

**Development of a Spatially-Explicit Health Index for the Coastal  
Bays of Maryland and Virginia**

**Draft**

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**A joint effort by the Integration and Application Network (IAN) of the University of  
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Program (MCBP), Assateague National Seashore (NPS), and the Maryland  
Department of Natural Resources (MD DNR)**

## Approach

The approach for the Coastal Bays Health Index (CBHI) builds upon the methods and analyses used in the Chesapeake Bay Health Index (Williams et al. 2009) and 2004 Coastal Bays report (Wazniak et al. 2004). To be consistent with the established reporting approach the indicators used for this index are based on:

- 1) The previous year's data. The purpose of the report is to provide a timely assessment of the previous year's health. Therefore, all indices are based on data collected in the previous year only. Currently used indicators are based on the calendar year (January 1<sup>st</sup> to December 31<sup>st</sup>).

*Why this approach?*

Annual assessment and reporting has several advantages because this: (i) includes only one seasonal cycle, (ii) enables easy comparison to previous years and previous year stressors such as nutrient loads and (iii) forces delivery and communication of data/information in a familiar timeframe that is relevant to the target audience.

- 2) Established indicators. It is recognized that not all indicators can be included since they may not be completed (i.e., Phytoplankton IBI), have the required spatial detail (e.g., fisheries indicators) or have timely data availability (i.e., brown tides).

*Why this approach?*

Indicators were chosen to provide pertinent and available information to the target audience. Including indicators other than those identified would diminish the logical framework, resulting in increased complexity and possible misinterpretation.

- 3) Reporting progress towards established goals or thresholds.

*Why this approach?*

Reporting progress towards established goals (i) capitalizes on the effort undertaken to develop thresholds, (ii) provides direct local assessment of progress towards the thresholds and thus effectiveness of management actions, (iii) provides consistency among indicators and enables production of defensible and simple index values, and (iv) avoids subjectivity in index grades.

## Indicator selection

The indicators to be included in the Coastal Bays Health Index (CBHI) maps are indicated in Table 1.

Table 1: Indicators that can potentially be used in a Coastal Bays health assessment.

<b>Water quality</b>	<b>Habitat and lower food web</b>	<b>Fish and Shellfish</b>
Dissolved oxygen	Bay grasses (SAV)	Hard Clams
Total Nitrogen	Brown Tides*	Blue crabs*
Total Phosphorus	Benthic IBI*	Oyster*
Chlorophyll <i>a</i>	Phytoplankton IBI*	Finfish*
Chemical contaminants*	Wetland area*	
	Natural Shoreline*	

\* Not quantified in 2008

Unfortunately, not all indicators can be included at this stage because some are unavailable or being developed (i.e., finfish, blue crabs, oysters, and the Phytoplankton Index of Biotic Integrity – P-IBI), and others are not suitable for including in a health index because of temporal and spatial sampling constraints (Benthic Index of Biotic Integrity – B-IBI, wetland area, natural shoreline). Based on this assessment, the indicators used in the 2008 CBHI and maps are presented in Table 2. As other indicators become available or suitable for inclusion in subsequent years they may also be included.

Table 2: Indicators used in the 2008 CBHI and spatially-explicit maps.

<b>Water quality</b>	<b>Habitat and Shelfish</b>
Dissolved oxygen	Bay grasses (SAV)
Total Nitrogen	Hard Clams
Total Phosphorus	
Chlorophyll <i>a</i>	

## Reporting regions

Reporting regions are six discrete regions of the Coastal Bays used for reporting and analysis (Table 3, Figure 1).

Table 3. Summary of data currently available for each of the proposed reporting regions

Reporting region	Total surface area (km <sup>2</sup> )	Proportion of total reporting area (%)	Number of water quality stations	Number of hard clam stations
St. Martin River	8.4	2.2	16	10
Assawoman Bay	20.9	5.4	7	20
Isle of Wight Bay	21.1	5.4	14	25
Newport Bay	15.9	4.1	17	10
Sinepuxent Bay	24.1	6.2	7	25
Chincoteague Bay	298.0	76.7	19	114
Total	388.4	100.0	80	204

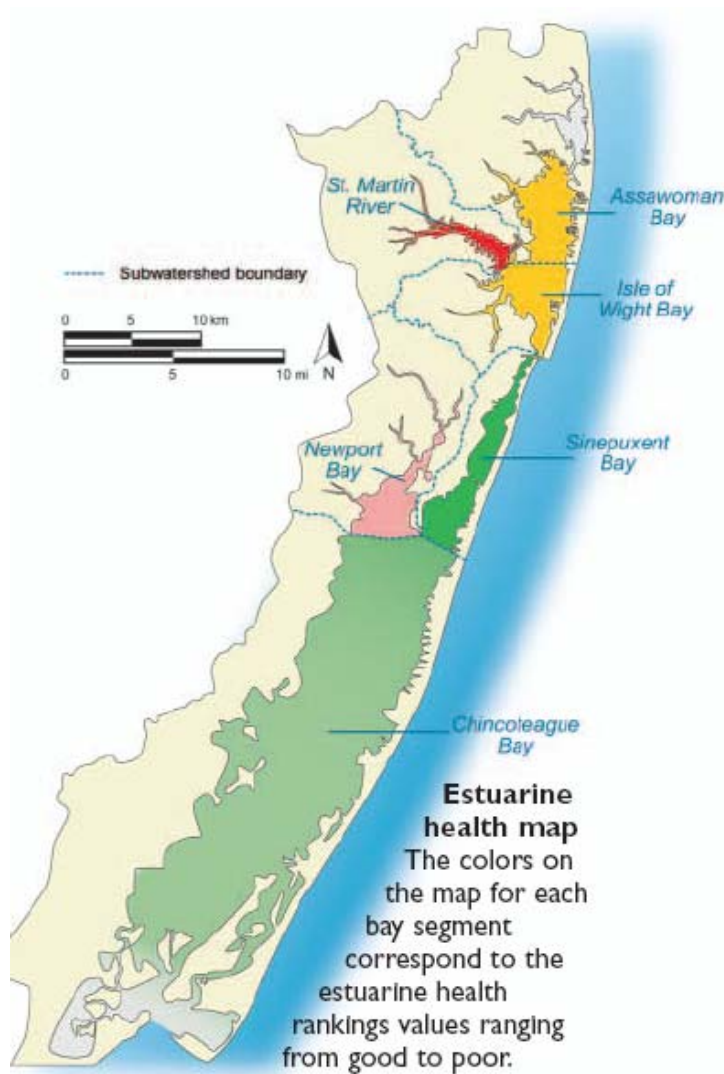


Figure 1. CBHI reporting regions. Note that this map appears in the 2004 Coastal Bays report and the colors do not correspond to the estuarine health as calculated in 2008.

# Methods - Water Quality Indicators

## Data and site selection

Data for the water quality indicators were derived from 80 fixed stations in 2008 (this will vary slightly from year to year) that are sampled bi-monthly to monthly throughout the year (Figure 2).

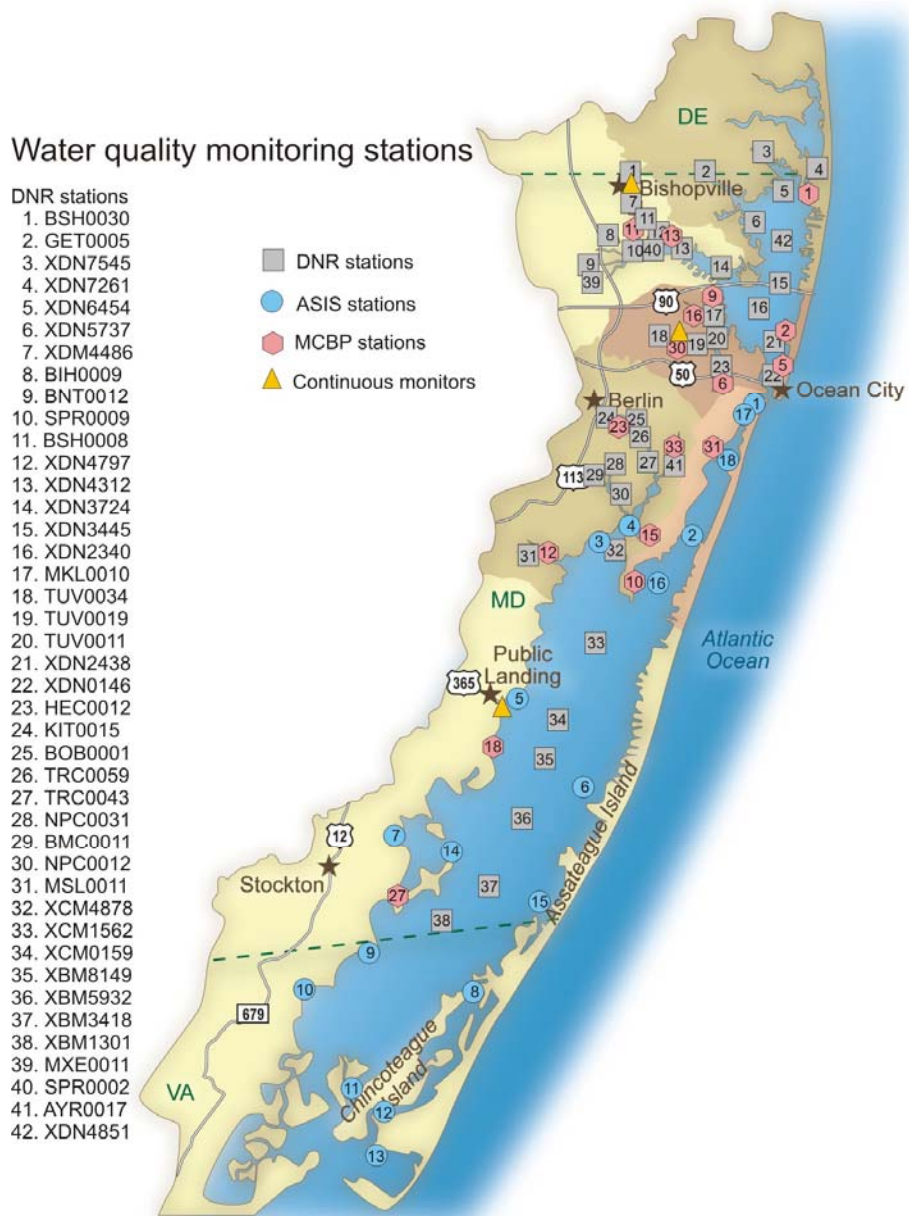


Figure 2. Locations of sampling stations used for the collection of water quality data in the Coastal Bays (note that continuous monitoring station data were not used).

## Water quality maps

Spatially-explicit maps of total nitrogen, total phosphorus, dissolved oxygen and chlorophyll-a on the Eco-Check website ([www.eco-check.org](http://www.eco-check.org)) will be based on the bi-monthly to monthly fixed-station data. The medians of each sampling station during the year were interpolated to generate a single map for each parameter that represents typical conditions.

## Status thresholds

A number of different thresholds were used in the CBHI analysis and these were chosen to have scientific rigor and an inherently clear association with the concept of ecosystem health. The final multiple thresholds used for DO, chlorophyll-a, and nutrients were derived from the 2004 Coastal Bays report (Wazniak et al. 2004), and are shown in Table 4.

Table 4. Multiple thresholds used for each water quality constituent.

Category	Score (%)	DO (mg L <sup>-1</sup> )	TN (mg L <sup>-1</sup> )	TP (mg L <sup>-1</sup> )	Chl-a (µg L <sup>-1</sup> )
<b>Very good</b>	100	≥7.0	<0.56	<0.026	<7.5
<b>Good</b>	80	≥6.0 - <7.0	≥0.56 - <0.65	≥0.026 - <0.038	≥7.5 - <15
<b>Moderate</b>	60	≥5.0 - <6.0	≥0.65 - <1.0	≥0.038 - <0.044	≥15 - <30
<b>Poor</b>	40	≥3.0 - <5.0	≥1.0 - <2.0	≥0.044 - <0.1	≥30 - <50
<b>Very poor</b>	20	<3.0	≥2.0	≥0.1	≥50

## Frequency of passing thresholds and water quality maps

The median of the sampling data for each water quality constituent was compared to the thresholds in Table 4 and a corresponding score was given. The average of these scores for all stations within a report region was then calculated.

## Methods - Biotic Parameters

### Submerged Aquatic Vegetation (SAV) compliance

#### Data selection and availability

Estimates of SAV cover for each the CBP segments were derived from annual aerial surveys of SAV done by the Virginia Institute of Marine Science (Orth et al., 2005). Further information can be obtained from the VIMS website ([www.vims.edu/bio/sav/](http://www.vims.edu/bio/sav/)).

#### SAV restoration goals

SAV restoration goals have been developed for all of the Coastal Bays reporting regions. The restoration goal for each reporting region is equivalent to the available shallow water area available for SAV growth, and restoration goals are presented in Table 5. A percent compliance was calculated as the ratio of the sum of the SAV acreage for each reporting region to the SAV restoration goal acreages for the same region.

Table 5. SAV restoration goal for each of the reporting regions.

Reporting region	Total surface area (km <sup>2</sup> )	SAV restoration goal by reporting region (acres)	Proportion SAV area of total (%)
St. Martin River	8.4	48	0.02
Assawoman Bay	20.9	1745	7.46
Isle of Wight Bay	21.1	1476	6.10
Newport Bay	15.9	341	0.63
Sinepuxent Bay	24.1	3031	24.49
Chincoteague Bay	298.0	12,174	61.30
Total	388.4	18,815	100.0

## Methods – Hard Clams

A hard clam density of 1.34 m<sup>-2</sup> is used as the threshold for this shellfish indicator. Therefore, the average density of hard clams from every sampling station within a reporting region was compared to this index and the % of the attainment toward this density threshold or goal is used in the calculation of the CBHI.

## Methods – Coastal Bays Health Index (CBHI)

The Coastal Bays Health Index (CBHI) is the average of the six indicator mentioned previously (i.e., total nitrogen, total phosphorus, dissolved oxygen, chlorophyll-a, submerged aquatic grasses, and hard clams). Therefore, all indicators were equally weighted. The CBHI for each reporting region was then binned and color-coded into % ranges of 0-20% (red = Very Poor), 21-40% (orange = Poor), 41-60% (yellow = moderate), 61-80% (light green = good), and 81-100% (dark green = Very Good). CBHI values ranged from 35 to 73 in 2008 (Table 6, Figure 3).

Table 6. The Coastal Bays Health Index for 2008 for all reporting regions ranked in descending order from the most to least healthy regions. The CBHI was calculated as the mean of the six indicator values calculated for each reporting region.

Region	Health Index	Grade
Sinepuxent	<b>73.2</b>	<b>B</b>
Chincoteague	<b>60.1</b>	<b>B minus</b>
Isle of Wight	<b>55.0</b>	<b>C plus</b>
Assawoman	<b>49.8</b>	<b>C</b>
Newport	<b>37.5</b>	<b>D plus</b>
St. Martin River	<b>34.9</b>	<b>D plus</b>
Enitre system	<b>58.6</b>	<b>C plus</b>

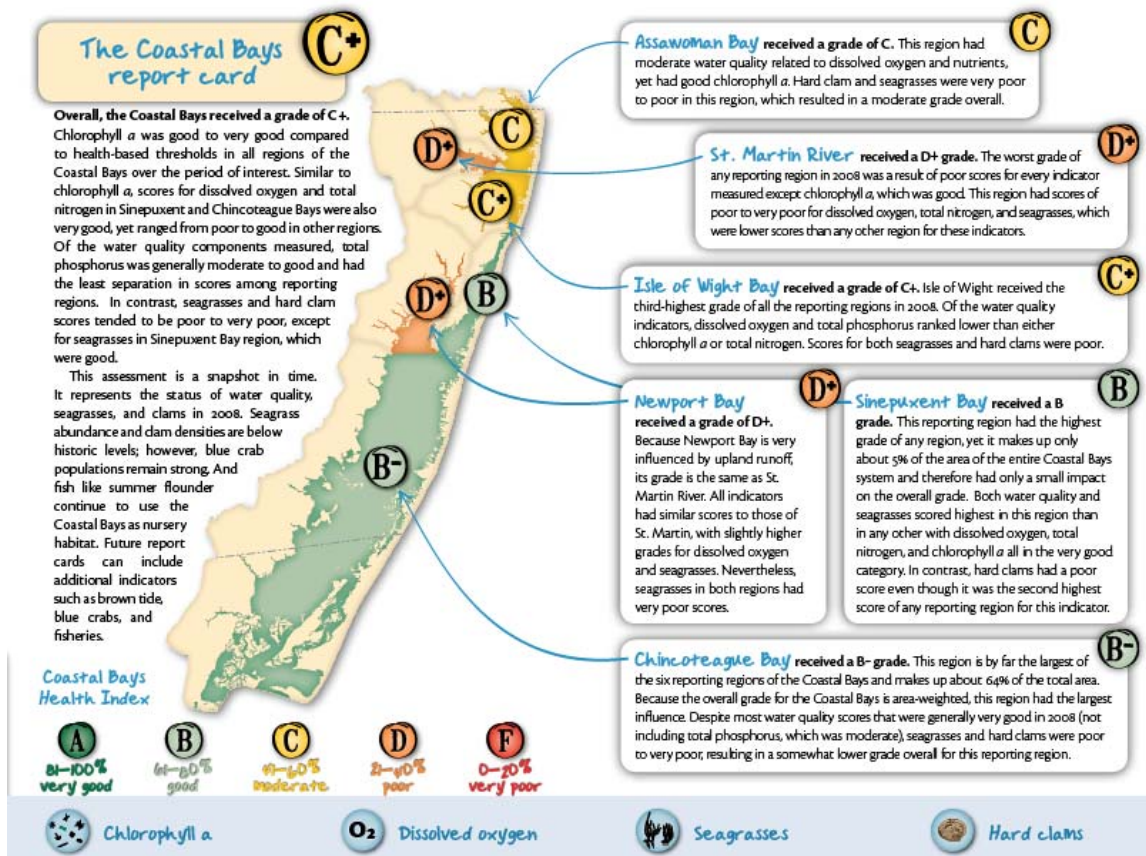


Figure 3. Final grades by reporting region as appears in the 2008 report card.

## Acknowledgements

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