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Environmental Indicator Report: Species and Habitats

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New Hampshire Estuaries Project

Environmental Indicator Report

SPECIES AND HABITATS

Final

April 30, 2003

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NHEP Technical Advisory Committee

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Tom Ballestero	UNH
Gregg Comstock	NHDES
Paul Currier	NHDES
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- Claire McBane, NHF&G
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- Ken Gallagher, NHOSP

INTRODUCTION

During the fall and winter of 2001-2002, the New Hampshire Estuaries Project's Technical Advisory Committee (TAC) developed a suite of environmental indicators to track progress toward the NHEP's management goals and objectives. These indicators were fully described in terms of their performance criteria, statistical methods, and measurable goals in the NHEP's Monitoring Plan, which was most recently updated in March 2003 (NHEP, 2003).

The next step is to use these indicators to produce an updated "State of the Estuaries" report by mid-2003. The TAC decided to break this task into three sections: shellfish indicators in the fall of 2002; water quality indicators in the winter of 2002-2003; and land use/habitat indicators in the spring of 2003. For each group of indicators, the NHEP Coastal Scientist would prepare an "Indicator Report" that summarizes the available information and results of statistical tests for each of the indicators. The TAC would review and comment on this report, and then recommend a subset of the most important or illustrative indicators to be presented to the Management Committee. Finally, after being presented to both the TAC and the Management Committee, the indicator charts and interpretation would be incorporated in the State of the Estuaries report.

This report is the last of four indicator reports to be presented to the TAC. The focus of this report is the NHEP's species and habitats indicators (see list below). In an effort to be brief, the details of the monitoring programs for each indicator are not included. Please refer to the NHEP Monitoring Plan (NHEP, 2003) for additional details for each indicator.

<u>NHEP Indicators Included in this Report</u>

<u>Critical Species and Habitats</u>
HAB2: Eelgrass distribution
HAB7: Abundance of juvenile finfish
HAB8: Anadromous fish returns
HAB9: Abundance of lobsters
HAB10: Abundance of wintering waterfowl

*Note: Other species and habitats of particular interest to the NHEP are clams and oysters. See the NHEP's Shellfish Indicator Report for details on these species.

<u>Habitat Protection</u>
HAB6: Conservation lands
HAB3: Shoreland development and protection
HAB4: Unfragmented forest blocks
HAB5: Rare and exemplary natural communities

<u>Habitat Restoration</u>
RST1: Restored salt marsh
RST2: Restored eelgrass beds
RST3: Restored oyster beds

ENVIRONMENTAL INDICATORS OF CRITICAL SPECIES AND HABITATS

HAB2. Eelgrass Distribution

a. Monitoring Objectives

The objective of this supporting variable is to track the area of eelgrass present in tidal tributaries to the Great Bay, Great Bay, and Little Bay. Water clarity is one of the main factors affecting the distribution of eelgrass. However, eelgrass can be affected by other factors such as disease on a rapid temporal scale. This indicator will provide information relevant to the following question:

- "Do the following indicators show that water quality is suitable for aquatic life: aquatic insects/invertebrates, wildlife, fish, diatoms/algae, large bivalves, *eelgrass*, marshes?

which will, in turn, provide supporting information on the following management goal:

- Land Use Goal #6: "Maintain habitats of sufficient size and quality to support populations of naturally occuring plants, animals, and communities.

b. Measurable Goals

Eelgrass distribution is a supporting variable which will not be used for management decisions so no measurable goals have been established.

c. Data Analysis and Statistical Methods

The method for eelgrass mapping in the Great Bay Estuary generally followed the standardized "C-CAP" protocol for mapping submerged aquatic vegetation (Coastal Change Analysis Program, NOAA). The aerial photographs were taken at 3,000 ft at low spring tide with roughly 60% overlap on a calm day without preceding rain events and when the sun was at a low angle to minimize reflection (between 7 and 10 am). The photographs were near-verticals, taken with a hand-held 35mm camera, which deviates from C-CAP's protocol, but follows a published method (Short and Burdick, 1996). Photographs were taken in late summer, usually late August or early September, depending on tides and weather, to reflect the time of maximum eelgrass biomass. Ground truthing was done from a small boat at the same season as the photographs were taken. Observations were made at low tide. Samples were collected with an eelgrass sampling hook. Positions were determined using GPS. The ground truth surveys assessed 10 - 20% of the eelgrass beds in the estuary. The photographs, in the form of 35mm slides or digital computer images, were projected on a screen and the eelgrass images were transferred to a base map. These maps were then digitized and verified using the ground truth data by placing the GPS points onto the digital image in ArcInfo.

For data analysis, ArcView/ArcInfo software was used to calculate the area of eelgrass coverage in the different areas of the Great Bay Estuary (see table below) from GIS files produced by the UNH Seagrass Ecology Group. For the purposes of calculating acreage totals, all areas mapped as being eelgrass by UNH were included equally in the total regardless of whether the eelgrass at the location was noted as "dense" or "scarce".

Area	Zone of eelgrass quantification
Squamscott and Lamprey rivers	upstream of a line connecting Sandy Point and Moody's Point
Oyster River	upstream from a line across the mouth of the Oyster River
Bellamy River	upstream of the Bellamy River Bridge.
Great Bay	From boundary of Squamscott/Lamprey Rivers to Adams Pt.
Little Bay	From Adams Pt to Gen. Sullivan Bridge minus Oyster and Bellamy Rivers.
Portsmouth/Little Harbor	From I-95 bridge across the Piscataqua to the Atlantic Ocean.

d. Results

Eelgrass (*Zostera marina*) is an essential habitat for the estuary because provides food for wintering waterfowl and habitat for juvenile fish (Thayer et al. 1984).

The UNH Seagrass Ecology Group has mapped the distribution of eelgrass in Great Bay every year from 1986 to 2001 in the Great Bay. The entire Great Bay Estuary system (Great Bay, Little Bay, tidal tributaries, Piscataqua River, and Portsmouth Harbor) was mapped in 1996, 1999, 2000, and 2001. Table 1 summarizes the acres of eelgrass in each assessment zone from 1986-2001. Figure 1 shows the trend in eelgrass cover in Great Bay over time.

Eelgrass cover in Great Bay has been relatively constant for the past 10 years at approximately 2,000 acres. In 1989, there was a dramatic crash of the eelgrass beds down to 300 acres (15% of normal levels). The cause of this crash was an infestation of a slime mold *Labryrinthula zosterae*, commonly called “wasting disease” (Muehlstein et al., 1991). The greatest extent of eelgrass was observed in 1996 following several years of good water quality (Fred Short, pers. comm.). Current (2001) eelgrass coverage in the estuary is shown in Figure 2.

Table 1: Eelgrass coverage in the Great Bay Estuary

Year	Great Bay	Little Bay	Portsmouth and Little Harbors	Piscataqua River	Squamscott and Lamprey Rivers	Oyster River	Bellamy River
1986	1,989	NS	NS	NS	29	NS	NS
1987	1,681	NS	NS	NS	7	NS	NS
1988	1,123	NS	NS	NS	64	NS	NS
1989	313	NS	NS	NS	0	NS	NS
1990	1,999	NS	NS	NS	13	NS	NS
1991	2,230	NS	NS	NS	17	NS	NS
1992	2,275	NS	NS	NS	50	NS	NS
1993	2,353	NS	NS	NS	83	NS	NS
1994	2,349	NS	NS	NS	76	NS	NS
1995	2,172	NS	NS	NS	42	NS	NS
1996	2,421	NA	NA	NA	65	NA	NA
1997	2,285	NS	NS	NS	3	NS	NS
1998	2,318	NS	NS	NS	61	NS	NS
1999	2,041	26	300	66	63	0	0
2000	1,873	7	329	63	72	0	0
2001	2,330	11	332	69	53	0	0

NS = Not sampled. The eelgrass surveys from all years except 1996 and 1999-2001 only covered Great Bay.
NA = Data not available for this report.

Figure 1: Eelgrass coverage in Great Bay

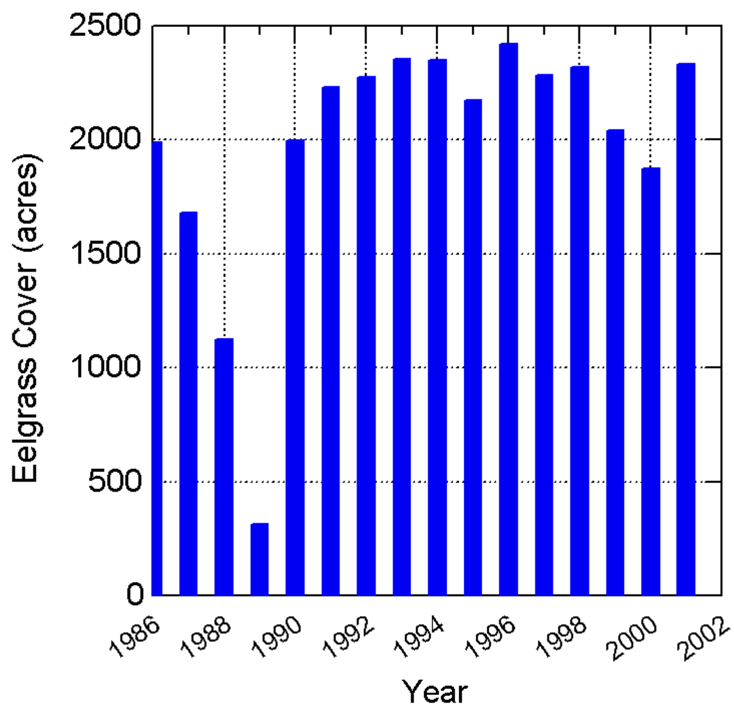
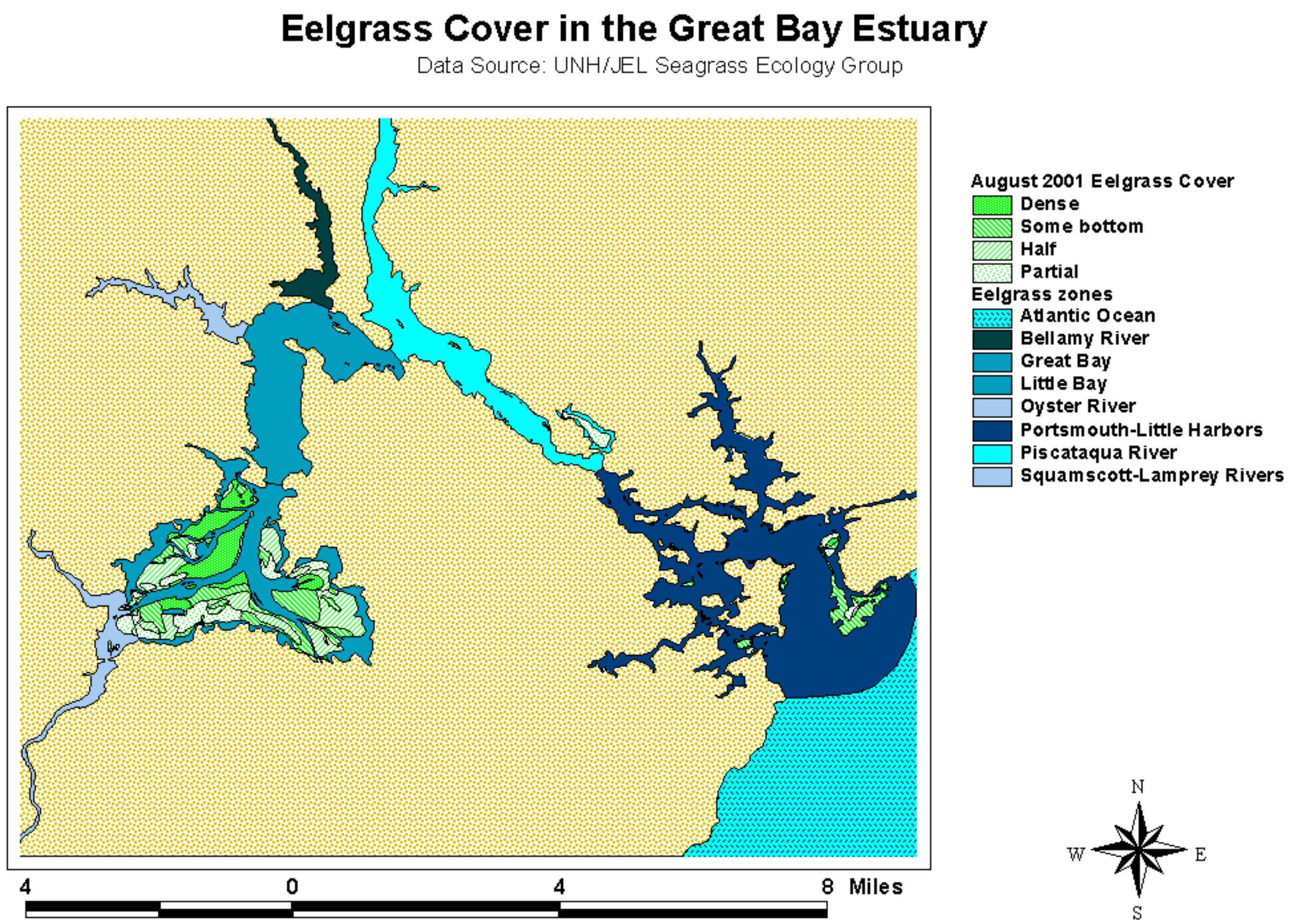


Figure 2: Eelgrass coverage in the Great Bay Estuary in 2001



HAB7. Abundance of Juvenile Finfish

a. Monitoring Objectives

Juvenile finfish are sensitive to estuarine conditions. Many juvenile fish species spend significant portions of their life history in the estuary, and are an important source of food. Since juvenile finfish occupy a lower niche in the food web, population dynamics are less complicated and more predictable. The objective of this supporting variable is to illustrate year to year trends in the abundance and diversity of juvenile finfish in the estuary. It will address the following monitoring question related to Land Use Goal #6:

- "Has the relative abundance, biology, and species composition of resident finfish changed significantly over time?"

which will, in turn, provide supporting information on the following management goal:

- Land Use Goal #6: "Maintain habitats of sufficient size and quality to support populations of naturally occuring plants, animals, and communities.

b. Measurable Goals

Since juvenile finfish is a supporting variable that will not be used to answer an management question, no goals have been set.

c. Data Analysis, Statistical Methods and Hypothesis

Data on juvenile fish abundance was provided by fish counts from standardized beach seine hauls conducted by NHF&G for the Atlantic Coastal Fisheries Cooperative Management Act (NHF&G, 2001). The data were analyzed several ways.

First, the average catch per unit effort (CPUE) for the most abundant species was calculated and compared to the range of observations from previous years. The geometric mean CPUE for all months combined for the selected species was taken from the annual reports by NHF&G. Results from Great Bay/Little Bay, the Piscataqua River, Little Harbor and Hampton Harbor were averaged separately because these areas have different environments with different fish assemblages. The average CPUE for each species in each area was compared to the range of all the previous observations.

Second, the Simpson diversity index (D) was calculated based on the counts of all juvenile fish species caught during the season. The equation for the Simpson index (Simpson, 1949) is:

$$D = \sum_i p_i{}^2 = \frac{\sum_i n_i(n_i - 1)}{N(N-1)}$$

where p_i is the proportion of each species i in the community, n_i is the number of fish collected for species i and N is the total number of fish collected. The CPUE values reported by NHF&G were multiplied by the effort required to capture one fish of the least abundant species and then rounded to the closest integer to transform the data into a format compatible with this equation.

Third, the species richness index (S) was calculated. The species richness index is simply the number of species observed each year.

d. Results

The average CPUE for the dominant species are shown in Table 2 and Figure 3. Table 3/Figure 4 and Table 4/Figure 5 contain the values of the Simpson diversity index (D) and the species richness index (S), respectively.

In all areas, the most abundant juvenile fish was the Atlantic Silverside. This species was 3-5 times more abundant than any other species in Hampton Harbor, Little Harbor, and the Piscataqua River in 2001. In Great Bay/Little Bay, Atlantic Silversides were over 20 times more abundant than any other species in 2001.

The values of the Simpson diversity index (D) reflect the dominance of the Atlantic Silversides. Values of D have hovered around 0.7 and 0.5 for the Great Bay/Little Bay and the three other areas, respectively. D is a measure of the probability of selecting a pair of individuals of the same species from a single random sample of the community. Therefore, there is a 70% chance that any two juvenile fish selected from the Great Bay/Little Bay at random will be Atlantic Silversides. The species richness index shows that there are slightly more fish species present in the Great Bay/Little Bay and Piscataqua River (19-20 species) than in the coastal harbors (12-14 species).

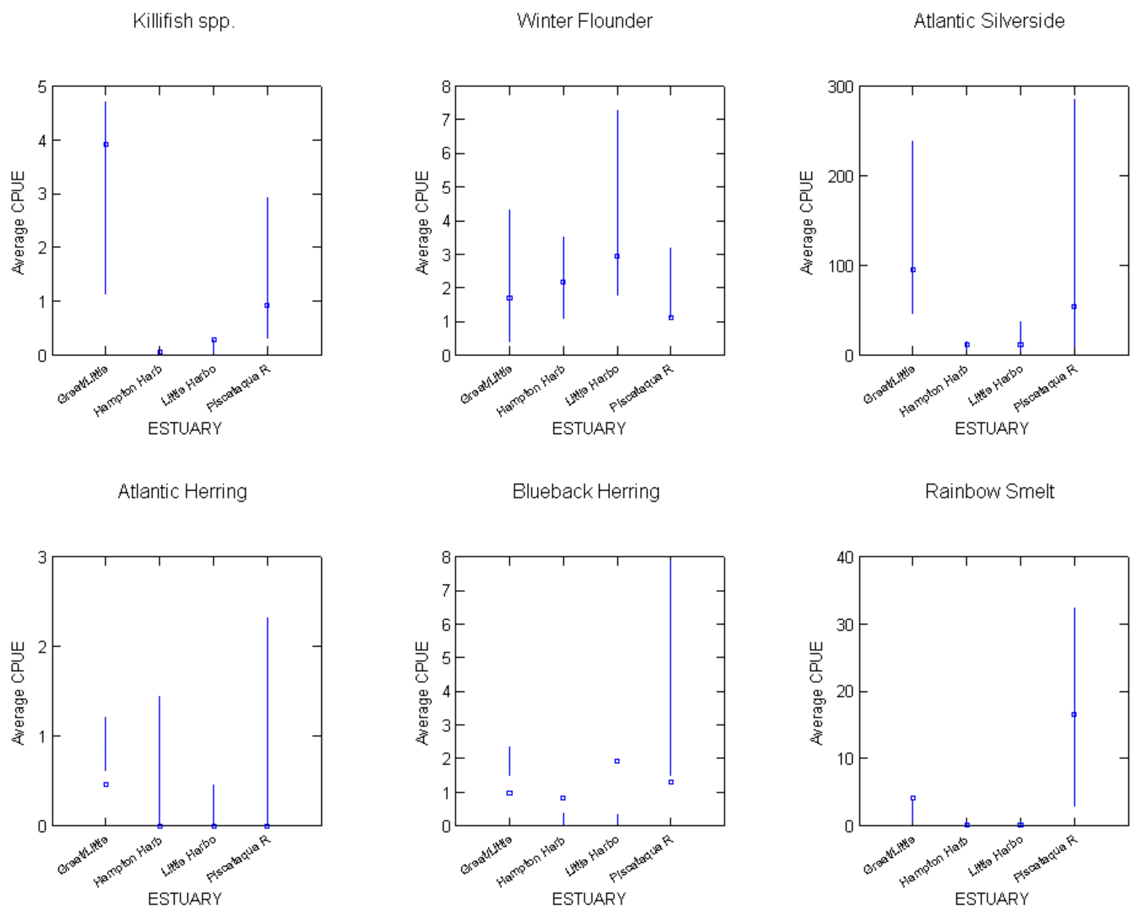
In general, the abundance of the dominant species in 2001 matched previous observations. Herring abundance was the only exception. In the Great Bay Estuary, both Atlantic Herring and Blueback Herring were less abundant than has been observed in previous years. In the coastal harbors, Atlantic Herring were less abundant but Blueback Herring were more abundant than in previous years. Only four years of data are available on juvenile fish populations so the range of previous observations is not expected to represent "baseline" conditions or to define the full range of possible outcomes. However, by making comparisons to previous data, the results from the latest year can be viewed in the context of what has been seen before.

Table 2: Average catch per unit effort (CPUE) for selected juvenile finfish in 2001

Location	Species	Ave. CPUE in 2001	Highest CPUE 98-00	Lowest CPUE 98-00
Great/Little Bay	Flounder, winter *Pleuronectes americanus*	1.70	4.32	0.38
	Herring, atlantic *Clupea harengus*	0.46	1.21	0.61
	Herring, blueback *Alosa aestivalis*	0.99	2.33	1.47
	Killifish *Fundulus spp.*	3.92	4.71	1.13
	Silverside, atlantic *Menidia menidia*	95.01	238.10	45.66
	Smelt, rainbow *Osmerus mordax*	4.17	3.79	0.36
Hampton Harbor	Flounder, winter *Pleuronectes americanus*	2.18	3.51	1.07
	Herring, atlantic *Clupea harengus*	0.00	1.44	0.00
	Herring, blueback *Alosa aestivalis*	0.84	0.37	0.00
	Killifish *Fundulus spp.*	0.06	0.01	0.00
	Silverside, atlantic *Menidia menidia*	11.53	14.93	3.53
	Smelt, rainbow *Osmerus mordax*	0.06	0.50	0.05
Little Harbor	Flounder, winter *Pleuronectes americanus*	2.95	7.26	1.74
	Herring, atlantic *Clupea harengus*	0.00	0.45	0.00
	Herring, blueback *Alosa aestivalis*	1.91	0.34	0.04
	Killifish *Fundulus spp.*	0.30	0.28	0.02
	Silverside, atlantic *Menidia menidia*	12.22	36.42	2.28
	Smelt, rainbow *Osmerus mordax*	0.12	0.58	0.17
Piscataqua River	Flounder, winter *Pleuronectes americanus*	1.12	3.18	1.11
	Herring, atlantic *Clupea harengus*	0.00	2.32	0.00
	Herring, blueback *Alosa aestivalis*	1.29	7.86	1.46
	Killifish *Fundulus spp.*	0.92	2.93	0.30
	Silverside, atlantic *Menidia menidia*	54.28	285.53	8.87
	Smelt, rainbow *Osmerus mordax*	16.62	32.43	2.83

Data Source: NHF&G ACFCMA Reports

Figure 3: Average catch per unit effort (CPUE) for selected juvenile finfish in 2001



The line represents the range of average CPUE values for the period 1998-2000. The square is the average 2001 CPUE

Table 3: Simpson's diversity index (D) for juvenile finfish diversity in Great Bay and Coastal Harbors

Year	Little Harbor	Hampton Harbor	Piscataqua River	Great/Little Bays
1998	0.396	0.406	0.308	0.624
1999	0.776	0.604	0.817	0.803
2000	0.454	0.456	0.472	0.697
2001	0.451	0.588	0.518	0.675

Data Source: NHF&G ACFCMA Reports

Figure 4: Simpson's diversity index (D) for juvenile finfish diversity in Great Bay and Coastal Harbors

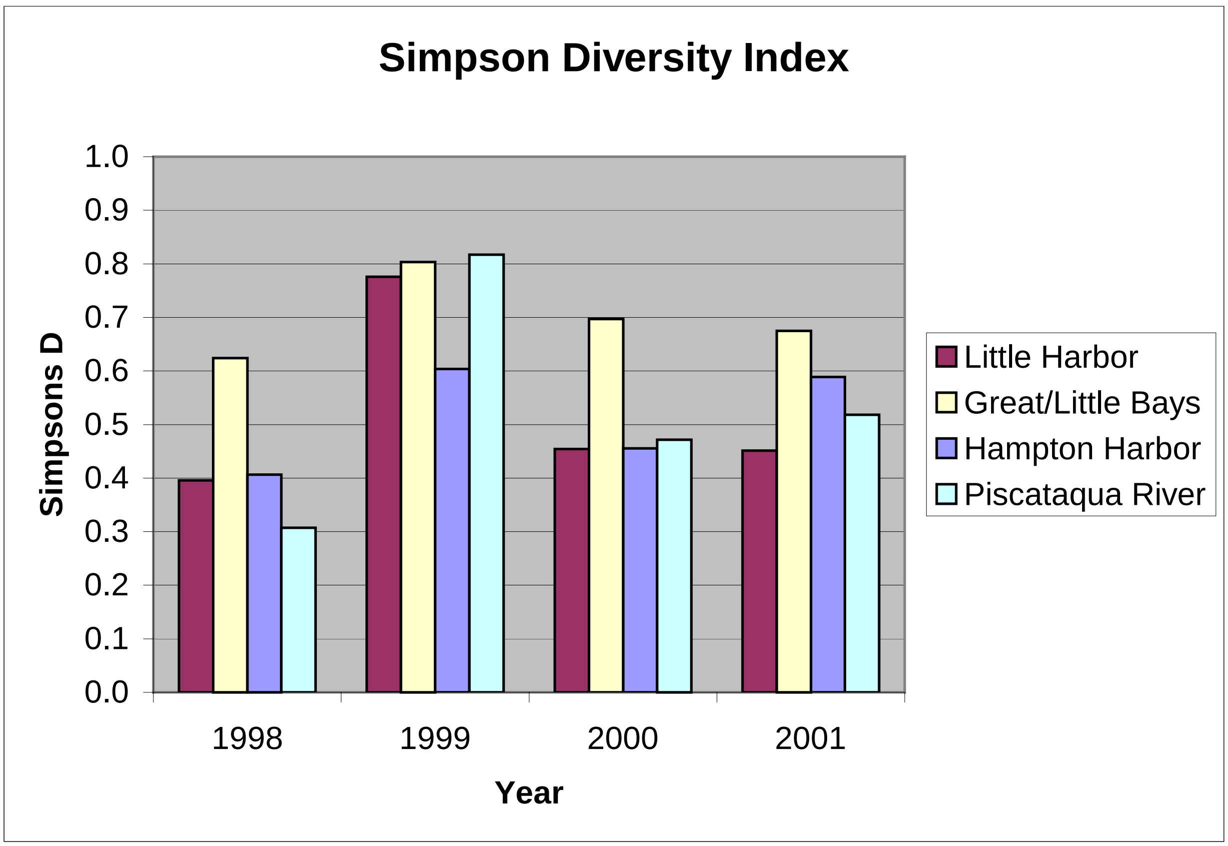
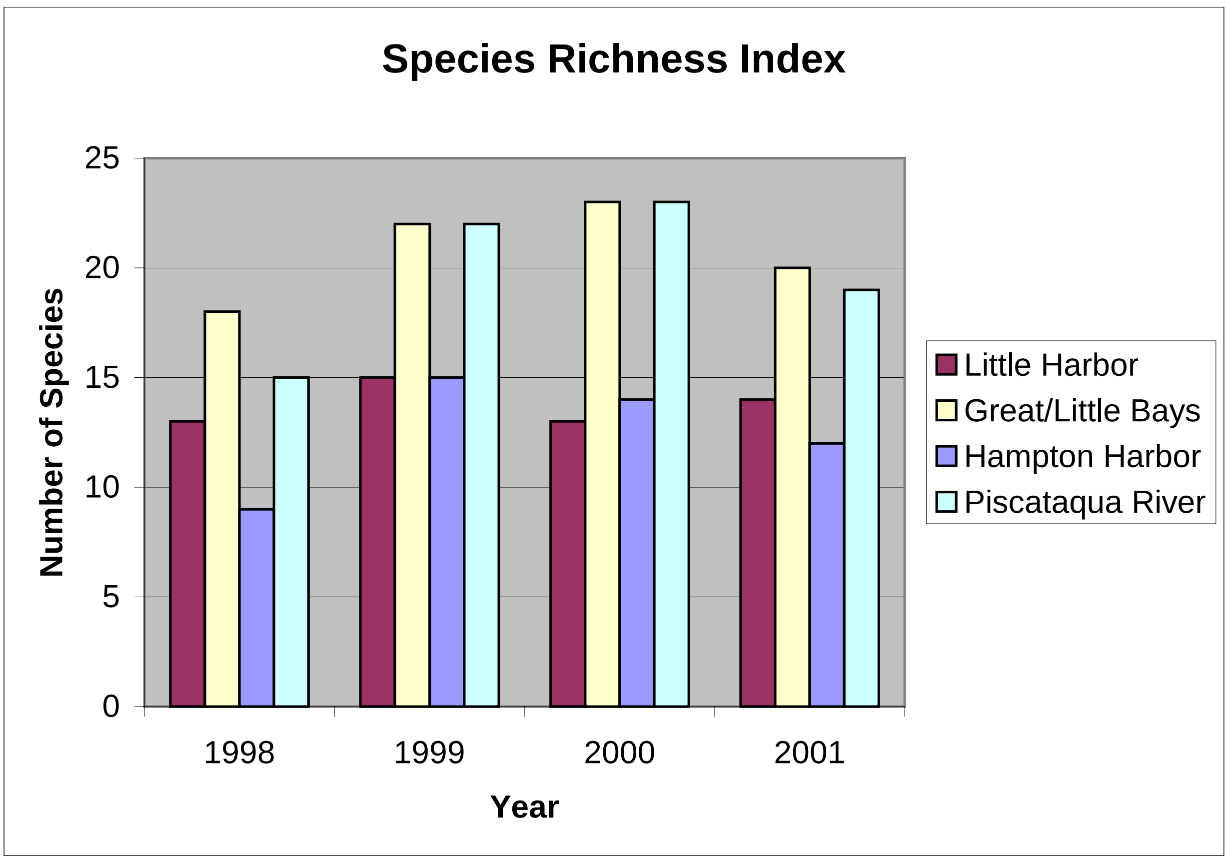


Table 4: Species richness index (S) for juvenile fish in Great Bay and Coastal Harbors

Year	Little Harbor	Hampton Harbor	Piscataqua River	Great/Little Bays
1998	13	9	15	18
1999	15	15	22	22
2000	13	14	23	23
2001	14	12	19	20

Data Source: NHF&G ACFCMA Reports

Figure 5: Species richness index (S) for juvenile fish in Great Bay and Coastal Harbors



HAB8. Anadromous Fish Returns

a. Monitoring Objectives

As a subset of the adult finfish, anadromous fish returns are indicative of conditions in the upper watershed. The juvenile fish need suitable habitat in the rivers and streams to thrive, adults need passage through dams and suitable upstream habitat to spawn. Therefore, changes in the anadromous fish returns could be due to many factors. The TAC felt that, despite the complexity of this indicator, tracking the returns of river herrings and smelt would be a useful indicator of ecological conditions in the coastal watershed as long as consideration was given to other factors that might affect fish returns (e.g., efficiency of the fish ladders, amount and quality of spawning habitat, predation levels, harvest pressure, stock enhancement). The objective of this supporting variable is to illustrate year to year trends in the abundance of anadromous finfish in the estuary. It will address the following monitoring question related to Land Use Goal #6:

- "Has the relative abundance, biology, and species composition of resident finfish changed significantly over time?"

which will, in turn, provide supporting information on the following management goal:

- Land Use Goal #6: "Maintain habitats of sufficient size and quality to support populations of naturally occuring plants, animals, and communities.

b. Measurable Goals

Since anadromous fish is a supporting variable that will not be used to answer an management question, no goals have been set.

c. Data Analysis and Statistical Methods

Measurements of abundance for five anadromous fish species were compiled for each year using data collected by NHF&G. For most anadromous fish, the measurements were counts of fish passing through fish ladders. The following table lists the species that were analyzed for this indicator.

Species	Abundance Measure	Location	Source
Herring (*Alosa pseudoharengus* and *Alosa aestivalis)*	Passage through fish ladders (# of fish/yr)	Exeter, Lamprey, Oyster, Cocheco, Winnicut, and Taylor rivers	NHF&G (2001b) F-61-R report Table 2-5
Shad (*Alosa sapidissima*)	Passage through fish ladders (# of fish/yr)	Exeter, Lamprey, and Cocheco rivers	NHF&G (2001b) F-61-R report, Table 1-3
Salmon (*Salmo salar*)	Passage through fish ladders (# of fish/yr)	Lamprey and Cocheco rivers	NHF&G (2001b) F-61-R report Table 4-4
Smelt, rainbow (*Osmerus mordax*)	CPUE (catch per angler hour)	Great Bay Ice Fishery	NHF&G (2001b) F-61-R report Table 3-6
Lamprey (*Petromyzon marinus*)	Passage through fish ladders (# of fish/yr)	Cocheco river	NHF&G records

d. Results

Many factors influence the returns of anadromous fish. Each species has its own life cycle history and has different habitat needs as larvae, juvenile, and adults. The following comments are simply summaries of the reported data. More in-depth analysis of the data is not possible.

Data on river herring returns are shown in Table 5 and Figure 6. In the late 1970s, extremely high returns were reported for the Taylor River. In recent years, the total returns have been steady at 150,000 fish with most of the counts coming from the Oyster, Cocheco and Lamprey rivers.

Returns of American Shad have been increasing in recent years. Table 6 and Figure 7 show that most of the returns are to the Exeter River.

Very few salmon have returned to NH's rivers. From 1992 to 2001, only 38 fish were recorded in fish ladders. The returns by year and location are shown in Table 7 and Figure 8.

Rainbow smelt abundance has followed a moderate cyclical pattern of increasing and decreasing values. Peak abundance in recent years was in 1989 and 1995 (Figure 9).

Table 9 and Figure 10 contain records of Lamprey returns to the Cocheco River. Although Lampreys have been sporadically recorded at other fish ladders, the records are best and most consistent at the Cocheco River ladder. From 1978 to 1988, a biological supply company harvested lampreys for their products. The number of returning fish was depressed following this harvest and only recently has begun to rebound.

Table 5: Numbers of river herring returning to fishways on coastal NH rivers

Year	Cocheco River	Exeter River	Oyster River	Lamprey River	Taylor River	Winnicut River	Notes
1972				2,528			
1973				1,380			
1974				1,627			
1975		2,639		2,882			
1976	9,500		11,777	3,951	450,000		
1977	29,500		359	11,256		2,700	
1978	1,925	205	419	20,461	168,256	3,229	
1979	586	186	496	23,747	375,302	3,410	
1980	7,713	2,516	2,921	26,512	205,420	4,393	
1981	6,559	15,626	5,099	50,226	94,060	2,316	
1982	4,129	542	6,563	66,189	126,182	2,500	
1983	968	1	8,866	54,546	151,100		
1984	477		5,179	40,213	45,600		
1985	974		4,116	54,365	108,201		
1986	2,612	1,125	93,024	46,623	117,000	1,000	
1987	3,557	220	57,745	45,895	63,514		
1988	3,915		73,866	31,897	30,297		
1989	18,455		38,925	26,149	41,395		
1990	31,697		154,588	25,457	27,210		
1991	25,753	313	151,975	29,871	46,392		
1992	72,491	537	157,024	16,511	49,108		
1993	40,372	278	73,788	25,289	84,859		
1994	33,140		91,974	14,119	42,164		(1)
1995	79,385	592	82,895	15,904	14,757		
1996	32,767	248	82,362	11,200	10,113		
1997	31,182	1,302	57,920	13,788	20,420		(2)
1998	25,277	392	85,116	15,947	11,979	219	
1999	16,679	2,821	88,063	20,067	25,197	305	
2000	30,938	533	70,873	25,678	44,010	525	
2001	46,590	6,703	66,989	39,330	7,065	1,118	

(1) Exeter fish trap was damaged in 1994 allowing fish to pass without being counted.
(2) Winnicut dam modified to allow fish passage. All previous returns were from hand-passing over the dam.
(3) Data Source: NHF&G F61R Reports

Figure 6: Returns of River Herring to NH coastal tributaries

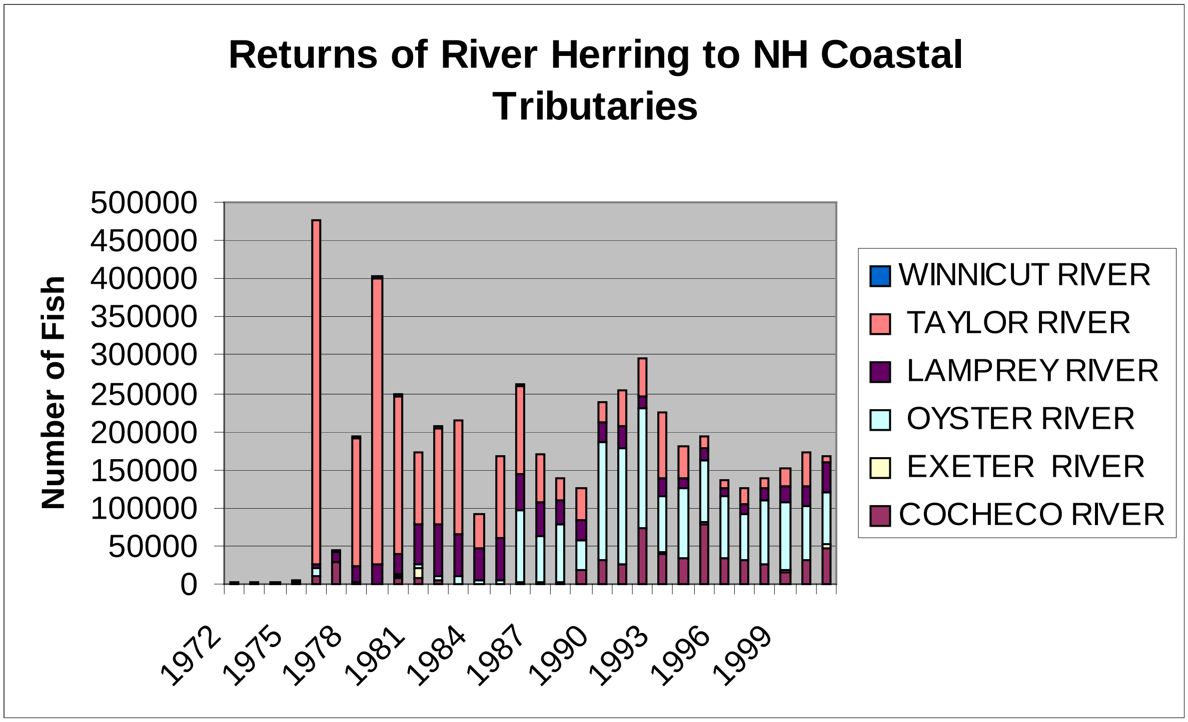


Table 6: American shad returns to New Hampshire coastal fishways

YEAR	Exeter River	Lamprey River	Cocheco River	Comments
1983	*	*	3	
1984	*	*	*	
1985	*	2	1	
1986	*	39	1	
1987	*	*	*	
1988	*	*	4	1
1989	*	*	8	1
1990	*	*	3	1
1991	12	2	6	
1992	22	5	24	
1993	21	200	17	2
1994	*	13	9	2, 3
1995	18	14	8	2
1996	58	2	5	2
1997	30	4	11	2
1998	33	3	6	2
1999	129	3	2	2
2000	163	7	14	2
2001	42	6	6	2

1 - No counts at Exeter or Lamprey rivers because ladder was operated as a swim through.
2 - Minimum counts for Lamprey River - ladder operated as swim through until 3rd/4th week of May.
3 - No counts at Exeter River because ladder was operated as a swim through.
4 – Data source: NHF&G F61R Reports. "*" signifies no data.

Figure 7: American shad returns to Great Bay tributaries

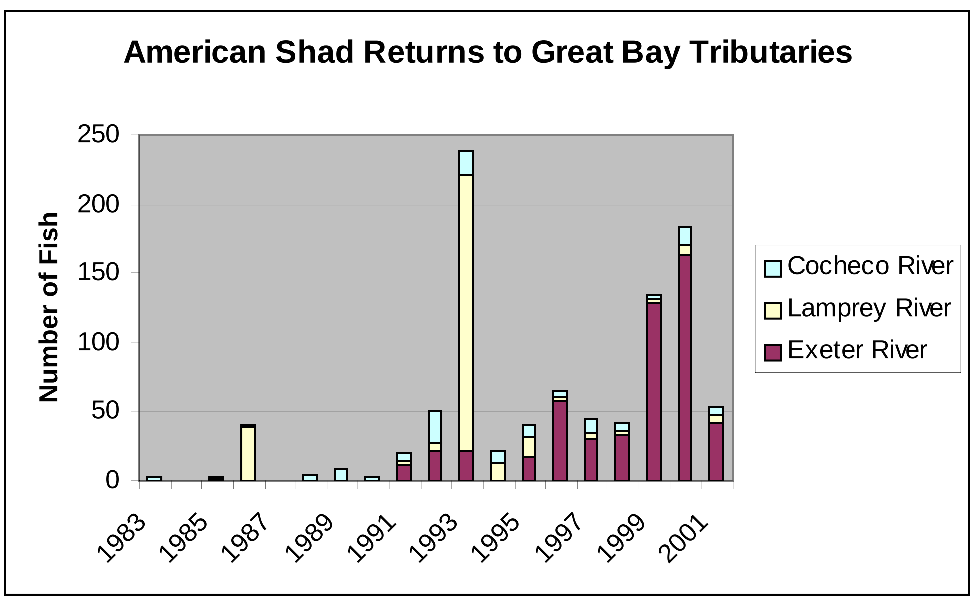


Table 7: Number of recorded salmon returns

Year	Cocheco River	Lamprey River	Total Salmon
1992	1	2	3
1993	4	8	12
1994	0	3	3
1995	1	1	2
1996	2	1	3
1997	0	0	0
1998	0	0	0
1999	3	6	9
2000	2	4	6
2001	0	0	0

Data Source: NHF&G F61R Reports

Figure 8: Salmon returns to Great Bay tributaries

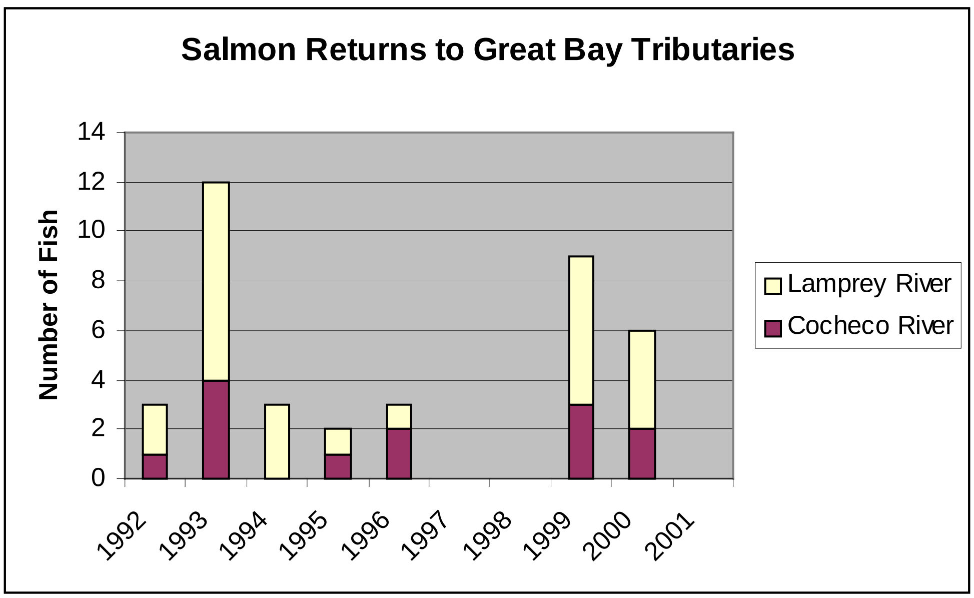


Table 8: Catch per unit effort of Rainbow Smelt in the Great Bay Ice Fishery

YEAR	CPUE (fish/angler hour)	Comments
1978	11.4	
1979	6.8	
1980	1.1	
1981	5.9	
1982	1.3	
1983		No survey
1984		No survey
1985		No survey
1986		No survey
1987	5.8	
1988	5.3	
1989	10.2	
1990	5.7	
1991	2.3	
1992	1.5	
1993	3.6	
1994	2.9	
1995	9.7	
1996	4.9	
1997	2.6	
1998	2	
1999	2.5	
2000	4	
2001	5.6	

Data Source: NHF&G F61R Reports

Figure 9: Abundance of Rainbow Smelt in the Great Bay Ice Fishery

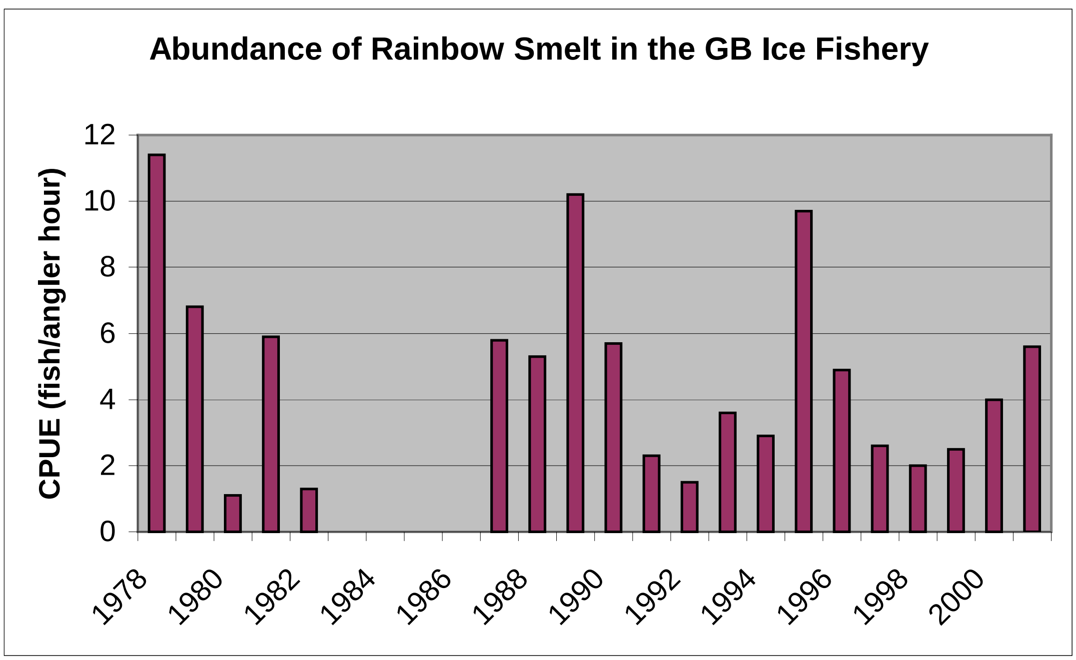
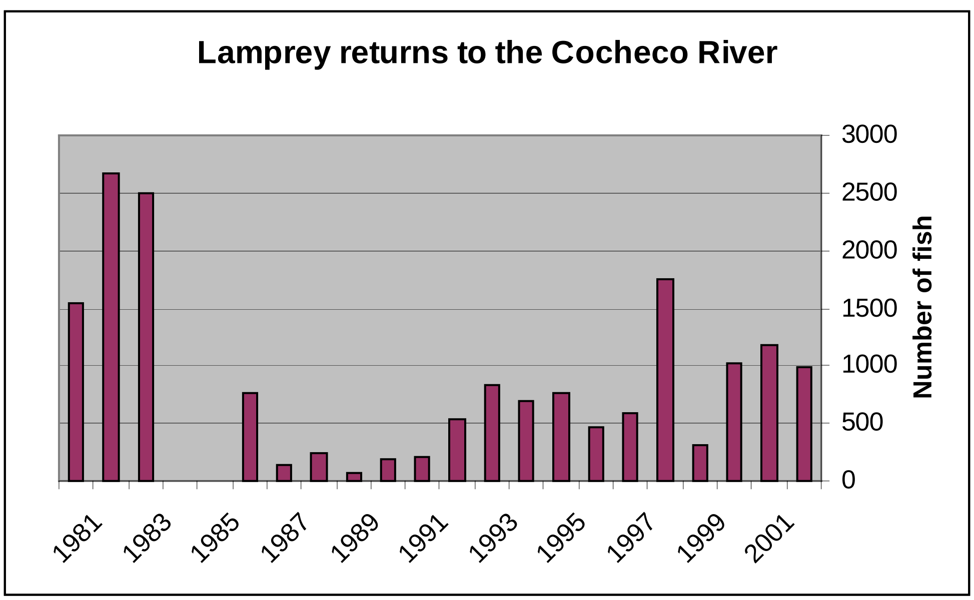


Table 9: Number of Lamprey returns to the Cocheco River

Year	Number of Lamprey returns	Comments
2001	993	
2000	1175	
1999	1020	
1998	313	
1997	1752	
1996	589	
1995	469	
1994	761	
1993	697	
1992	824	
1991	533	
1990	201	
1989	184	
1988	62	
1987	251	
1986	146	
1985	768	
1984		(1)
1983		(1)
1982	2500	(1)
1981	2662	(1)
1980	1547	(1)

(1). The numbers from 1980 to 1982 are from the annual report of M. L. Taylor, a biological supply company that collected lampreys from 1978 to 1988. This company's records for 1983 and 1984 were either lost or were never filed. NHF&G monitoring began in 1985.
Data Source: NHF&G

Figure 10: Number of Lamprey returns to the Cocheco River



HAB9. Abundance of Lobsters

a. Monitoring Objectives

The commercial fishery for lobster is the largest and most important fishery in New Hampshire. Although lobsters are not exclusively dependent on conditions in the estuary to survive, a crash in the lobster population would be a cause for concern both ecologically and commercially. The objective for this supporting variable is to track the overall abundance of lobsters (total and legal size) to illustrate any trends over time. It will address the following monitoring question related to Land Use Goal #6:

- “Has the relative abundance, biology, and species composition of resident finfish changed significantly over time?”

which will, in turn, provide supporting information on the following management goal:

- Land Use Goal #6: “Maintain habitats of sufficient size and quality to support populations of naturally occuring plants, animals, and communities.

b. Measurable Goals

Since lobster abundance is a supporting variable that will not be used to answer a management question, no goals have been set.

c. Data Analysis and Statistical Methods

Measurements of lobster abundance were tracked for each year using data from NHF&G (NHF&G, 2002). Specifically, the average total catch per trap haul set over day (Total CTHSOD) and marketable catch per trap haul (Marketable CTH) for all areas of the NH coast during July through October was plotted against year to illustrate trends over time. Annual statistics for total CTHSOD and marketable CTH were taken from the NHF&G Lobster Sea Sampling reports (NHF&G, 2002). Annual average marketable CTHSOD was calculated from data presented in the 2000 and 2001 reports and will be tracked in the future. Information on commercial landings of lobsters was obtained from the National Marine Fisheries Service.

d. Results

Over 2 million pounds of lobsters were harvested commercially in NH in 2001 (Table 10). The value of this harvest was over $8 million (Figure 11). The lobster harvest in 2001 was the largest since 1991 when the records began.

Over the past 10 years, the abundance of lobsters along the NH coast has been variable. In recent years, the expected total catch per trap haul set over a day (CTHSOD) has been approximately 0.6 to 0.8, with marketable lobsters making up approximately one-third of this catch (marketable CTHSOD=0.20-0.25) (Table 11, Figure 12).

The abundance of lobsters changes with the seasons. Total CTHSOD tends to be lowest in July, while marketable catch per trap haul tends to be lowest in July and highest in October (NHF&G, 2002).

Table 10: Commercial lobster landings in NH

Year	Species	Metric Tons	Pounds	Value ($)
1991	LOBSTER, AMERICAN	817.4	1,802,035	4,934,205
1992	LOBSTER, AMERICAN	693.7	1,529,292	5,033,198
1993	LOBSTER, AMERICAN	768.1	1,693,347	5,567,109
1994	LOBSTER, AMERICAN	748.8	1,650,751	5,566,282
1995	LOBSTER, AMERICAN	832.3	1,834,794	6,655,660
1996	LOBSTER, AMERICAN	740.6	1,632,829	6,563,641
1997	LOBSTER, AMERICAN	641.4	1,414,133	5,544,727
1998	LOBSTER, AMERICAN	541.9	1,194,653	4,702,353
1999	LOBSTER, AMERICAN	626.1	1,380,360	5,915,579
2000	LOBSTER, AMERICAN	775.5	1,709,746	7,080,967
2001	LOBSTER, AMERICAN	919.8	2,027,725	8,071,915
GRAND TOTALS:		8,105.60	17,869,665	65,635,636

Data Source: NMFS Commercial Landings Statistics

Figure 11: Commercial lobster landings in NH

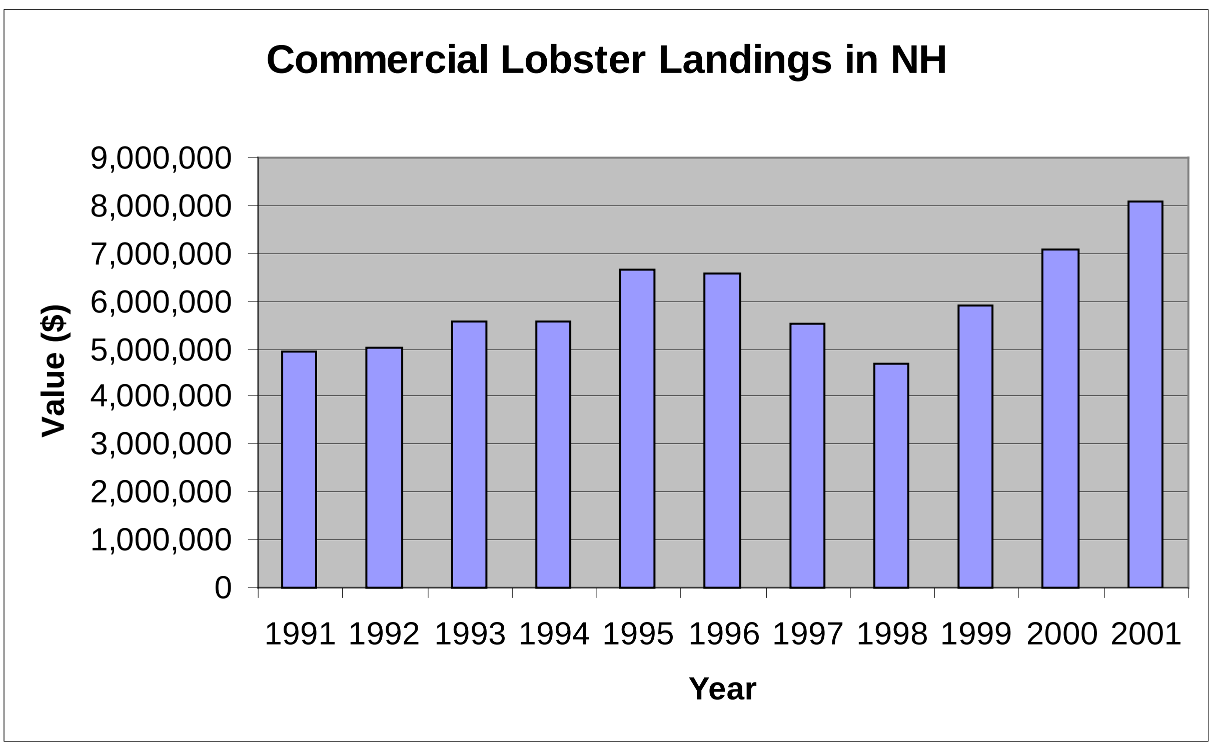
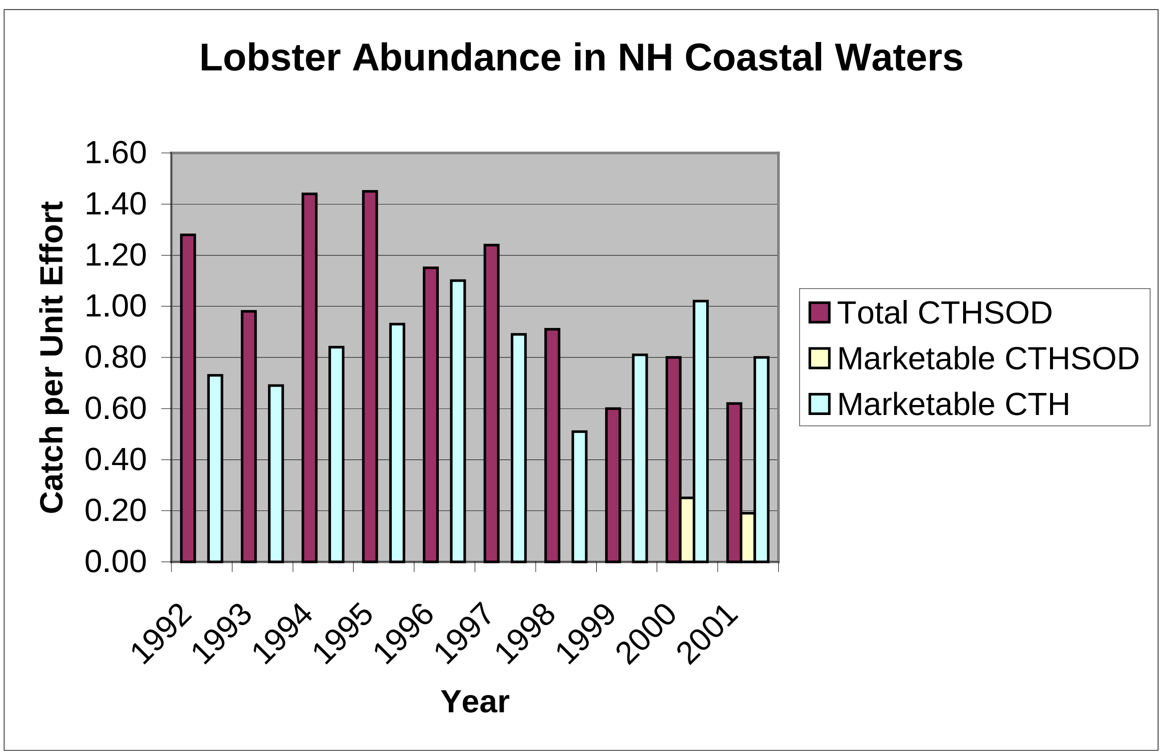


Table 11: Lobster abundance in NH coastal waters

Year	Total CTHSOD	Marketable CTHSOD	Marketable CTH	Comments
1992	1.28	NA	0.73	
1993	0.98	NA	0.69	
1994	1.44	NA	0.84	
1995	1.45	NA	0.93	
1996	1.15	NA	1.10	
1997	1.24	NA	0.89	
1998	0.91	NA	0.51	(2)
1999	0.60	NA	0.81	
2000	0.80	0.25	1.02	
2001	0.62	0.19	0.80	

(1) Averages computed using data from the River, Shoals, and North Coast stations during July through October.
(2) Data from Shoals station missing for August 1998.
(3) Data source: NHF&G Lobster Sea Sampling reports
(4) CTHSOD=catch per trap haul set over day
CTH=catch per trap haul

Figure 12: Lobster abundance in NH coastal waters



HAB10. Abundance of Wintering Waterfowl

a. Monitoring Objectives

Waterfowl are one of most important wildlife species in the estuary. Approximately 75% of all the waterfowl that winter in New Hampshire do so in the seacoast region, mainly in the Great Bay or Hampton Harbor (NHF&G, 1995). Salt marshes and tidal flats of estuaries are the most important types of wetlands for waterfowl. Eelgrass and tidal flats provide winter forage for the birds (NHF&G, 1995). The population wintering over in any particular estuary along the Atlantic Flyway depends on multiple factors including the local and regional climatic conditions and the total number of birds in the migration (e.g., ice cover, amount of forage available, weather patterns). Data collected on waterfowl in New Hampshire is combined with data from states along the Atlantic flyway to provide meaningful estimates of the total waterfowl population (NHF&G, 1995). Therefore, the objective of this supporting variable is track the abundance of wintering waterfowl in Great Bay and the Atlantic Flyway to illustrate changes over time. This supporting variable will be used to partially answer the following question:

- "Do the following indicators show that water quality is suitable for aquatic life: aquatic insects/invertebrates, *wildlife*, fish, diatoms/algae, large bivalves, eelgrass, marshes?

which will, in turn, provide supporting information on the following management goal:

- Land Use Goal #6: "Maintain habitats of sufficient size and quality to support populations of naturally occuring plants, animals, and communities.

b. Measurable Goals

Since wintering waterfowl is a supporting variable that will not be used to answer an management question, no goals have been set.

c. Data Analysis and Statistical Methods

Each January, biologists from NHF&G use aircraft surveys to count the number and species of waterfowl present along the NH coast. Simultaneous surveys are conducted in other Atlantic Flyway states. Annual mid-winter waterfowl counts were compiled for the NH coastal region and the Atlantic Flyway. The latest years results (2002) were compared to the 10-year average population for reference. The waterfowl species that were compiled were:

- Mallard (*Anas platyrhynchos*)
- Black Duck (*Anas rubripes*)
- Greater/Lesser Scaup (*Aythya marila/affinis*)
- Canada Goose (*Branta canadensis*)

d. Results

The most abundant waterfowl in both the NH coast and the Atlantic Flyway is the Canada Goose, which constitutes approximately half of the birds counted. The next most abundant species are Scaup in the Flyway and Black Duck on the NH coast. In 2002, nearly 8,000 wintering waterfowl were observed on the NH coast, which is higher than the 10-year average of 5,500 birds observed. The birds stopping in the NH coast are just a fraction of the nearly 2 million waterfowl that migrate along the Atlantic Flyway. Bird counts in the NH coast and the Atlantic Flyway are shown in Table 12, Figure 13, and Figure 14.

Table 12: Wintering waterfowl in NH and the Atlantic Flyway

Species	New Hampshire Coast			Atlantic Flyway		
	2002	1993-2002 Average		2002	1993-2002 Average	
	Bird Counts	Bird Counts	Relative Percent	Bird Counts	Bird Counts	Relative Percent
Mallard (*Anas platyrhynchos*)	554	651	12%	161,365	164,711	9%
Black Duck (*Anas rubripes*)	2,292	1,495	27%	255,298	224,669	13%
Scaup (*Aythya marila/affinis*)	1,625	696	13%	424,035	575,966	33%
Canada Goose (*Branta canadensis*)	3,382	2,684	49%	1,050,698	803,099	45%
Total	7,853	5,526	100%	1,891,396	1,768,445	100%

Figure 13: Wintering waterfowl on the NH coast

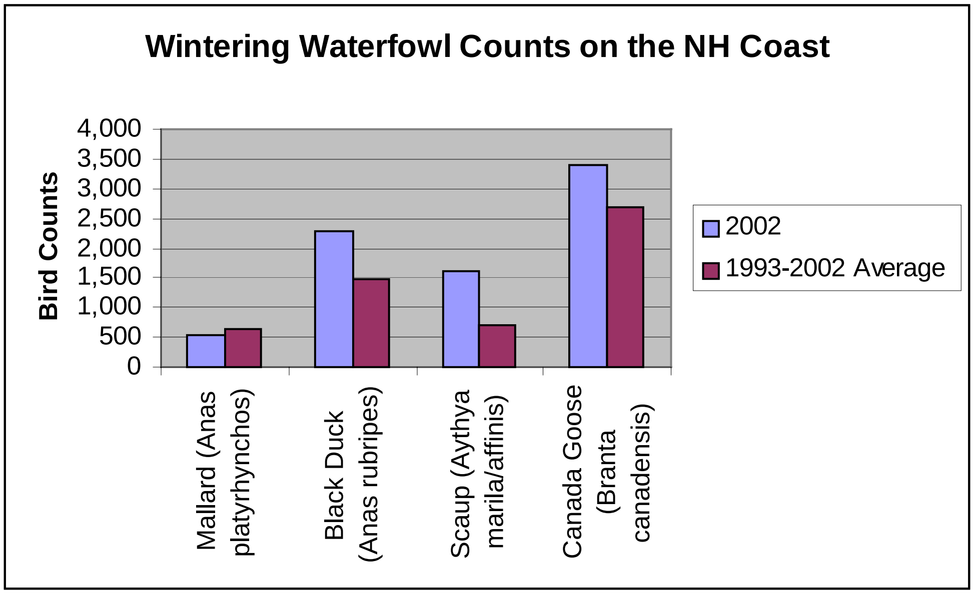
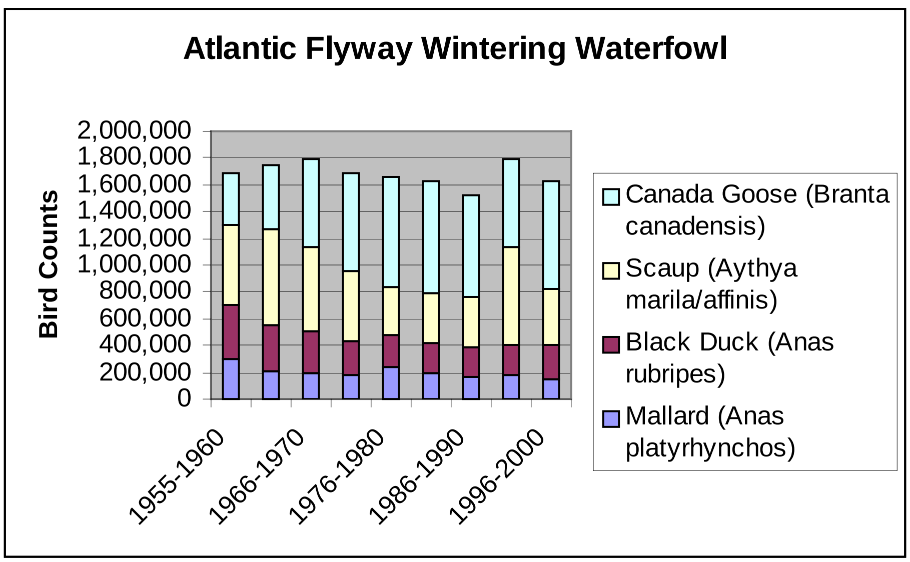


Figure 14: Wintering waterfowl in the Atlantic Flyway



ENVIRONMENTAL INDICATORS OF HABITAT PROTECTION

HAB6. Conservation Lands

a. Monitoring Objectives

The objective of this indicator is to report on the total acres of lands protected from development in the coastal watershed. By repeating this assessment over time and stratifying the results by private and public lands, the indicator will be able to answer the following monitoring question:

- "Has the acreage of privately owned lands managed to benefit wildlife and natural communities significantly changed over time?"

which will, in turn, report on progress toward the following management objectives:

- LND6-1: "By 2005, determine the existing acres of permanently protected land in the NH coastal watershed in the following categories: tidal shoreland, large contiguous forest blocks, wetlands with high habitat values, freshwater shorelands, and rare and exemplary natural communities."
- LND6-2: "Increase the acreage of protected land containing significant habitats in the NH coastal watershed through fee acquisition or conservation easements by 2010."
- LND6-4: "Increase the use of buffers around wildlife areas and maintain contiguous habitat blocks in the NH coastal watershed by 2010."

b. Measurable Goals

The NHEP Land Use Team set the following goal for this indicator: Increase the acres of protected private and public lands from baseline levels to 15% of the coastal watershed and 15% of the coastal communities by 2010. This goal is consistent with the NH Everlasting campaign of the Society for the Protection of NH Forests which calls for 25% of each town to be protected in the next 25 years (SPNHF, 2001). The goal is also compatible with the Gulf of Maine Council on the Marine Environment's goal to protect an additional 5,000 acres in "coastal communities" (i.e., towns that border salt water) by 2006 (GOMC, 2002). There are 17 coastal communities in NH's coastal watershed.

c. Data Analysis and Statistical Methods

The most recent (October 2002) coverage of conservation lands in the state was the primary data source for this indicator. The database was queried to identify the conservation lands within the coastal watershed (HUC8 01060003). Lands were grouped into categories of publicly-owned and privately-owned and then further stratified based on the type of owner using fields in the conservation lands database (query details provided in NHEP, 2003). The total acres of public and private conservation lands in the coastal watershed and the 17 coastal communities was calculated by summing the areas of individual conservation polygons in these two zones.

Error bars on acreage totals were not calculated because it was assumed that parcels under easement had been surveyed and therefore had accurate acreage values.

d. Results

The baseline condition for the watershed is that, in 2002, there were 42,585 acres of protected land. This area is equivalent to 7% of the watershed area. Three-quarters of the protected lands are owned and managed by public agencies. The total amount of conservation lands in the 17 coastal communities was 18,116 acres, which is 12% of the total area of these communities. Table 13 summarizes the acres of different types of conservation lands in the coastal watershed. In order to reach the goals for 2010, an additional 48,084 acres should be protected in the watershed, including at least 4,795 acres in the 17 coastal communities.

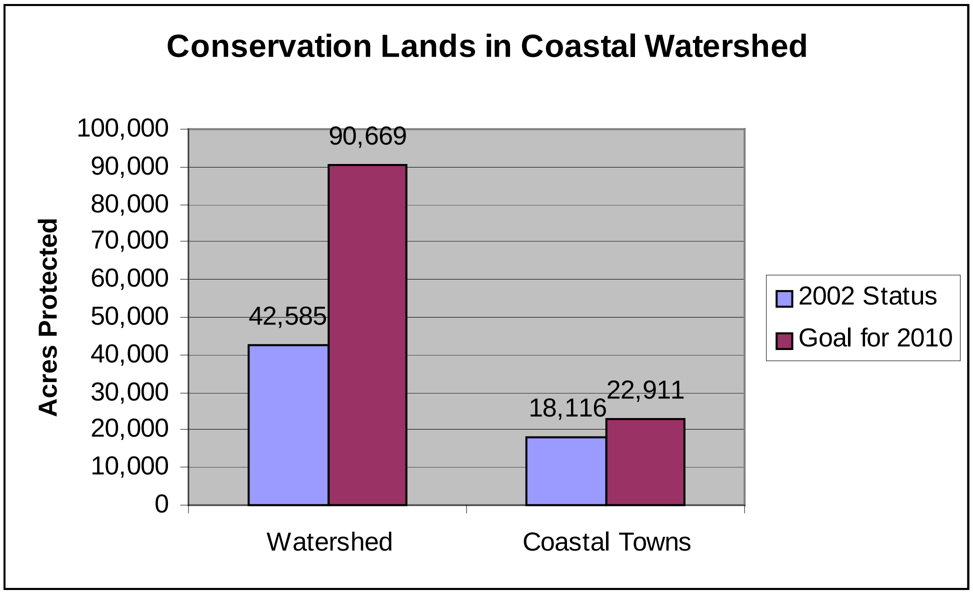
Table 13: Acres of conservation lands in the coastal watershed in 2002

Type	Subtype	Number of Parcels	Acres of Land
Easements and Deed Restrictions on Private Lands	Agricultural Preservation Restriction	12	352.47
	Conservation Easement	212	8352.45
	Deed Restriction	15	98.20
	Historic Preservation Easement	0	0
	Scenic Easement	0	0
	Protective Easement (for Water Supply)	3	1.81
	Open Space Areas of Developments	57	889.55
Publicly-Owned Lands	Town/County owned	553	11528.71
	State owned	170	15215.32
	Federal owned	2	1057.12
	NGO owned	117	4234.05
	Other / Quasi-Public Entities owned	13	358.81
Other*	NA	19	496.48
Subtotal – Private	NA	299	9694.48
Subtotal – Public	NA	855	32394.01
Subtotal – Other	NA	19	496.48
Grand Total	NA	1173	42584.97
Coastal Watershed Area (land and water)	NA	NA	604461.09
Percent of Coastal Watershed that is protected			**7.0%**
NHEP Conservation Goal for the Coastal Watershed			**15% by 2010**
Total Conservation Lands in 17 Coastal Communities			18115.99
Total Area Covered by 17 Coastal Communities			152739.4
Percent of Coastal Communities protected			**11.9%**
NHEP Conservation Goal for the Coastal Communities			**15% by 2010**

** Conservation lands designated as "other" are lands protected because of flowage rights (FE), leases (LE), reverter (RV), right of way (RW), and executory interest (EI).*

Data Source: GRANIT Conservation Lands datalayer (current as of October 2002)

Figure 15: Conservation lands in the coastal watershed



HAB3. Shoreland Development and Protection

a. Monitoring Objectives

The objective of this indicator is to track the amount of development in the tidal and freshwater shorelands of the coastal watershed. Development will be measured by the presence of significant amounts of impervious surface. The undeveloped shorelands will be further stratified into "protected" and "unprotected" categories depending on whether they are permanently protected from development. This indicator will answer the following monitoring question:

- "Has the acreage of permanently protected important habitats (tidal shorelines….freshwater shorelines…) significantly changed over time?"

which will, in turn, report on progress toward the following management objectives:

- LND6-1: "By 2005, determine the existing acres of permanently protected land in the NH coastal watershed in the following categories: *tidal shoreland*, large contiguous forest blocks, wetlands with high habitat values, *freshwater shorelands*, and rare and exemplary natural communities."
- LND6-2: "Increase the acreage of protected land containing significant habitats in the NH coastal watershed through fee acquisition or conservation easements by 2010."
- LND6-4: "Increase the use of buffers around wildlife areas and maintain contiguous habitat blocks in the NH coastal watershed by 2010."

b. Measurable Goals

The goal is to increase the acres of permanently protected, undeveloped shorelands from baseline (2002) levels by 2010. Tidal and freshwater shorelands will be assessed separately.

c. Data Analysis and Statistical Methods

Impervious surfaces were mapped throughout the coastal watershed using satellite imagery (Landsat TM, 30-meter resolution) from 2000 which was post-processed using subpixelization analysis (Justice and Rubin, 2002). Each pixel was assigned a value between 0 and 10 proportional to the percentage of that pixel that is covered by impervious surfaces. A pixel was considered "developed" if it was assigned a value representative of 30 to 100% impervious cover. The threshold of 30% was chosen after consulting with the Complex Systems Research Center at UNH and reviewing impervious surface coefficients for different land use types (NOAA, 2002). For example, developed land has a median imperviousness coefficient between 30 and 40%. The coefficients for other land use types were between 10% and zero.

Shorelands were defined as land within 250 feet of tidal waters, salt marshes ("E2EM" wetlands from the National Wetlands Inventory), great ponds/lakes, and third order or higher rivers. This definition matches the jurisdiction of the Comprehensive Shoreland Protection Act (RSA 483-B) with the exception that the Act only covers 4th order or higher rivers. If a pixel straddled the shoreland buffer boundary, the pixel was clipped to the boundary and only the portion of the pixel inside the buffer was counted.

Lands protected from development by conservation or other easements were taken from the most recent version of the conservations lands database (October 2002).

ArcView/ArcInfo software was used to combine the impervious surface, shorelands buffer, and conservation lands datalayers. Spatial queries were used to calculate the total area of (1) developed shorelands; (2) undeveloped shorelands not protected by easements; and (3) undeveloped shorelands protected by easements. Using these area totals, the percent of shorelands in each category was calculated.

Unlike the "conservation lands" indicator discussed previously, there is uncertainty in the results of this indicator due to potential errors in the classification of lands as "developed" or "undeveloped" from the remote sensing data as well as from erroneously omitted or added shorelands. Therefore, confidence intervals for the percent of shorelands in each category were generated using the method of partial derivatives from Kline (1985) assuming 10% error in the developed/undeveloped area totals and 1% error in the protected lands and total shoreland areas. The developed/undeveloped classification was based on the impervious surface data from Justice and Rubin (2002). The overall accuracy of the impervious surface classification was between 93% and 99%. Therefore, 10% is a conservative estimate of the error in the sum of the impervious surface pixels within the shorelands buffer. The 1% error in the protected lands and total shoreland areas was assumed to account for any defects in the shoreland buffer theme due to vagaries of the hydrography coverages. For each category, the error was added to and subtracted from the calculated percent to approximate a 95th percentile upper and lower confidence interval. No goal has been set for this indicator so this confidence interval was not used to determine whether the goal was being met. However, the confidence intervals were still useful for understanding the accuracy of the estimates.

d. Results

There are 5,873 acres of tidal shorelands and 24,390 acres of freshwater shorelands in the coastal watershed. Therefore, freshwater shorelands represent approximately 80% of the total shorelands in the watershed. Table 14 summarizes the acres of tidal and freshwater shorelands in the different classes (protected, developed, undeveloped/unprotected) in 2000. Figure 18 illustrates the overlays of impervious surfaces, shoreland buffers, and conservation lands in Portsmouth Harbor.

In 2000, 20-24% of all tidal shorelands were already developed (Table 14, Figure 16). Another 54-59% of tidal shorelands were undeveloped but were not protected from future development. Some of these lands are not developable in reality due to zoning or physical constraints. The remaining 21-22% of tidal shorelands were already protected from development by easements or public ownership.

These results are consistent with what the NHEP found during a critical lands analysis for the Technical Characterization Report (NHEP, 2000). For this analysis, lands within a 300 foot buffer on tidal shorelands were classified as either protected, developed, developable, or undevelopable. Developed land was identified through classification of large scale aerial photographs. Definitions of the other classes and the datasets used are described in Rubin and Merriam (1998). The results were that 32% of the tidal shorelands were developed, 16% were protected, and 52% were undeveloped (combination of "developable" and "undevelopable" classes). These results are reasonably consistent with the numbers reported above given the differences in the methods (e.g., use of imperviousness as an indicator for development), the different size buffer (e.g., 300 feet versus 250 feet), and changes to the conservation lands database.

For freshwater shorelands, a much lower percentage of the total have already been developed (Figure 17). Only 6-7% of the freshwater shoreland were classified as developed in 2000. Approximately 80% of the freshwater shorelands were undeveloped but could be developed in the future. As stated above, zoning or physical constraints will prevent some of these properties from being developed. Finally, 14% of the freshwater shorelands were already protected from further development in 2000.

Table 14: Protected and developed shorelands in the coastal watershed in 2000

Category	Tidal Shorelands		Freshwater Shorelands	
	Acres	Percent	Acres	Percent
Developed	1,307	20% - 24%	1,646	6% - 7%
Undeveloped/Protected	1,255	21% - 22%	3,408	14% - 14%
Undeveloped/Unprotected	3,311	54% - 59%	19,337	78% - 81%
Total	5,873	100%	24,390	100%

Figure 16: Protected and developed tidal shorelands in 2000

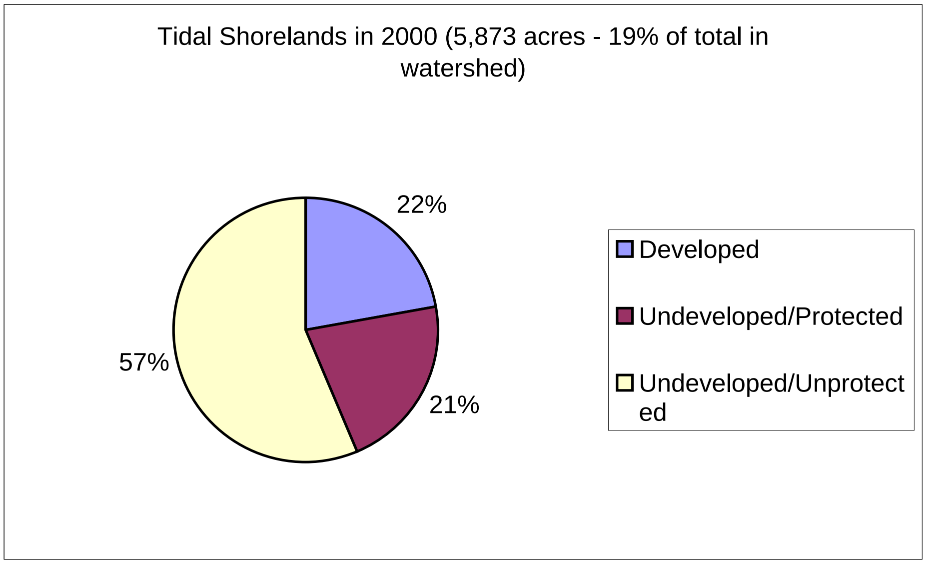


Figure 17: Protected and developed freshwater shorelands in 2000

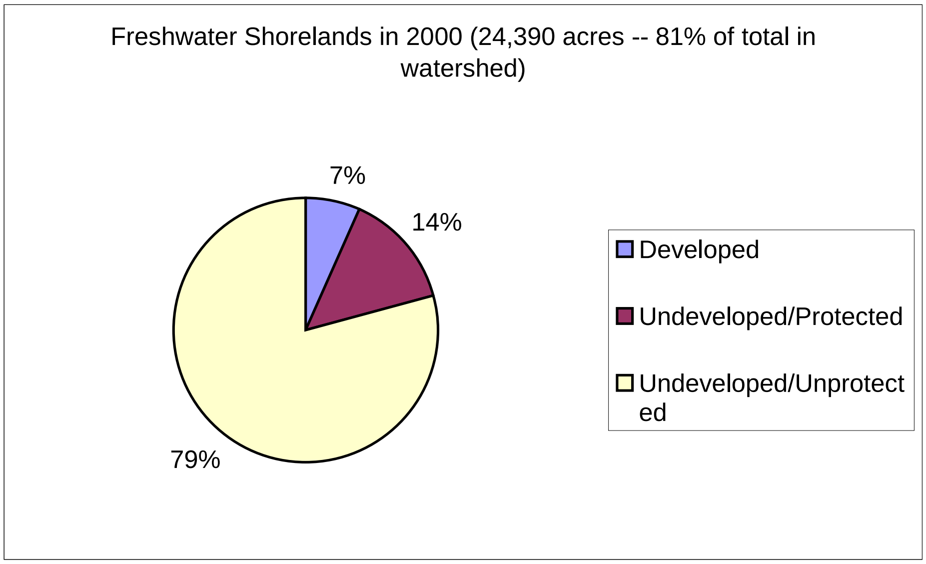
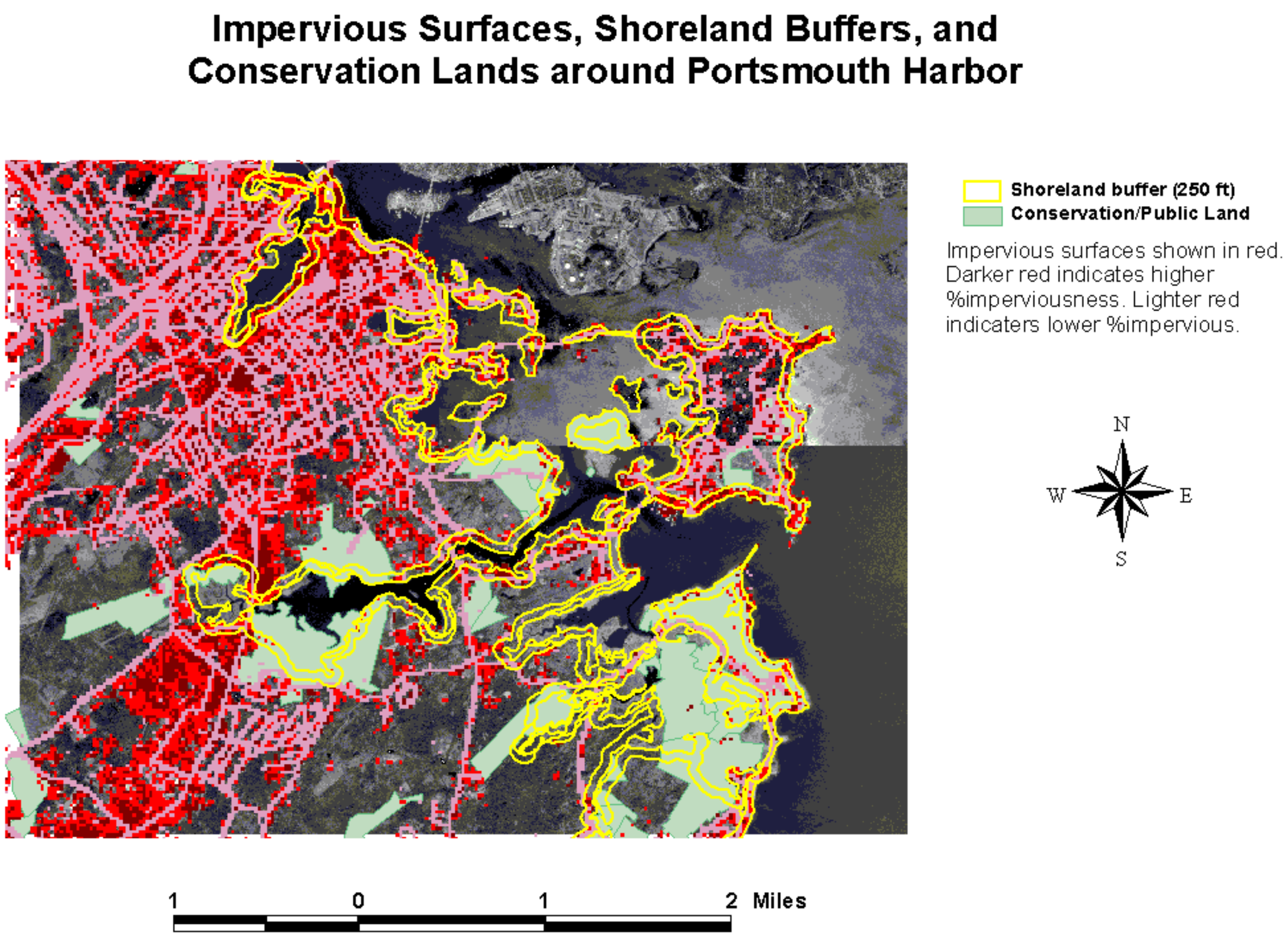


Figure 18: Impervious surfaces, shoreland buffers, and conservation lands in Portsmouth Harbor



HAB4. Unfragmented Forest Blocks

a. Monitoring Objectives

The objective of this indicator is to report on the total acreage of protected, large, unfragmented forest blocks in the coastal watershed. This indicator will answer the following monitoring question:

- "Has the acreage of permanently protected important habitats (…large contiguous forest tracts….) significantly changed over time?"

which will, in turn, report on progress toward the following management objectives:

- LND6-1: "By 2005, determine the existing acres of permanently protected land in the NH coastal watershed in the following categories: tidal shoreland, *large contiguous forest blocks*, wetlands with high habitat values, freshwater shorelands, and rare and exemplary natural communities."
- LND6-2: "Increase the acreage of protected land containing significant habitats in the NH coastal watershed through fee acquisition or conservation easements by 2010."
- LND6-4: "Increase the use of buffers around wildlife areas and maintain habitat blocks in the NH coastal watershed by 2010."

b. Measurable Goals

The goal for this indicator is for the total acreage of protected forest blocks in the coastal watershed to increase from baseline (2002) levels by 2010.

c. Data Analysis and Statistical Methods

Unfragmented lands data was obtained from the Society for the Protection of New Hampshire Forests (SPNHF). SPNHF had processed 2001 land cover data from GRANIT using USGS digital line graphs of roads and NHDOT's G_roads datalayer to identify blocks of unfragmented lands in southeastern New Hampshire. The methodology and assumptions used by SPNHF to process the data are included below.

> Natural land cover types were extracted from the GRANIT land cover data for the study area as a precursor to generating an unfragmented blocks datalayer. These land cover types included: all forest cover types except Alpine (440), forested and non-forested wetlands, and tidal wetlands; and bedrock/vegetated, sand dunes, and cleared or disturbed land covers. Active agriculture was excluded.
>
> A special roads datalayer was generated for use as a fragmenting feature; only traveled roadways were included. The USGS-based datalayer and the NHDOT datalayer were merged after selecting out all jeep trails, Cl 6 roads, and other non-traveled roadways; private roads in the NHDOT datalayer were included in the merged dataset even though some function only as occasional use access roads.
>
> Note that the influence of urban land uses and transportation land cover types as fragmenting features was automatically accounted for in the selection of natural land cover types above, but the transportation land cover type was found to be insufficient within the GRANIT land cover mapping due to tree cover occluding many road segments. Furthermore, frontage development could not be accounted for in the GRANIT land cover mapping, so a 300' buffer was created from the merged road datalayers.

NHDES clipped the unfragmented data layer from SPNHF to the coastal watershed boundary (HUC8 01060003) and then selected only those blocks that covered greater than 250 acres inside the watershed. The selected blocks were then unioned with the latest conservation lands datalayer (October 2002) to identify the portions of these blocks that were already protected from development.

Unlike the "conservation lands" indicator discussed previously, there is uncertainty in the results of this indicator due to potential errors in the identification of unfragmented blocks as well as from incorrect records in the conservation lands datalayer. Therefore, a confidence interval for the percent of unfragmented lands under conservation easement was generated using the method of partial derivatives from Kline (1985) assuming 10% error in the unfragmented block classification and 1% error in the protected lands classification. The error value for both the unfragmented blocks and conservation lands are assumed. The 1% error in the conservation lands coverage was assumed to account for any defects in the coverage. An error ten times larger (10%) was assumed for the unfragmented block coverage because of the complexity of the classification process. The error was added to and subtracted from the calculated percent to approximate a 95th percentile upper and lower confidence interval. No goal has been set for this indicator so this confidence interval was not used to determine whether the goal was being met. However, the confidence interval was still useful for understanding the accuracy of the estimate.

d. Results

As of 2001, there were 282 unfragmented blocks greater than 250 acres in the coastal watershed. The majority of the blocks are less than 1000 acres in size. There are only 4 blocks greater than 5000 acres (Table 15). Figure 19 shows the locations of the unfragmented blocks in the coastal watershed.

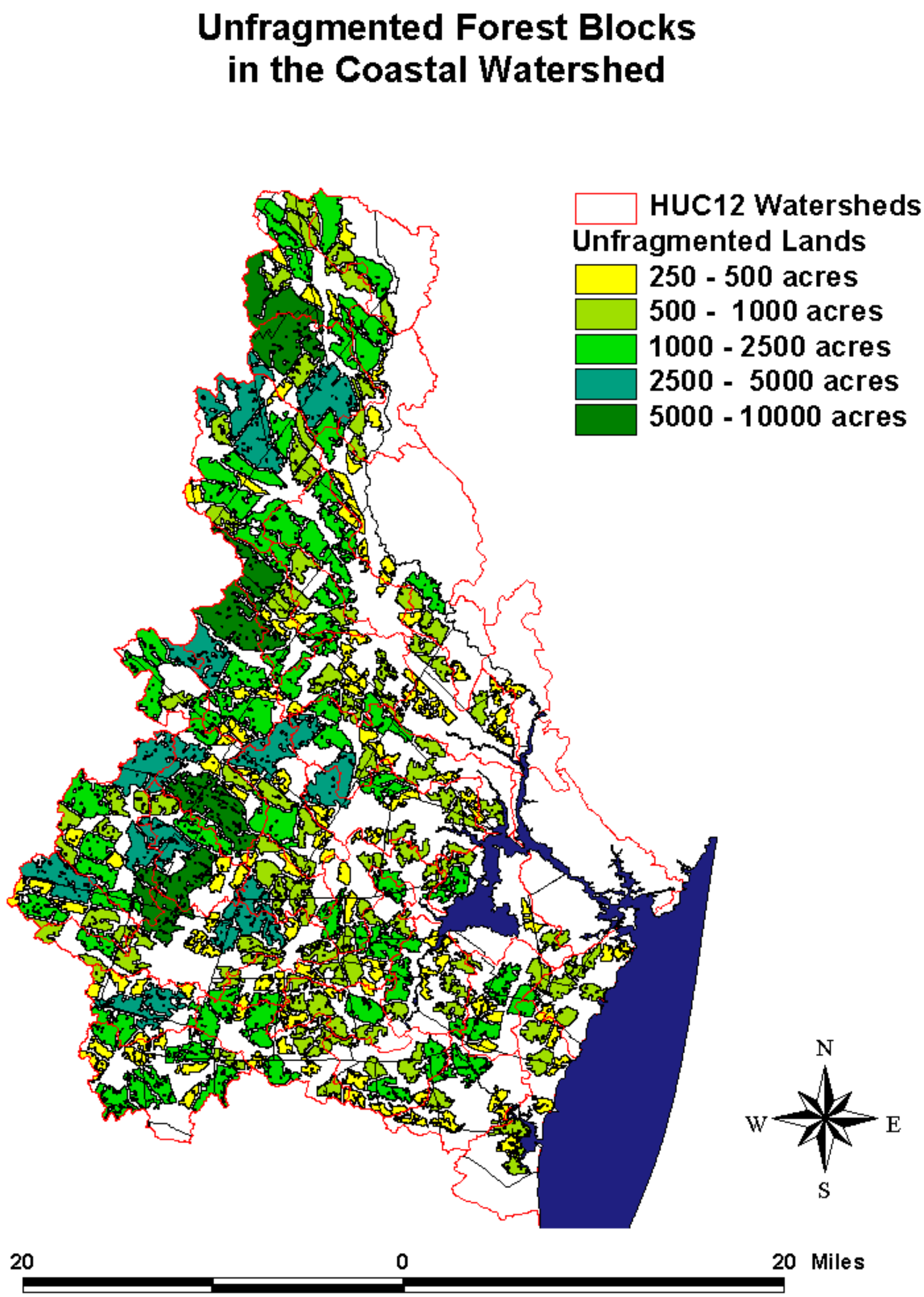
Ten percent (10%) of the blocks are currently protected from development.

Table 15: Number and acreage of large, unfragmented forest blocks in the coastal watershed

	Unfragmented Block Size (Acres)					
	250 to 500	500 to 1000	1000 to 2500	2500 to 5000	5000 to 10000	Total
Number of unfragmented blocks	112	95	60	11	4	282
Acres of unfragmented blocks	40,486	65,629	87,751	40,202	28,019	262,087
Protected lands in blocks >250 ac.						25,236
Percent of unfragmented blocks that are protected						8.7-10.6%

Data Source: 2001 land cover from GRANIT processed by SPNHF and the Oct 2002 conservation lands datalayer.

Figure 19: Unfragmented forest blocks in the coastal watershed



HAB5. Rare and Exemplary Natural Communities

a. Monitoring Objectives

The objective for this supporting variable is to track the percentage of known rare and exemplary natural communities in the coastal watershed that exist on land protected from development. The NH Natural Heritage Bureau (NHB) will be the primary data source for this indicator. The following monitoring question will be addressed:

- "Has the acreage of permanently protected important habitats (…rare and exemplary natural communities….) significantly changed over time?"

which will, in turn, report on progress toward the following management objectives:

- LND6-1: "By 2005, determine the existing acres of permanently protected land in the NH coastal watershed in the following categories: tidal shoreland, large contiguous forest blocks, wetlands with high habitat values, freshwater shorelands, and *rare and exemplary natural communities*."
- LND6-2: "Increase the acreage of protected land containing significant habitats in the NH coastal watershed through fee acquisition or conservation easements by 2010."
- LND6-4: "Increase the use of buffers around wildlife areas and maintain contiguous habitat blocks in the NH coastal watershed by 2010."

b. Measurable Goals

Since rare and exemplary natural communities is a supporting variable that will not be used to answer an management question, no goals have been set.

c. Data Analysis and Statistical Methods

In February 2003, the NH Natural Heritage Bureau queried the NHB database (using unshifted georeference points and polygons and data current through January 2003) for the total number and area of the NHB records that were within the coastal watershed. The following quadrangles from the NH Natural Heritage Bureau were used: 114-115, 126-128, 138-142, 152-156, 166-171, 182-186, 202. The records from these quadrangles were clipped using the watershed boundary of HUC8 01060003. Only records whose location was known to within 300 feet (PRECISION="S") and that had been field verified since 1980 were used. The NH Natural Heritage Bureau then determined the number and area of the records that occur on land protected from development using all the properties in the conservation lands database (February 2002). A record was considered to be "on protected land" if >50% of the polygon representing the record overlapped with protected lands.

d. Results

The results of the NHB analysis are shown in Table 16. Approximately one-quarter of the NHB records are on protected lands. Protected lands are parcels that are mostly undeveloped and that are protected from future development. However, they may be managed for uses (e.g., timber extraction or off-road vehicle use) that can have negative impacts on rare species and exemplary natural communities. Only 7% of the coastal watershed is covered by protected lands (see "Conservation Lands" indicator). The high rate at which NHB records collocate with conservation lands is probably due to targeted natural resource assessments on conservation lands.

Table 16: Summary of NH Natural Heritage Bureau data for the coastal watershed

Record Type	Location	No. of records in Watershed	No. records on Protected Lands*	Area in Watershed (acres)	Area Protected (area)
Plant community	Estuarine	61	18	34,900	5,400
	Palustrine	56	21	3,200	900
	Terrestrial	44	21	1,800	850
Plant species	NA	330	84	NA	NA
Insects	NA	4	2	NA	NA
Mussels	NA	2	0	NA	NA
Fish	NA	0	0	NA	NA
Birds	NA	31	4	NA	NA
Reptiles	NA	35	7	NA	NA
Amphibians	NA	0	0	NA	NA
TOTAL		563	157	39,900	7,150

**All properties in the most recent conservation lands data layer (public and private combined).*
Data Source: NH Natural Heritage Bureau

ENVIRONMENTAL INDICATORS OF HABITAT RESTORATION

RST1. Restored Salt Marsh

a. Monitoring Objectives

The objective of this indicator is to track the cumulative acres of salt marsh with tidal restrictions that have been restored since NHEP implementation began (2000). This indicator will directly report on progress toward the following management objective:

- RST1-1A: Increase acreage of restored estuarine habitats by 2010: Restore 300 acres of salt marsh with tidal restrictions.

and partially answer the following monitoring question:

- Have restoration efforts resulted in a significant increase in the acreage of tidal or freshwater wetlands?

b. Measurable Goal

The goal is to restore 300 acres of salt marsh by 2010.

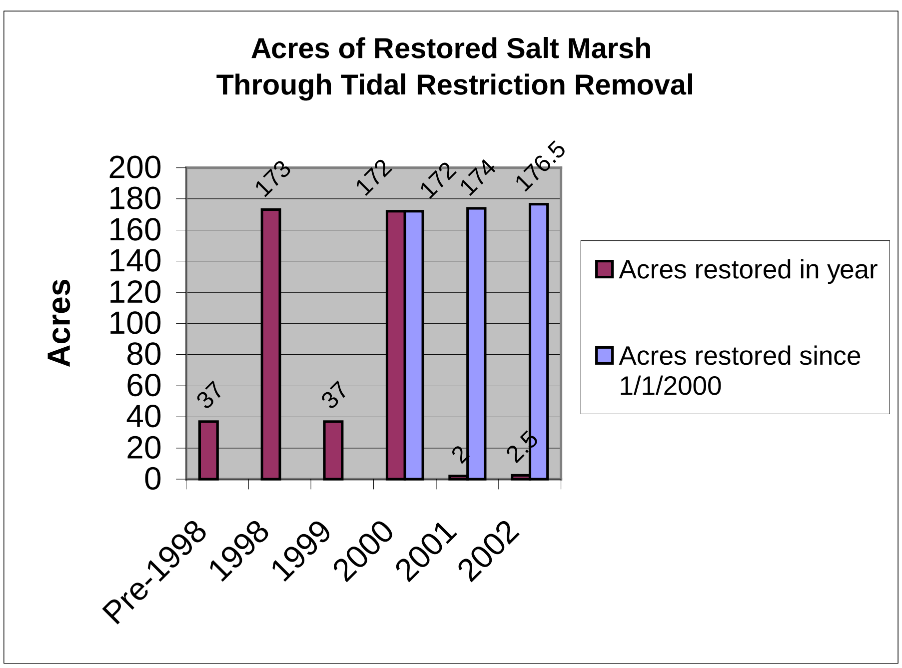
c. Data Analysis and Statistical Methods

The total acres of salt marshes that have been restored since January 1, 2000 will be recalculated each year and compared to the goal of 300 total acres. The salt marsh will be considered "restored" at the conclusion of the restoration project. The total area of restored salt marsh will be determined by the restoration project manager. No statistical tests will be applied.

d. Results

There has been significant progress toward the goal of restoring 300 acres between 2000 and 2010. The current tally of restored salt marsh by tidal restriction removal since 1/1/2000 is 176.5 acres (59%). Many more salt marsh restoration projects were completed before 2000. The NH Coastal Program is currently planning another 129 acres of salt marsh restoration by tidal restriction removal, which, if completed, would surpass the NHEP goal.

Figure 20: Acres of salt marsh restoration through tidal restriction removal



RST2. Restored Eelgrass Beds

a. Monitoring Objectives

The objective of this indicator is to track the cumulative acres of eelgrass beds that have been restored since NHEP implementation began (2000). This indicator will directly report on progress toward the following management objective:

- RST1-1A: Increase acreage of restored estuarine habitats by 2010: Restore 50 acres of eelgrass in Portsmouth Harbor, Little Bay, and the Piscataqua, Bellamy, and Oyster rivers.

b. Measurable Goal

The goal is to restore 50 acres of eelgrass beds by 2010.

c. Data Analysis and Statistical Methods

The total acres of eelgrass beds that have been restored since January 1, 2000 will be recalculated each year and compared to the goal. The eelgrass bed will be considered "restored" at the conclusion of the restoration project. Only projects that actively plant eelgrass in areas will be considered restoration projects. Expanded eelgrass coverage due to improving water quality will not be considered eelgrass restoration. The total area of restored eelgrass bed will be determined by the restoration project manager. No statistical tests will be applied.

d. Results

One major eelgrass restoration project has been completed since 1/1/2000. In 2001, an eelgrass mitigation project for the US Army Corps of Engineers was completed in Little Harbor. Eelgrass was transplanted over 5.5 acres. The restoration was monitored for one year following the transplant and found to be successful. However, because the impetus for this project was to replace eelgrass beds that were destroyed, it is not appropriate to consider this project a "restoration".

A smaller, community-based project was attempted in South Mill Pond in 2000. Eelgrass was transplanted over twenty frames (0.25 m^2/frame). None of the transplants survived.

Therefore, there have been no successful eelgrass restoration projects since 1/1/2000.

RST3. Restored Oyster Beds

a. Monitoring Objectives

The objective of this indicator is to track the cumulative acres of oyster beds that have been restored since NHEP implementation began (2000). This indicator will directly report on progress toward the following management objective:

- RST1-1A: Increase acreage of restored estuarine habitats by 2010: Restore 20 acres of oyster habitat in Great Bay and the tidal tributaries.

and partially answer the monitoring question of:

- Have restoration efforts resulted in a significant increase in the acreage and/or density of soft-shell clam and oyster beds?

b. Measurable Goal

The goal is to restore 20 acres of oyster beds by 2010. This is roughly equivalent to the known losses in oyster habitat in the Great Bay Estuary and its tributaries over the past 20 years.

c. Data Analysis and Statistical Methods

The total acres of oyster beds that have been restored since January 1, 2000 will be recalculated each year and compared to the goal. The oyster bed will be considered “restored” at the conclusion of the restoration project. Only projects that actively transplant oysters to reefs will be considered restoration projects. Expanded oyster density or bed size due to improving water quality or decreasing effects of disease will not be considered oyster restoration. The total area of each restored oyster bed will be determined by the restoration project manager. No statistical tests will be applied.

d. Results

The only oyster reef restoration project conducted since 1/1/2000 was the construction of a set of experimental reefs in the Salmon Falls River by UNH in May and October 2000 (Grizzle et al, 2003). One of the reefs was constructed from transplanted native oysters from the Upper Piscataqua River. The other reef was seeded with disease-resistant oyster strains. The intent was not to increase reef acreage but rather to test two possible methods that might be used in larger scale efforts. The constructed reefs have persisted for over two years but only cover 0.12 acres (<1% of the NHEP goal). A major impediment to oyster restoration efforts in the Great Bay is the ongoing oyster mortality due to MSX infections in native oysters.

INDICATORS MISSING FROM THIS REPORT

Several of the species and habits indicators from the Monitoring Plan were not included in this report. The main reason for this was insufficient data. The list of missing indicators and the reason why they were not included is below.

Indicator	Reason for absence
HAB1: Salt marsh extent and condition	Salt marshes in the coastal watershed will be uniformly mapped using aerial imagery by NH OSP in 2003. The data were not available for this report.

SUMMARY

While it is hard to summarize overall conditions in the NHEP project area, the species and habitats indicators presented in this report show that:

- The populations of critical species and the extent of critical habitats are similar to previous observations.
- A sizeable fraction of the watershed (7%) has been protected from development. A higher percentage of tidal and freshwater shorelands are currently under protection (21% and 14%, respectively). Approximately 10% of large, unfragmented forest blocks are also protected. The NHEP has established a goal to have 15% of the coastal watershed and 15% of the coastal communities protected from development by 2010. In order to reach these goals, an additional 48,084 acres should be protected in the watershed, including at least 4,795 acres in the 17 coastal communities, during the next seven years.
- Good progress is being made toward the NHEP's goal of restoring 300 acres of salt marshes by 2010. Between 2000 and 2002, 176.5 salt marsh acres were restored through tidal restriction removal. In contrast, few eelgrass and oyster restorations have been attempted in 2000, 2001, and 2002.

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