

State of New Hampshire
Inter-Department Communication

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At (Office): Environmental Services
Watershed Management

Subject: Probabilistic Assessments of Estuarine Waters for the 2006 305(b) Report

To: Gregg Comstock, Supervisor, Water Quality Planning Section

The purpose of this memorandum is to summarize the results of probabilistic assessments of water quality in estuarine waters for New Hampshire's 2006 305(b) Report. Probability based monitoring uses randomly assigned stations to take an unbiased sample of a natural resource. Statistics from the sample can be used to make inferences about conditions throughout the resource. The major advantage of this approach is that 100% of the resource can be assessed at minimal cost. The biggest disadvantage is that the specific locations of water quality violations cannot be inferred from the sample. Therefore, the results of the probabilistic assessment must be used in concert with the deterministic assessments of individual assessment units.

Methods

Data Source

The National Coastal Assessment (NCA) was the data source for these assessments. The National Coastal Assessment is a seven year monitoring effort funded by the U.S. Environmental Protection Agency (EPA) and implemented by DES and the University of New Hampshire. Each coastal state was monitored using a consistent suite of indicators and a probabilistic monitoring design so that an accurate assessment of the nation's coastal resources could be completed.

Study Area

For the NCA, the study area was all of the estuarine waters in New Hampshire (17.9 square miles). NCA data were collected in both the New Hampshire and Maine portions of the Piscataqua River system. However, DES only used data collected in New Hampshire waters for the 305(b) report.

In 2000 and 2001, the NCA study design did not include estuarine waters of Rye Harbor (Figure 1). In 2002-2003, Rye Harbor was included in the NCA design (Figure 2). The legend on Figure 2 is not entirely accurate. Rye Harbor is labeled as being part of the Maine estuarine waters, when in fact, Rye Harbor is in NH. The reason for the discrepancy is that DES classifies Rye Harbor as an ocean water body (NHOCN000000000-11). The NH estuarine waters shown on the map in blue are only the estuarine assessment units (i.e., assessment units beginning with NHEST). The green waters are the estuarine waters considered for the NCA which are not overlain by a NHEST assessment unit. For all areas besides Rye Harbor and a small tongue extending from Hampton/Seabrook Harbor, the green areas are the Maine portion of the Piscataqua River estuary. For the purposes of this assessment, Rye Harbor was considered to be part of NH estuarine waters, even though it is technically an ocean assessment unit. The area of Rye Harbor and the

small tongue extending from Hampton/Seabrook Harbor is negligible compared to the total area of estuarine waters in New Hampshire.

Statistical Methods

The estuarine waters in New Hampshire were overlain with a hexagonal grid consisting of 67 and 71 hexagons for the 2000-2001 NCA design and the 2002-2003 NCA design, respectively (Figures 1 and 2). An additional 11 hexagons covered the Maine portion of the Piscataqua River estuary in both designs. ArcInfo software was used to randomly assign sampling stations in the resource (i.e., NH estuarine waters) inside each hexagon. Each of the hexagons was assigned a weighting factor which was the ratio of the resource inside the hexagon to the total resource in the state. The station weights were discounted if the field crews were unable to collect the sample at the primary site in the hexagon. If the sample was collected from the primary site, then the station weight was equal to the hexagon weight. If the sample was collected from the first alternate site, the station weight was 50% of the hexagon weight. If the sample was collected from the second alternate site, the station weight was 33% of the hexagon weight.

The data from each station was evaluated and classified into categories for each designated use. The proportion of the resource assigned to each category was calculated by summing the station weights for all the stations with the same category. For two hexagons, the water and sediment samples were taken at different locations inside the hexagon. The station weights for the water sample were used for assessments which included both water and sediment indicators. The uncertainty in the proportions was estimated using the equation for variance in a binomial proportion given the sample size and assuming equal station weights. A 95th percentile precision was used for confidence limit calculations.

The results for each designated use were presented as both the percent of the resource and the square miles of estuarine waters in each category.

Environmental Indicators

Three designated uses in the estuaries were assessed using the NCA dataset: Aquatic life use support, primary contact recreation, and secondary contact recreation. The core indicators for aquatic life use support were dissolved oxygen, pH, and sediment impairments. For primary contact recreation, the indicators were enterococcus and chlorophyll-a. Enterococcus was the only indicator for secondary contact recreation. These indicators were evaluated at each of the stations to determine whether the station should be classified as fully supporting, insufficient information, or not supporting per the DES Consolidated Assessment and Listing Methodology (CALM) (DES, 2006). Data for aquatic life use support assessments were collected in 2000 and 2001. Data for primary and secondary contact recreation assessments were collected in 2002 and 2003. Each station in the probabilistic design was visited once. Sometimes the indicators were measured more than once during a station visit. In these instances, the worst case value for the indicator was chosen and used in the assessments.

The probabilistic assessments for aquatic life use support deviated from the requirements in the CALM in two ways. First, sample size requirements for the indicators (e.g., 10 samples per assessment unit) were waived, since only one visit was made to each station and the results for all the stations were aggregated. Second, the daily average dissolved oxygen indicator was not required. Per the CALM and State water quality standards, assessments of dissolved oxygen should use data on both instantaneous dissolved oxygen concentrations (in mg/L) and daily average measurements of dissolved oxygen saturation. Since the NCA dataset consisted of grab

samples for water quality, daily average dissolved oxygen data were not available. This exception is warranted since most of the documented violations of the dissolved oxygen standard in the estuarine assessment units were captured with instantaneous dissolved oxygen readings, not daily averages. However, the NCA sampling design was not optimized to detect the daily minimum dissolved oxygen concentration. Station visits were not standardized by tide or time of day. Therefore, the NCA data may underestimate the occurrence of violations of the dissolved oxygen standards.

Sediment impairments were determined using a combination of sediment chemistry, sediment toxicity and benthic community data. Sediment chemistry data were evaluated using screening values from the DES Sediment Policy (DES, 2005). Sediment toxicity was assessed using the test organism *Ampelisca abdita*, a small shrimp-like amphipod. A sediment sample was considered to have significant toxicity if the percent survival of organisms exposed to the sediment was statistically different compared to an unexposed control group. Benthic community data was evaluated using a benthic index for Gulf of Maine sediments developed by the Atlantic Ecology Division of EPA. The index was calculated as follows:

$$\text{Benthic Index} = 0.494 * \text{Shannon} + 0.670 * \text{MN_ES50.05} - 0.034 * \text{PctCapitellidae}$$

where:

Shannon = Shannon-Wiener H' diversity index

MN_ES50.05 = Station mean of 5th percentile of total abundance frequency distribution of each species in relation to its ES50 value, where ES50 is the expected number of species in a sample of 50 individuals

PctCapitellidae = percent abundance of capitellid polychaetes

The benthic index was considered poor for values less than 4

A sediment sample was considered impaired for aquatic life use support if the concentration of a chemical was higher than a Probable Effect Concentration or five times a Threshold Effect Concentration screening value from DES (2005) and either the sediment toxicity test indicated significant toxicity or the benthic index was poor.

Table 1 illustrates how the results from the three indicators were combined to classify individual stations for aquatic life use support.

Table 1: Decision Rule for Aquatic Life Use Support Classifications

Criteria	Classification
If the minimum DO at the site ≥ 5 mg/L AND If the minimum pH at the site ≥ 6.5 AND If the maximum pH at the site ≤ 8.5 AND If sediments were sampled but were not impaired	Fully Supporting
If the minimum DO at the site was < 5 mg/L OR If the minimum pH at the site was < 6.5 OR If the maximum pH at the site was > 8.5 OR If the sediments were impaired	Not Supporting
If data were missing for any of the three indicators but none of the available data violated state standards or criteria	Insufficient Information
If no data were available for any of the three indicators	Not Assessed

For primary contact recreation, the results for enterococcus and chlorophyll-a were combined. As with aquatic life use support, the sample size requirements from the CALM were waived because each station was only sampled once and the results from all the stations were aggregated. In addition, geometric mean concentrations of enterococcus were not calculated because stations

were not visited more than once during the field season. The CALM states that a fully supporting assessment can be made in the absence of a geometric mean concentration if at least two individual samples have concentrations that are less than 75% of the geometric mean criterion and no samples are greater than 75% of the geometric mean criteria. Therefore, 75% of the geometric mean criterion was used as the threshold below which the waters would be considered fully supporting. The following decision tree was used to make use support classifications.

Table 2: Decision Rule for Primary Contact Recreation Classifications

Criteria	Classification
If the enterococcus concentration was less than 75% of the geometric mean criterion (26 cts/100ml) AND If the chlorophyll-a concentration was either <=20 ug/L OR not measured.	Fully Supporting
If the enterococcus concentration was greater than the single sample maximum criterion (104 cts/100ml) OR If the chlorophyll-a concentration was >20 ug/L	Not Supporting
If the enterococcus concentration was between 75% of the GMC (26 cts/100ml) and SSMC (104 cts/100ml) OR If there were no data for enterococcus and the chlorophyll-a concentration was <=20 ug/L.	Insufficient Information
If no data were available for enterococcus or chlorophyll-a.	Not Assessed

The decision rule for assigning categories for secondary contact recreation is summarized in Table 3. The same issues regarding sample sizes and geometric means for primary contact recreation also apply for secondary contact recreation.

Table 3: Decision Rule for Secondary Contact Recreation Classifications

Criteria	Classification
If the enterococcus concentration was less than 75% of the geometric mean criterion (131 cts/100ml)	Fully Supporting
If the enterococcus concentration was greater than the single sample maximum criterion (520 cts/100ml)	Not Supporting
If the enterococcus concentration was between 75% of the GMC (131 cts/100ml) and SSMC (520 cts/100ml)	Insufficient Information
If no data were available for enterococcus.	Not Assessed

Results and Discussion

The results of the statistical analysis for aquatic life use support, primary contact recreation and secondary contact recreation are shown in Figures 3, 4 and 5, respectively.

For aquatic life use support, 90.9% of the estuaries were found to be fully supporting and only 1.0% not supporting. A total of five samples out of 76 were categorized as not supporting this use. Three of the samples were not supporting because of low dissolved oxygen and two samples were not supporting because of sediment impairments. The dissolved oxygen violations occurred in the Squamscott River and lower Piscataqua River. The sediment impairments were found in the Lamprey and Cocheco rivers.

For primary contact recreation, 76.2% of the estuaries were fully supporting and only 2.7% not supporting. Six samples were categorized as not supporting: Two for enterococcus, three for

chlorophyll-a and one for both enterococcus and chlorophyll-a. The enterococcus violations were observed in the Lamprey and Cocheco rivers. The high chlorophyll-a concentrations occurred in the Lamprey, Squamscott and the mouth of the Winnicut River.

Only one sample was categorized as not supporting for secondary contact recreation. The sample was collected in the Lamprey River. Nearly all of the estuarine waters (84.9%) were categorized as fully supporting for this use.

Significant amounts of the estuarine waters were categorized as not assessed because of missing samples from NCA hexagons. The percent of estuarine waters that were not assessed by the NCA was 2.9% for aquatic life use support, 7.7% for primary contact recreation and 14.8% for secondary contact recreation. Designated uses that were evaluated with multiple indicators tended to have a lower percentage of waters in the “not assessed” category because there were multiple chances to collect data for the assessment.

In Figures 3 through 5, the second pie chart shows the percentages of waters in the fully supporting, not supporting and insufficient information categories if the not assessed waters are excluded. Excluding the not assessed waters is equivalent to assuming that conditions in the sampled hexagons are representative of all estuarine waters. These pie charts show that 93.7%, 82.5% and 99.6% of the estuarine waters are fully supporting for aquatic life use support, primary contact recreation and secondary contact recreation, respectively.

The 305(b) reporting elements for probabilistic assessments are provided in Appendix A. The percentages reported in the appendix do not sum to 100%. The difference is the percentage of waters that were categorized as not assessed.

References

- DES (2006) 2006 Section 305(b) and 303(d) Consolidated Assessment and Listing Methodology. NHDES-R-WD-05-29. NH Department of Environmental Services, Watershed Management Bureau, Concord, NH.
- DES (2005) Evaluation of Sediment Quality Guidance Document. NHDES # WD-04-09. April 15, 2005. New Hampshire Department of Environmental Services, Concord, NH.

Figure 1

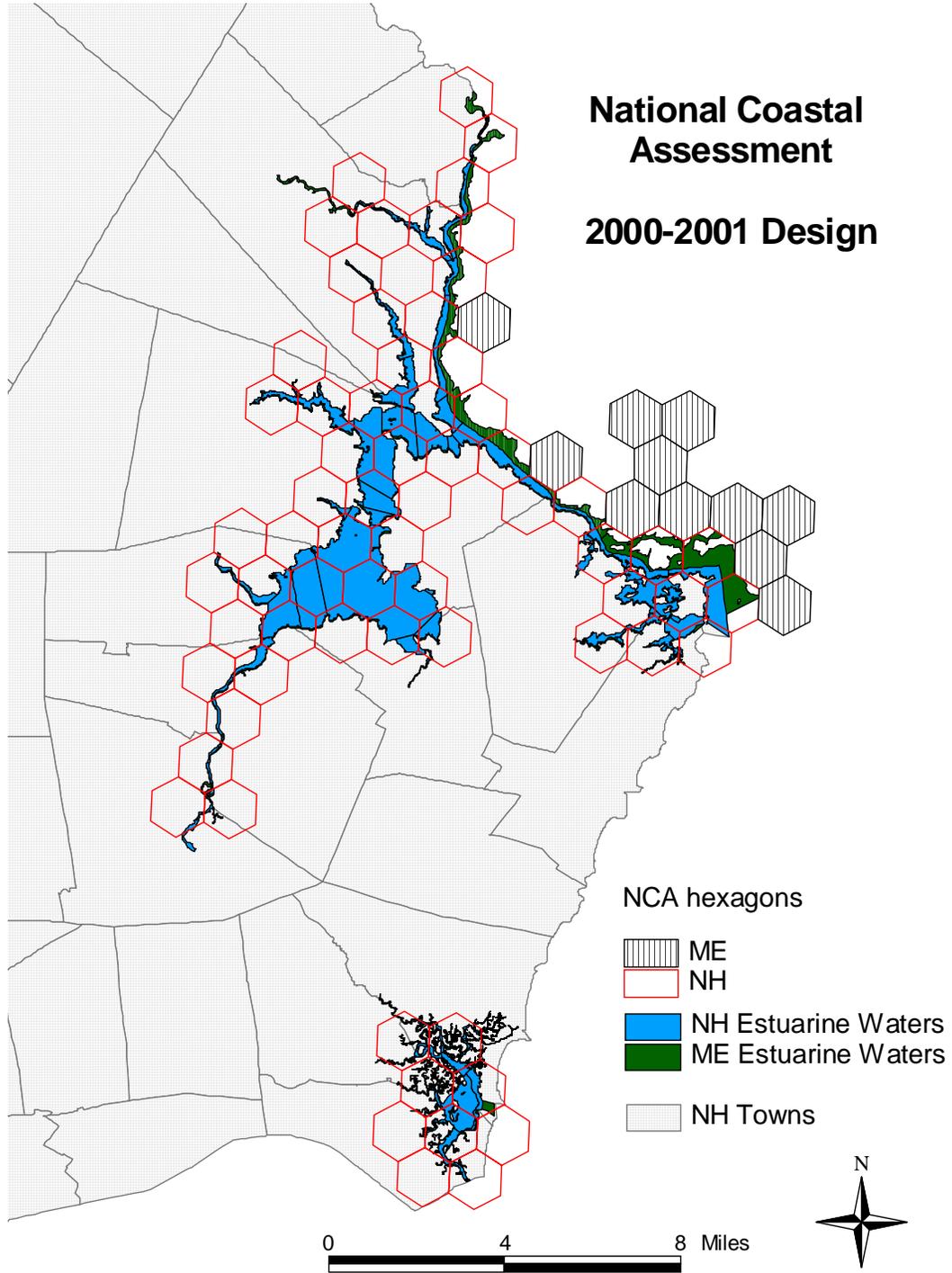


Figure 2

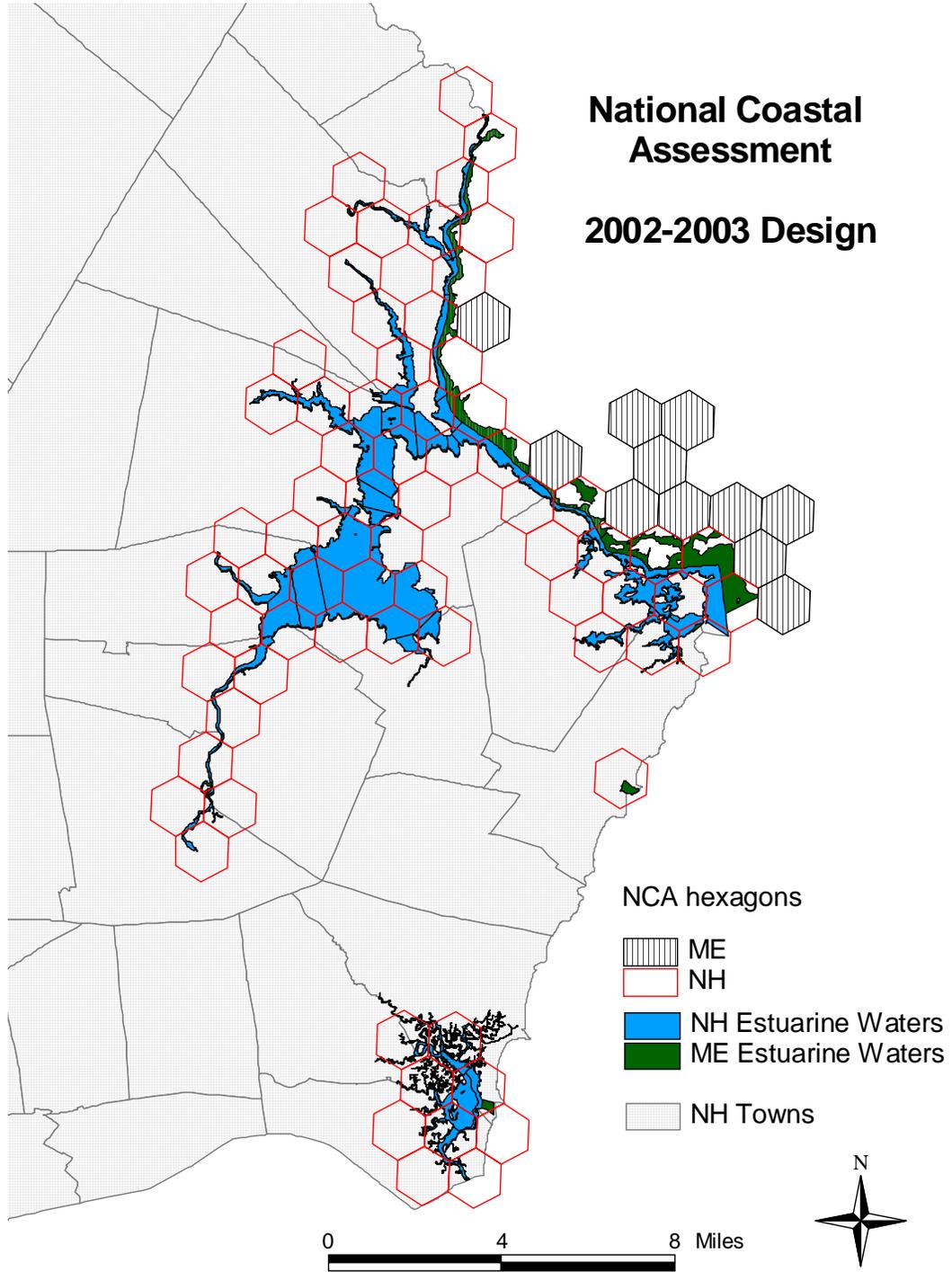


Figure 3

Aquatic Life Use Support in Estuarine Waters

Category	Percent of Resource		Square Miles	
	Value	Error	Value	Error
Full Supporting	90.9%	7.0%	16.3	1.2
Insufficient Info	5.2%	5.4%	0.9	1.0
Not Supporting	1.0%	2.4%	0.2	0.4
Not Assessed	2.9%		0.5	0.0
Total	100.0%		17.9	

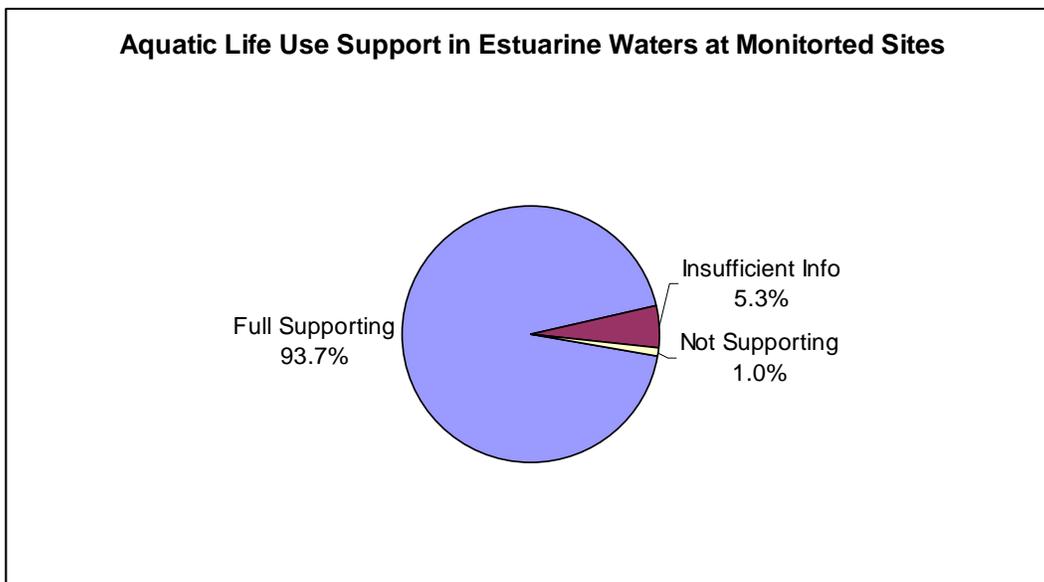
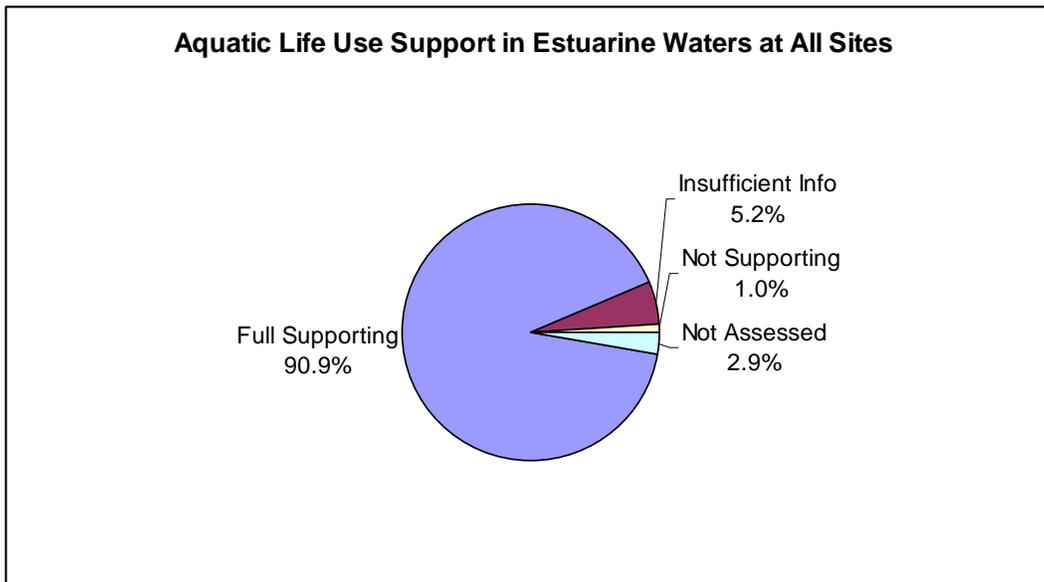


Figure 4

Primary Contact Recreation in Estuarine Waters

Category	Percent of Resource		Square Miles	
	Value	Error	Value	Error
Full Supporting	76.2%	10.1%	13.6	1.8
Insufficient Info	13.4%	8.0%	2.4	1.4
Not Supporting	2.7%	3.8%	0.5	0.7
Not Assessed	7.7%	0.0%	1.4	0.0
Total	100.0%		17.9	

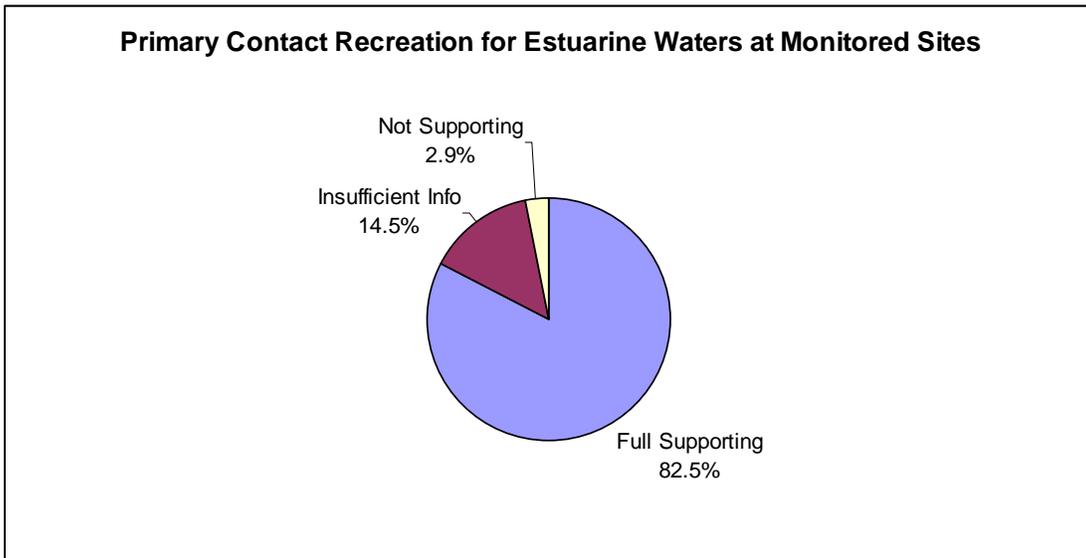
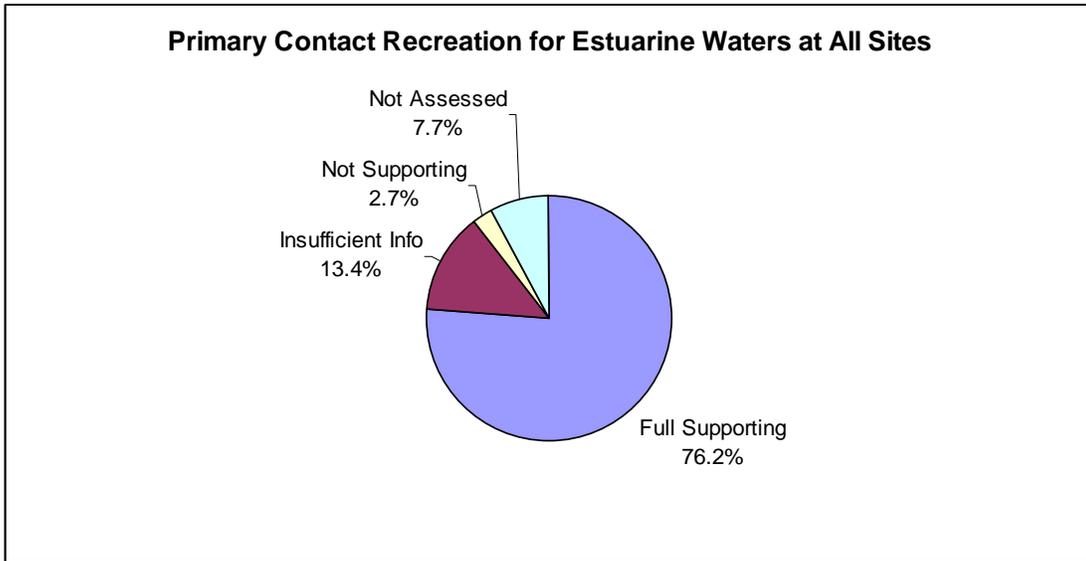
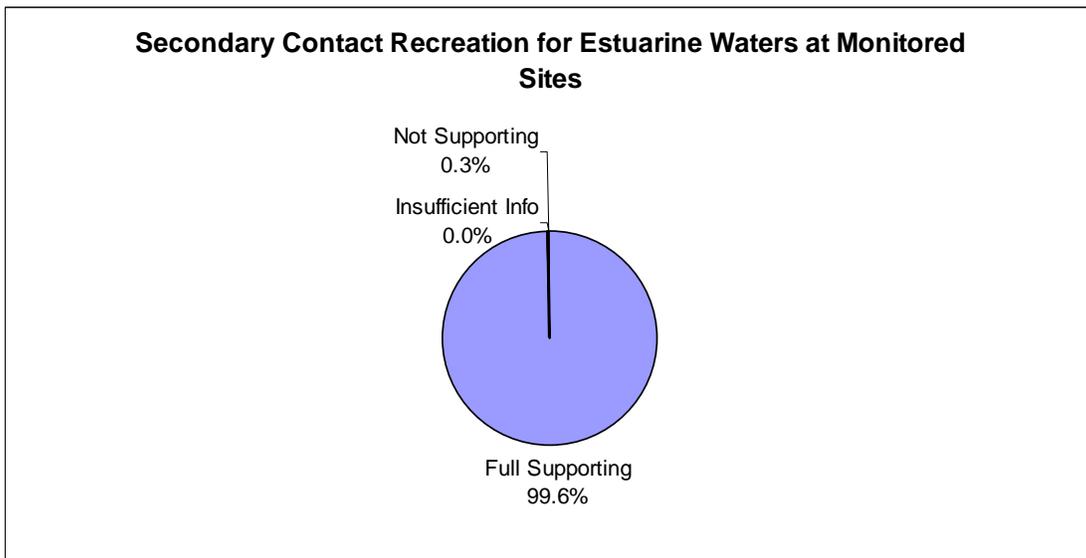
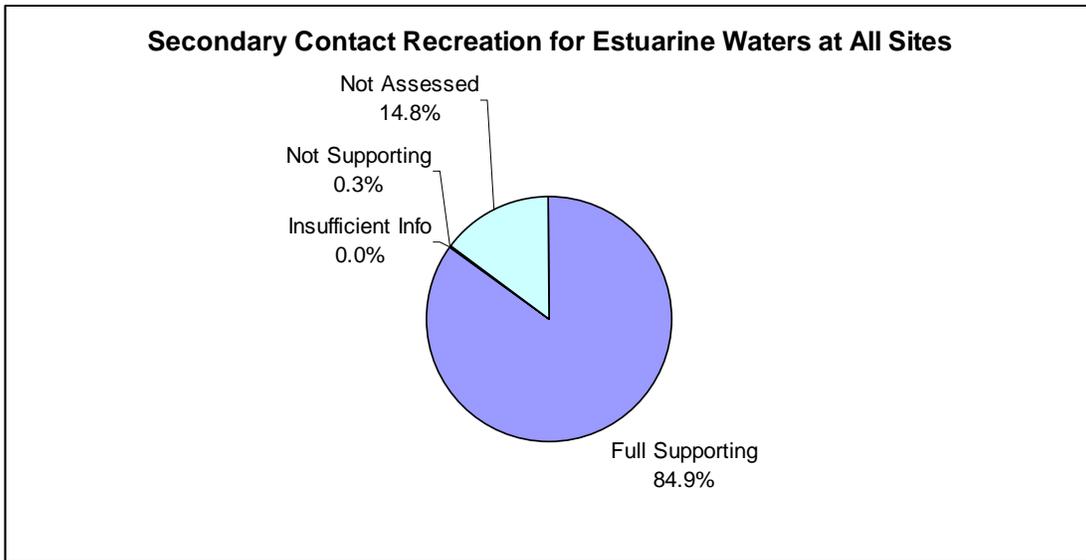


Figure 5

Secondary Contact Recreation in Estuarine Waters

Category	Percent of Resource		Square Miles	
	Value	Error	Value	Error
Full Supporting	84.9%	8.7%	15.2	1.6
Insufficient Info	0.0%	0.2%	0.0	0.0
Not Supporting	0.3%	1.3%	0.1	0.2
Not Assessed	14.8%	0.0%	2.7	0.0
Total	100.0%		17.9	



Appendix A: Section 305(b) Reporting Data Elements

Table A1: Aquatic Life Use Support

Data Element	Result
Probabilistic Network Name	National Coastal Assessment
Project ID (Assessment Unit ID)	Assessment units starting in "NHEST"
Target Population	NH's estuarine waters
Resource Type	Estuary
Designated Use	Aquatic Life Use Support
Indicator	Dissolved Oxygen, pH, Sediment Quality
Size	17.9
Units	Square miles
Number of sites	65 stations in NH monitored in 2000 and 2001. There are also 11 stations on the Maine side of the border. These stations will be included in estuary-wide assessments but were not included in this assessment.
Percent attaining	90.9%
Percent insufficient information or not assessed	8.1%
Percent not attaining	1.0%
Assessment Data	20060306
Precision	95%
Confidence	+/-7%

Table A2: Primary Contact Recreation

Data Element	Result
Probabilistic Network Name	National Coastal Assessment
Project ID (Assessment Unit ID)	Assessment units starting in "NHEST"
Target Population	NH's estuarine waters
Resource Type	Estuary
Designated Use	Primary Contact Recreation
Indicator	Enterococcus, Chlorophyll-a
Size	17.9
Units	Square miles
Number of sites	69 stations in NH monitored in 2002 and 2003. There are also 13 stations on the Maine side of the border. These stations will be included in estuary-wide assessments but were not included in this assessment.
Percent attaining	76.2%
Percent insufficient information or not assessed	21.1%
Percent not attaining	2.7%
Assessment Data	20060306
Precision	95%
Confidence	+/-10.1%

Table A3: Secondary Contact Recreation

Data Element	Result
Probabilistic Network Name	National Coastal Assessment
Project ID (Assessment Unit ID)	Assessment units starting in "NHEST"
Target Population	NH's estuarine waters
Resource Type	Estuary
Designated Use	Secondary Contact Recreation
Indicator	Enterococcus
Size	17.9
Units	Square miles
Number of sites	65 stations in NH monitored in 2002 and 2003. There are also 17 stations on the Maine side of the border. These stations will be included in estuary-wide assessments but were not included in this assessment.
Percent attaining	84.9%
Percent insufficient information or not assessed	14.8%
Percent not attaining	0.3%
Assessment Data	20060306
Precision	95%
Confidence	+/-8.7%