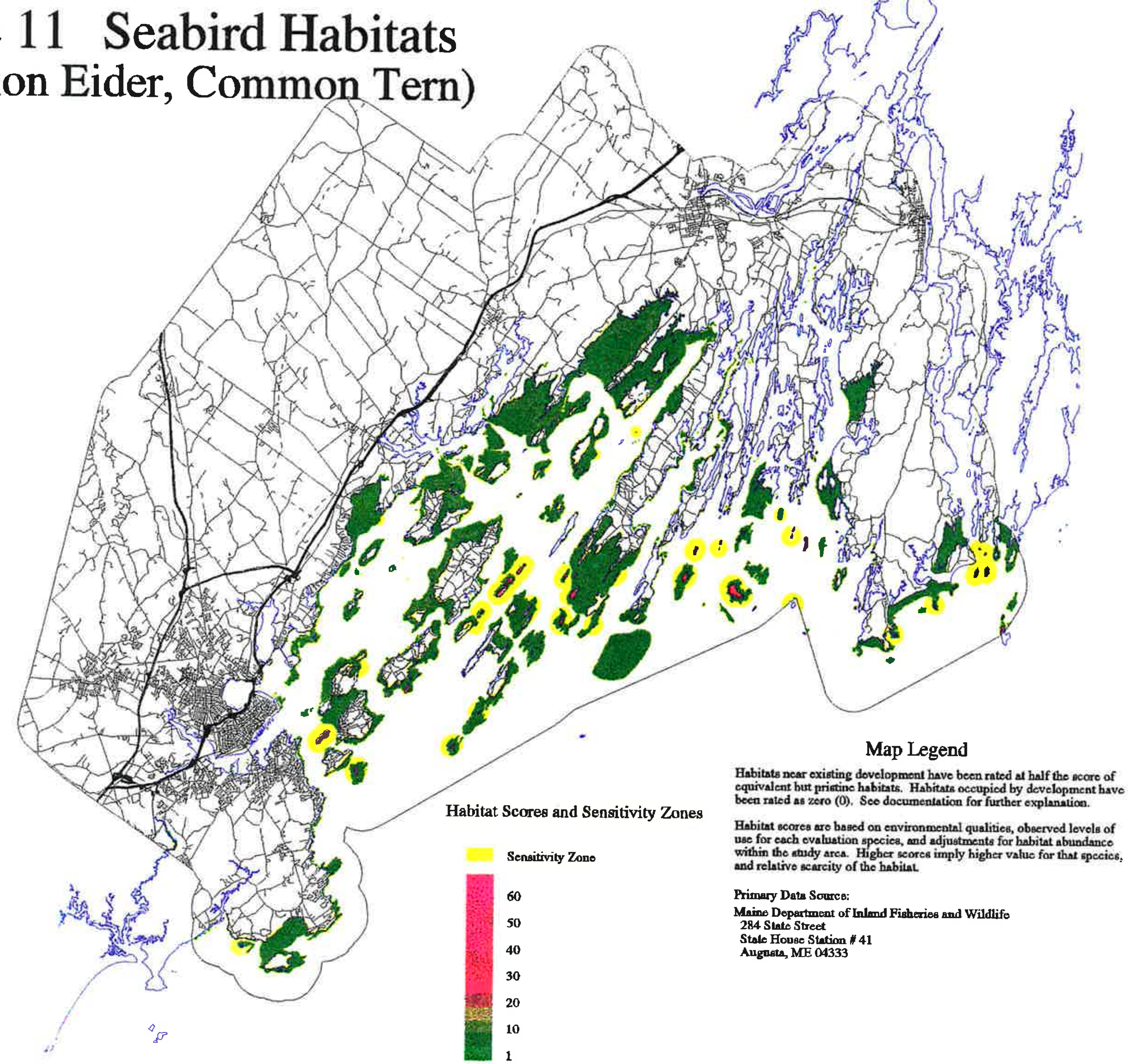
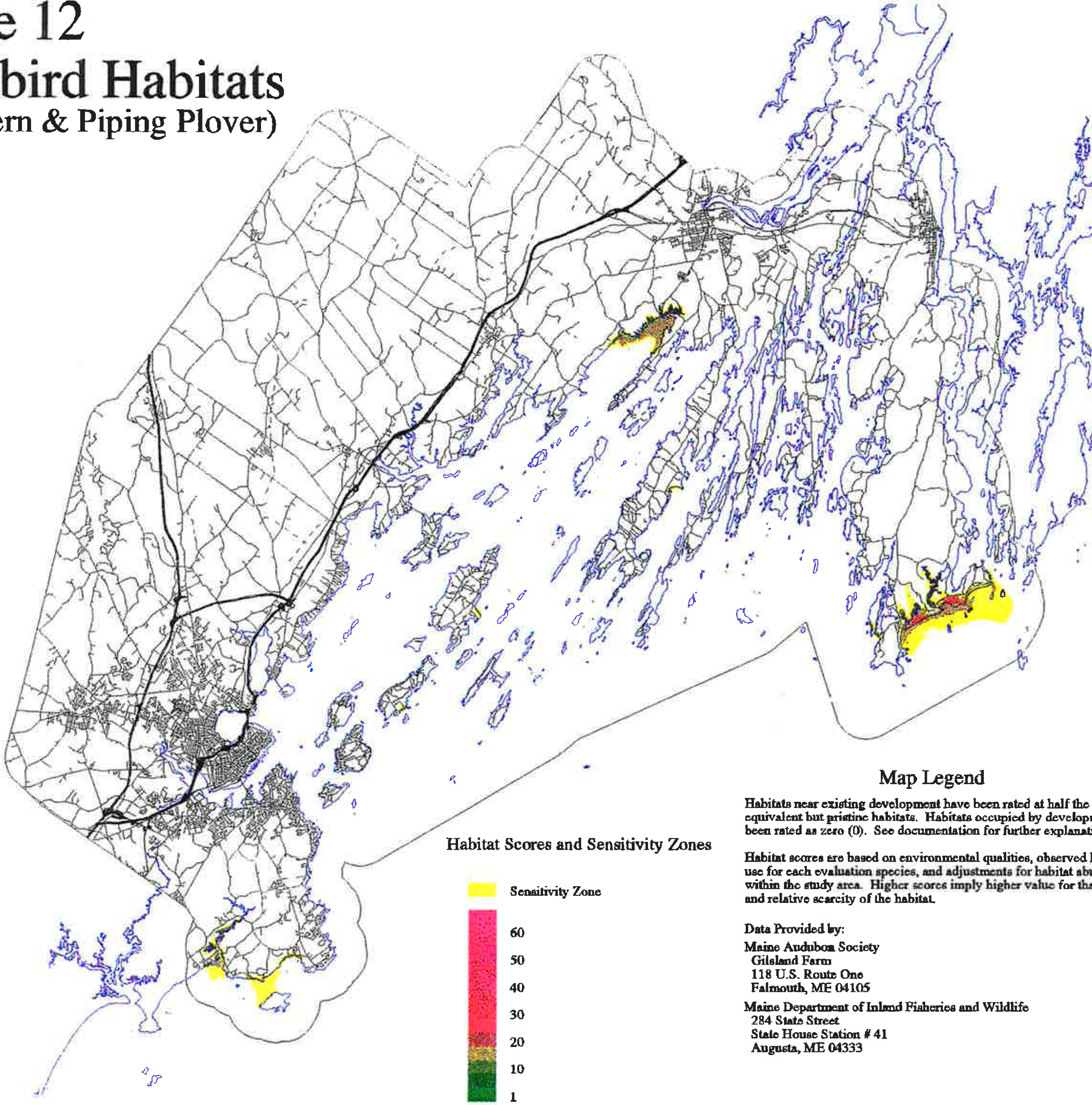


Figure 12
Shorebird Habitats
(Least Tern & Piping Plover)



Habitat Scores and Sensitivity Zones

Sensitivity Zone

60
50
40
30
20
10
1

Map Legend

Habitats near existing development have been rated at half the score of equivalent but pristine habitats. Habitats occupied by development have been rated as zero (0). See documentation for further explanation.

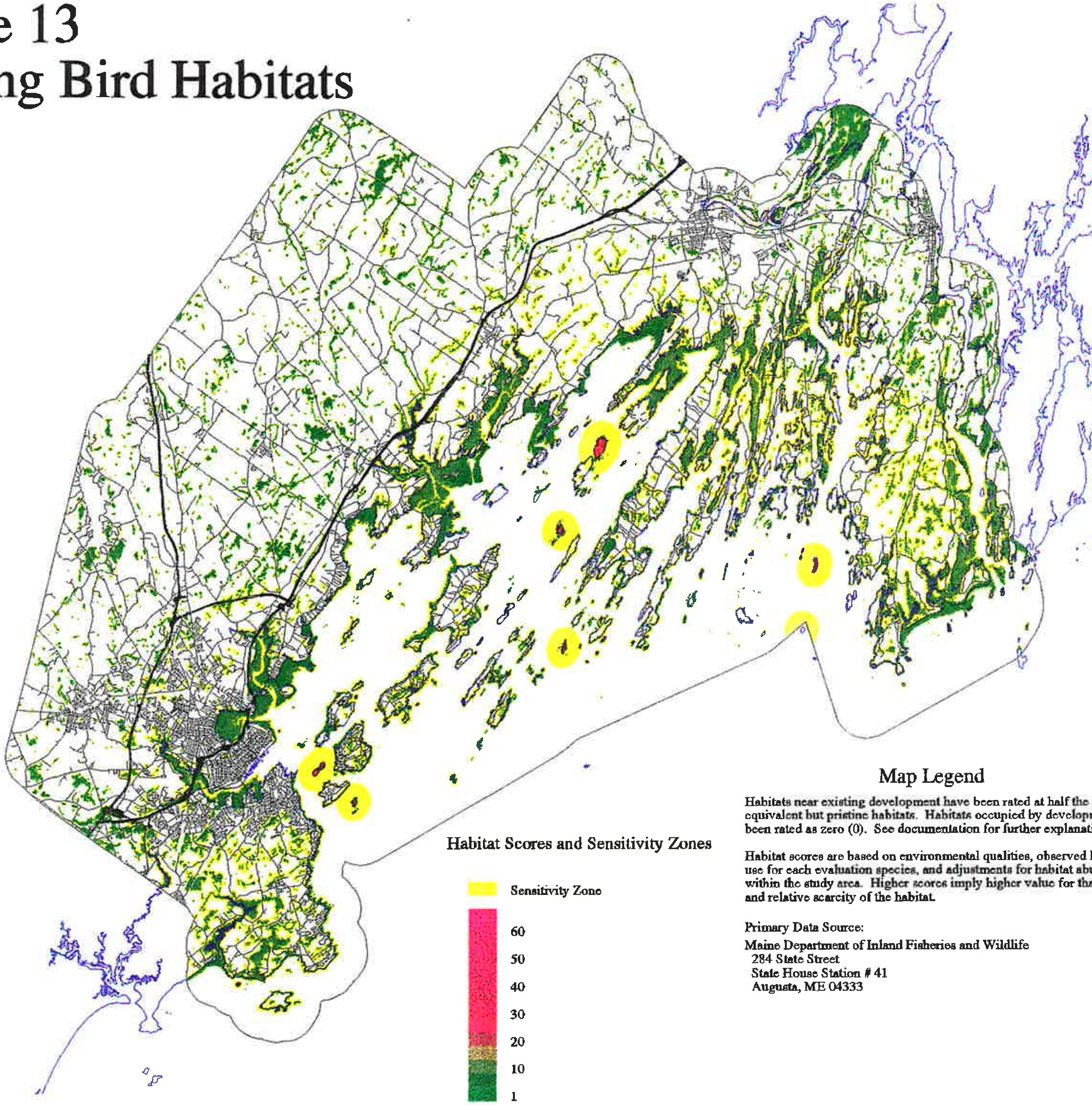
Habitat scores are based on environmental qualities, observed levels of use for each evaluation species, and adjustments for habitat abundance within the study area. Higher scores imply higher value for that species, and relative scarcity of the habitat.

Data Provided by:

Maine Audubon Society
Gilsland Farm
118 U.S. Route One
Falmouth, ME 04105

Maine Department of Inland Fisheries and Wildlife
284 State Street
State House Station # 41
Augusta, ME 04333

Figure 13
Wading Bird Habitats



Map Legend

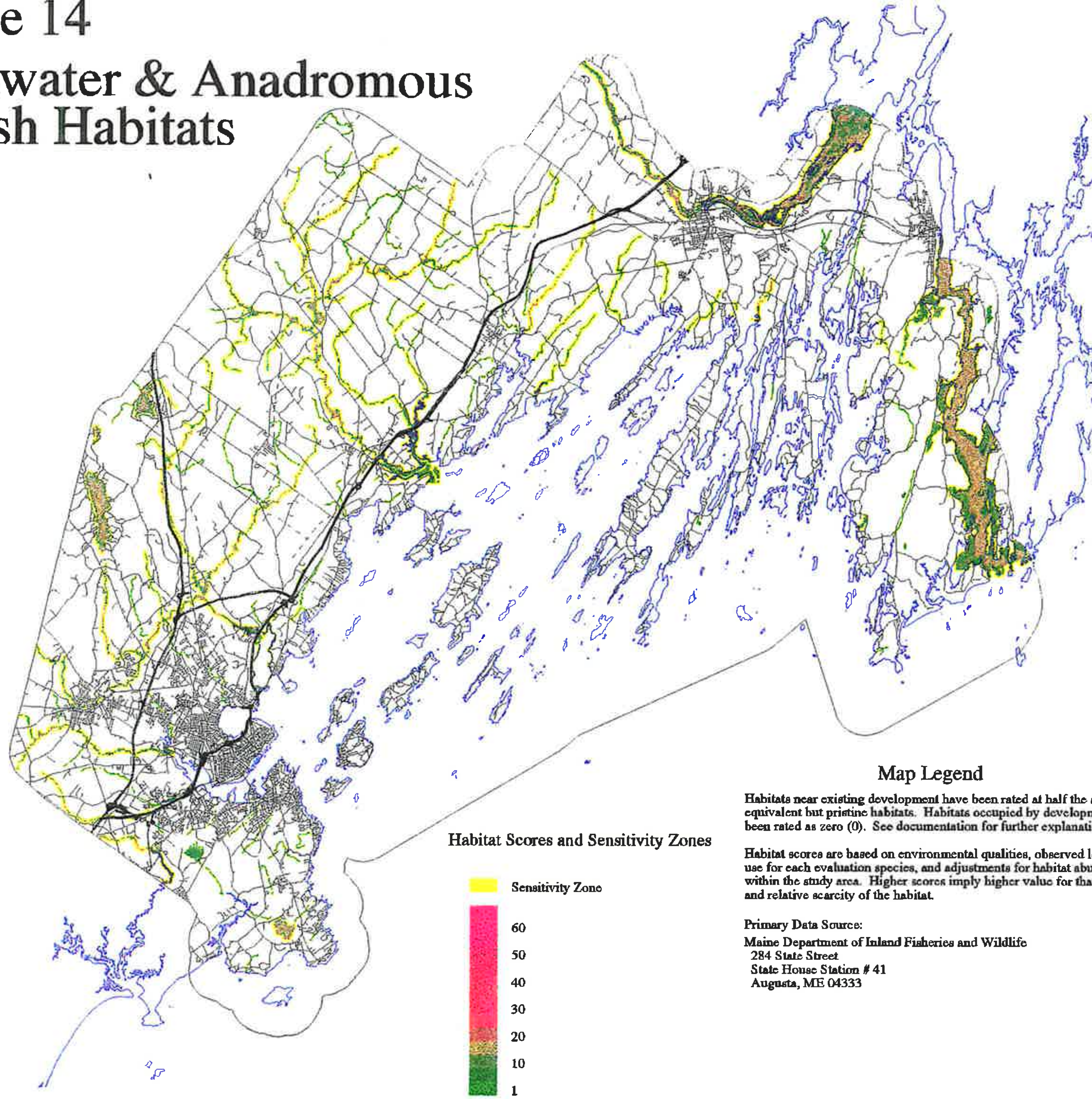
Habitats near existing development have been rated at half the score of equivalent but pristine habitats. Habitats occupied by development have been rated as zero (0). See documentation for further explanation.

Habitat scores are based on environmental qualities, observed levels of use for each evaluation species, and adjustments for habitat abundance within the study area. Higher scores imply higher value for that species, and relative scarcity of the habitat.

Primary Data Source:
Maine Department of Inland Fisheries and Wildlife
284 State Street
State House Station # 41
Augusta, ME 04333

Figure 14

Freshwater & Anadromous Fish Habitats



Map Legend

Habitats near existing development have been rated at half the score of equivalent but pristine habitats. Habitats occupied by development have been rated as zero (0). See documentation for further explanation.

Habitat scores are based on environmental qualities, observed levels of use for each evaluation species, and adjustments for habitat abundance within the study area. Higher scores imply higher value for that species, and relative scarcity of the habitat.

Primary Data Source:

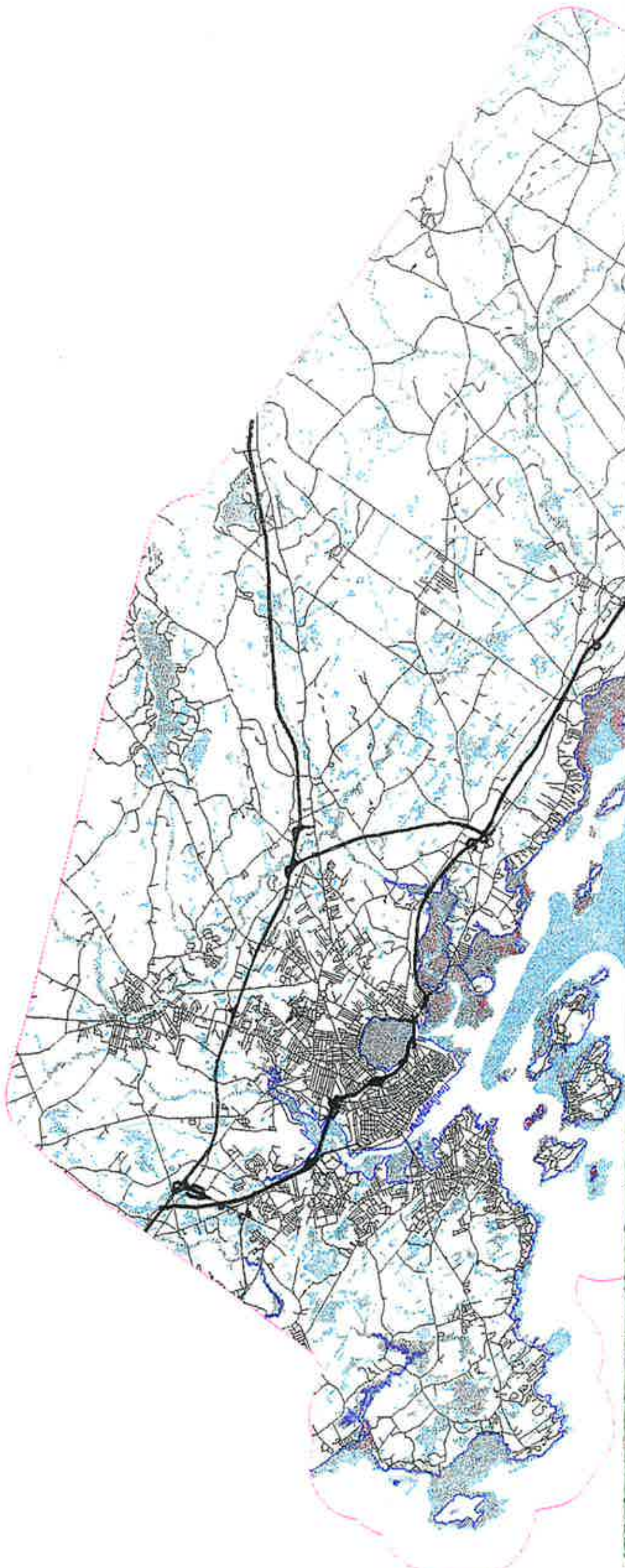
Maine Department of Inland Fisheries and Wildlife
284 State Street
State House Station # 41
Augusta, ME 04333

Figure 15 IMPC FOR ALI

the distribution of habitats suitable for the following
ɔllfish (softshell clam, blue mussel, northern
llops), marine worms (bloodworms, sandworms), cordgrass,
ack ducks, Canada geese), bald eagles, roseate terns, seabirds
mon tern), shorebirds (least tern, piping plover), wading birds,
nadromous fishes.

abitat maps for each species, scoring areas on the basis of
observed level of use. These scores were indexed, based on
nce within the study area and the species' Gulf ofMaine Council
d for all species, producing the gradient of total scores displayed
nmed scores highlight areas having thegreatest values for the largest
species. While this process clearly discloses areas having high
portant to keep in mind that a) other areas within the watershed
rtant for other fish and wildlife species, and b) the evaluation is
t available information but may not accurately portray most recent
occupation by the evaluation species.

existing development have been rated at half the score
tine habitats. Habitats occupied by development have
). See documentation for further explanation.



Area of Detail