2. APPROACH

EVALUATING EUTROPHICATION

How do we evaluate eutrophication?

The eutrophic condition of a system is evaluated by examining the following three components:

- **Influencing factors:** physical, hydrologic, and anthropogenic.
- **Overall eutrophic condition:** derived from data for five eutrophic symptoms (Figure 2.2).
- **Future outlook:** expected changes in the system.

These components are then combined to provide a single rating for the estuary, called ASSETS.

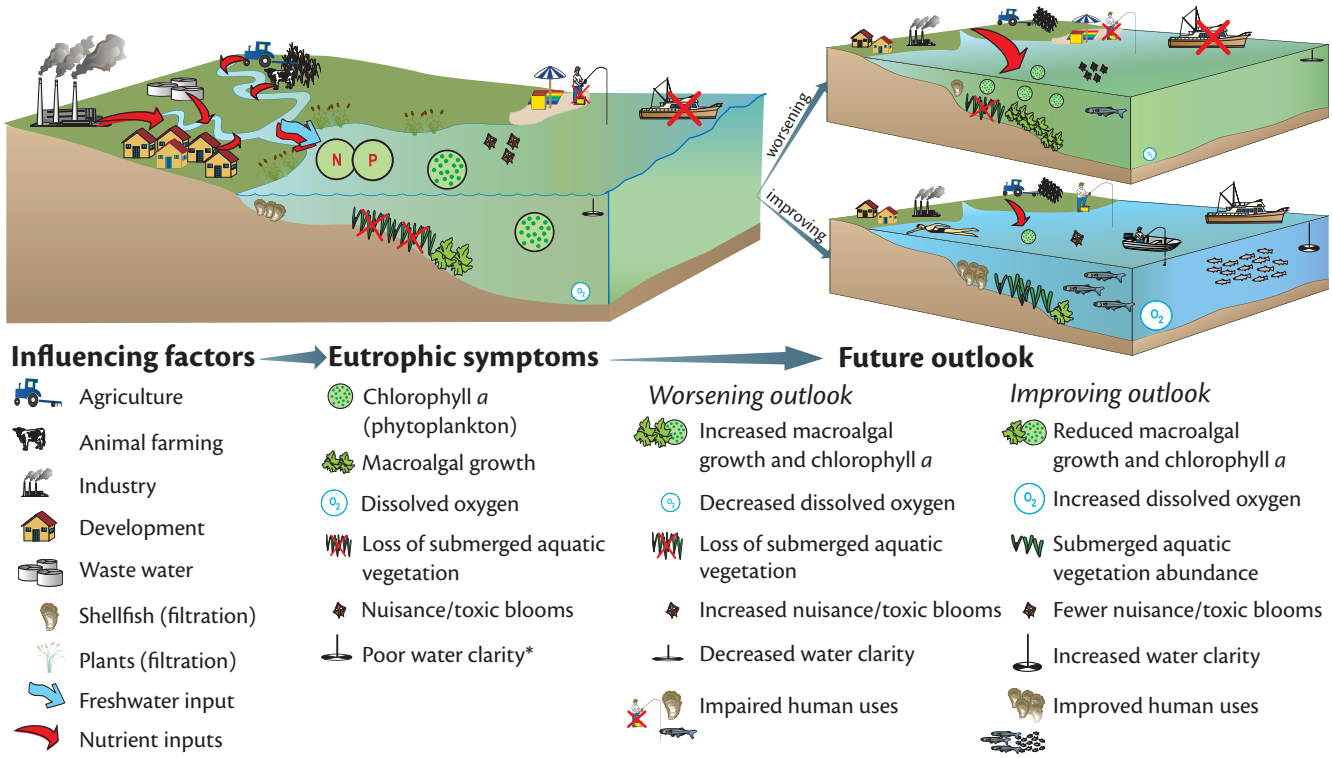
Influencing factors

In order to provide a sound basis for coastal resource management, this assessment evaluates the factors that influence water quality (Figure 2.1). This evaluation requires the inclusion of national data sets such as physical and hydrologic characteristics and nutrient loading. Influencing factors help establish a link between a system's natural sensitivity to eutrophication and the nutrient loading and eutrophic symptoms actually observed. This understanding also helps illustrate the relationship between eutrophic conditions and use impairments.

Overall eutrophic condition

The assessment of a system's eutrophic condition is based on a compilation of information for five water quality variables related to nutrient enrichment (Figure 2.2). The data set includes concentration or occurrence of problem conditions, and also characteristics such as duration, spatial coverage, frequency of occurrence of observed conditions, and data confidence. An increase in two of the primary symptoms—chlorophyll *a* (phytoplankton biomass) and macroalgal abundance—represents the first possible stage of water quality degradation associated with eutrophication. In the 1999 assessment, epiphytes were also used as a primary symptom indicator (Bricker et al. 1999). However, they have been omitted from the current assessment due to the lack of a standard measure and data availability (Bricker et al. 2006, Scavia and Bricker 2006). The three secondary symptoms represent more serious impacts: low dissolved oxygen levels, loss of submerged aquatic vegetation, and occurrences of nuisance/toxic algal blooms. Nutrient concentrations are not used because they reflect the net biological, physical, and chemical processes such that even a severely degraded water body may exhibit low

Figure 2.1. The NEEA update evaluates influencing factors, eutrophic symptoms, and future outlook for the system.



*A symptom not included in rating system

Figure 2.2. A description of the eutrophic symptoms included in this assessment.

Primary symptoms	Description
Chlorophyll *a* (Phytoplankton)	A measure used to indicate the amount of microscopic algae (phytoplankton) growing in a water body. High concentrations can lead to low dissolved oxygen levels as a result of decomposition.
Macroalgal blooms	Large algae commonly referred to as "seaweed." Blooms can cause losses of submerged aquatic vegetation by blocking sunlight. Additionally, blooms may smother immobile shellfish, corals, or other habitat. The unsightly nature of some blooms may impact tourism due to the declining value of swimming, fishing, and boating.
Secondary symptoms	**Description**
Dissolved oxygen	Low dissolved oxygen is a eutrophic symptom because it occurs as a result of decomposing organic matter (from dense algal blooms), which sinks to the bottom and uses oxygen during decay. Low dissolved oxygen can cause fish kills, habitat loss, and degraded aesthetic values, resulting in the loss of tourism and recreational water use.
Submerged aquatic vegetation	Loss of submerged aquatic vegetation (SAV) occurs when dense algal blooms caused by excess nutrient additions (and absence of grazers) decrease water clarity and light penetration. Turbidity caused by other factors (e.g., wave energy, color) similarly affects SAV. The loss of SAV can have negative effects on an estuary's functionality and may impact some fisheries due to loss of a critical nursery habitat.
Nuisance/toxic blooms	Thought to be caused by a change in the natural mixture of nutrients that occurs when nutrient inputs increase over a long period of time. These blooms may release toxins that kill fish and shellfish. Human health problems may also occur due to the consumption of contaminated shellfish or from inhalation of airborne toxins. Many nuisance/toxic blooms occur naturally, some are advected into estuaries from the ocean; the role of nutrient enrichment is unclear.

concentrations due to uptake by phytoplankton and macroalgae. Conversely, a relatively healthy system might have high nutrient concentrations due to low algal uptake as a result of light-limiting turbid waters, or may simply flush nutrients so quickly that phytoplankton do not have the opportunity to bloom extensively. For these reasons, nutrient concentrations may not serve as accurate indicators.

In many estuaries, primary symptoms lead to more serious secondary symptoms, including low dissolved oxygen, loss of submerged aquatic vegetation (SAV), and nuisance/toxic blooms. In some cases, secondary symptoms can exist in the estuary without originating from primary symptoms. This occurs in many North Atlantic estuaries, where toxic algal blooms are transported into the system from the coastal ocean. Such systems were consequently given a lower rating for nuisance/toxic blooms. Low ratings were also used because it is unclear whether offshore nuisance/toxic algal blooms grow and are maintained as a result of land-based nutrient sources (an increasing problem, regardless of bloom origin).

Future outlook

The assessment also evaluates the future outlook for a system to try to forecast national trends over long periods of time. In this update, future outlook combines the susceptibility of a system and the predicted future nutrient loads to determine whether conditions will worsen or improve. In addition, recommendations for potential management responses to eutrophication were developed from conclusions based upon the evaluation of influencing factors and future outlook.

Primary and secondary symptoms

Primary symptoms (phytoplankton and macroalgal abundance) represent the first possible stage of water quality degradation due to eutrophication. Because short-term nutrient measurements are highly variable, nitrogen and phosphorus concentrations cannot be used as a measure of eutrophication.

Secondary symptoms often represent a more advanced stage of eutrophication. In some cases, secondary symptoms can exist without the presence of primary symptoms.

DETERMINING INFLUENCING FACTORS

How are influencing factors evaluated?

The influencing factors for a system take into account both the natural characteristics of, and human impacts to systems. They are determined by calculating susceptibility and nitrogen load:

- Susceptibility is a measure of a system's nutrient retention based upon flushing and dilution.
- Nitrogen loads are the amount of nitrogen input to a system. For influencing factors, nitrogen loads are estimated as a ratio between ocean and land inputs (see pages 12-13).

Jane Thomas, University of Maryland Center for Env. Science

Flushing, one of the components of susceptibility, refers to an estuary's ability to move freshwater out to the ocean. Above, waters of different salinities mix in Ocean City Inlet, Maryland.

Susceptibility

Susceptibility is an estimate of the natural tendency of an estuary to retain or flush nutrients. In general, susceptibility is influenced by the flow of water. The flushing capability of a system is determined by tidal action and the amount of freshwater flowing in from its tributaries. In most cases, if the water (and therefore nutrients) are flushed quickly, there is insufficient time for eutrophic symptoms to develop (i.e., low susceptibility). However, if the estuary has a long residence time, there is time for nutrients to be taken up by algae and for blooms to develop. This assessment uses physical and hydrologic data to separately define dilution and flushing ratings. When combined, these produce a susceptibility rating.

In addition to evaluating influencing factors, susceptibility can be used to forecast not only the extent to which eutrophic symptoms may occur, but also what symptoms may potentially occur. For example, in some shallow lagoonal systems, additional nutrients will result in increased macroalgal abundance rather than high concentrations of phytoplankton/chlorophyll *a* (Nobre et al. 2005). A typology of these systems is being developed in order to increase projection accuracy by accounting for differences in how systems respond to nutrient inputs (see *Chapter 6*).

Calculating influencing factors

Overall, the impact of influencing factors for an estuarine system is determined by a matrix (figure at right). Several calculations were made to create the matrix. First, both susceptibility and load were determined for each estuary and placed in one of three categories: low, moderate, or high. The load refers to a ratio of land-based to oceanic nitrogen inputs, with a high rating indicating primarily land-based inputs (Bricker et al. 2003; Ferriera et al. 2007). The estuary's susceptibility and nutrient loads were compared in a matrix and given an influencing factors rating. For example, an estuary with low nutrient loads and moderate susceptibility is moderately/slightly influenced. Each of the systems in the survey can fall into one of five categories: slightly influenced, moderately/slightly influenced, moderately influenced, highly/moderately influenced, and highly influenced (see Bricker et al. 1999 for details).

Determination of influencing factors

Susceptibility (flushing and dilution)	low nitrogen input	moderate nitrogen input	high nitrogen input
high susceptibility	Moderately influenced	Highly/moderately influenced*	Highly influenced
moderate susceptibility	Moderately/slightly influenced*	Moderately influenced	Highly/moderately influenced*
low susceptibility	Slightly influenced	Slightly influenced	Moderately/slightly influenced*

***Load** (nitrogen ratio)*

Due to the uncertainty in loading estimates, moderately/slightly and slightly influenced have been combined to both be slightly influenced, and highly/moderately and highly influenced are combined to be highly influenced throughout the report (colors indicate grouping).

Nitrogen load

Nitrogen loads are the critical component for determining an influencing factors score. Although there are data for both nitrogen and phosphorus loads, only nitrogen is analyzed because it is typically the limiting nutrient in estuaries and coastal waters. However, it is known that in some systems or seasons phosphorus may be the limiting nutrient. While natural processes contribute some nitrogen inputs, for many systems, inputs are now mostly human-related, from concentrated point sources such as wastewater treatment, or non-point sources such as urban runoff, agriculture, and atmospheric deposition.

In this update, two sources are used for load estimates: the online survey entries and the Watershed Assessment Tool for Evaluating Reduction Strategies for Nitrogen model (WATERSN, see box at right). The online survey allowed experts to enter information regarding the magnitude and projected changes for nutrient loads. Results from the WATERSN model were used as a source of load data for systems where this information was not entered online.

The USGS SPARROW model (SPAtially Referenced Regressions On Watershed Attributes) load estimates (Smith et al. 1997) were used in the 1999 assessment but were unavailable for this study. A comparison of WATERSN and SPARROW results was made to determine the suitability of the WATERSN results for use here. When the SPARROW results (only base year 1987 available) were compared statistically with WATERSN model results (base year 1997), they were found to be significantly different. In general, the WATERSN estimates were higher than the SPARROW load estimates. The WATERSN results were compared statistically with the loads entered into the online survey by participants for 11 systems (only systems where both were available) and found to be not significantly different. Furthermore, the WATERSN estimates use a time frame similar to the data entered in the online survey and had a much more recent base year than the SPARROW estimates. Therefore, WATERSN estimates were used in areas where participants did not provide loads. Due to the change in load estimate methods between the two assessments, a trend analysis was not performed.

For this assessment, the loading component is estimated as the ratio of nitrogen coming from the land (i.e., human-related) to that coming from the ocean and is given a rating of low, moderate, or high (Bricker et al. 2003; Ferreira et al. 2007). For example, a high rating means that greater than 80% of the nutrient load comes from land, whereas a low rating signifies a land-percentage of less than 20%. This rating also provides insight into loading management, since loads to systems with primarily ocean-derived nitrogen are not easily controlled. Understanding the sizes of current and expected future loads provides further insight into the application and success of management measures.

Suzanne Bricker, NOAA

NEEA participants, experts from each region or system, contribute data to the NEEA website.

Determining load using the online survey and WATERSN estimates

Load estimates, when available, were contributed by participants who either attended the national workshop, or remotely accessed the NEEA online database. The most current loading estimates were used, though the methods for calculating loads may vary. The online survey offered the option of including estimates for dissolved inorganic nutrients or total nitrogen and phosphorus, to strengthen the resulting database with all available nutrient information for each estuary.

For those systems which had no available loading information, a model was used. The model, called WATERSN (Castro et al. 2001), provided loading data for 32 systems along the Atlantic and Gulf coasts. These loading estimates were based on watershed attributes, using 1997 as a base year for data.

After being compiled, the loading estimates were used to help determine the influencing factors of each individual system and to expand the depth of the NEEA database.

DETERMINING EUTROPHIC CONDITION

How is the eutrophic condition evaluated?

Eutrophic condition ratings are determined by evaluating the occurrence, spatial coverage, and frequency (of problem levels) of each symptom in each salinity zone of an estuary. These individual symptom ratings are then synthesized in a matrix that assigns an overall rating for the system.

Symptom expressions and values

In order to evaluate symptom expressions and values, a rating system was developed to integrate information for the primary and secondary symptoms. The four steps of the process are described in Figure 2.3: (1) determining symptom expression values, (2) calculating system values, (3) assigning categories for primary and secondary symptoms, and (4) determining the overall eutrophic condition.

Determining symptom expression

The first step in determining the eutrophic condition is to calculate an expression value for each eutrophic symptom. The symptom expression value is a combination of the concentration, frequency of occurrence, and spatial coverage of problem levels of each indicator (see box at right and figure 2.4). Symptom expressions are high, moderate, low, or no problem. However, throughout the report, low and no problem are combined into a single rating of low for discussion and tabulation.

Calculating estuary system value

After the symptom expression is determined for all five symptoms and for each salinity zone, the estuary-wide values for each symptom are calculated by taking the symptom (e.g., chlorophyll *a*) values in each salinity zone and creating a combined estuary-wide value for that symptom.

Assigning categories for primary and secondary symptoms

The rating system used in the NEEA averages the primary symptoms (chlorophyll *a* and macroalgae), giving them equal weight. The resulting values are highest for estuaries with multiple primary symptoms that occur with great frequency, over large spatial areas of the estuary, and for extended periods of time. In contrast, low scores indicate estuaries that exhibit few, if any, of the primary symptoms.

Symptom expression index values

Each symptom expression index value combines the following three measurements:

The extreme concentration or problem occurrence of the symptom. For example, for chlorophyll *a*, the 90th percentile of annual chlorophyll *a* data would be used in the calculation. If, however, the symptom present is low dissolved oxygen, the 10th percentile of annual data would be used.

The frequency with which the problem occurs. For example, if the symptom occurs episodically, annually, or persistently.

The area of the system over which the symptom was observed. The calculation uses the percent of area of the estuary over which the problem levels of a symptom are observed.

Using a precautionary approach to evaluate secondary symptoms, the highest of the secondary symptom expression values is selected as representative of more serious impacts within the estuary. An average of the symptom expression values is not used because normal measurements for dissolved oxygen might, for instance, obscure high losses of SAV. In addition, the higher weight given to the secondary symptoms recognizes that these symptoms are indicative of more advanced nutrient-related impacts.

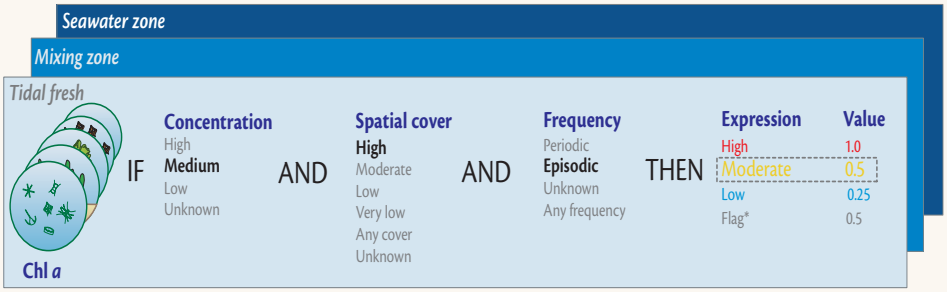
National Oceanic and Atmospheric Administration

Determining the overall eutrophic condition of an estuary allows researchers to track the water quality changes in a system such as Otter Island, South Carolina, shown here.

Figure 2.3. Determination of overall eutrophic condition.

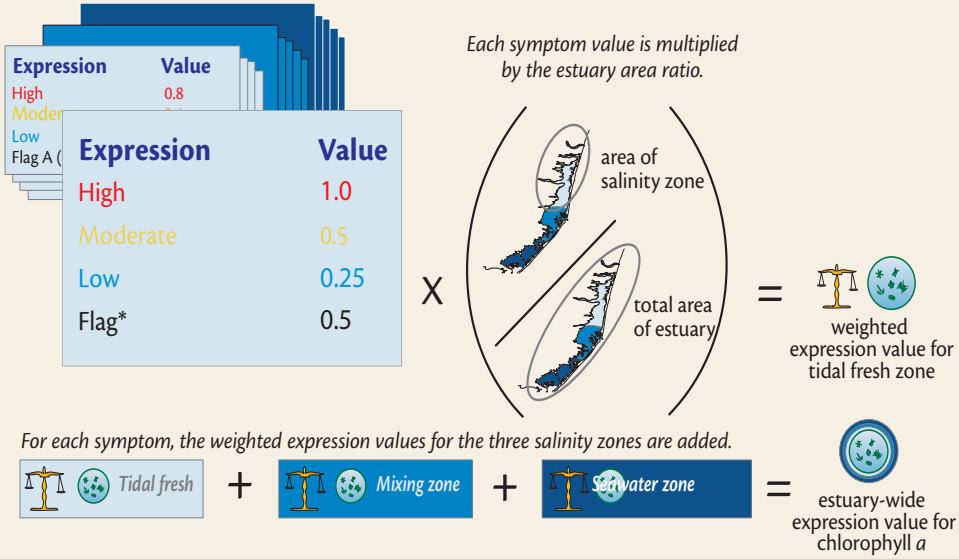
Step 1: Determine expression value for each eutrophic symptom in each salinity zone.

Eutrophic symptom expression values are determined for *each* symptom in *each* salinity zone (seawater, mixing, and tidal fresh), resulting in a total of 15 calculations. The expression is based on a set of IF, AND, THEN, decision rules that incorporate the symptom level (e.g., concentration), spatial coverage, and frequency.



Step 2: Calculate estuary-wide symptom expressions (using chlorophyll *a* as an example).

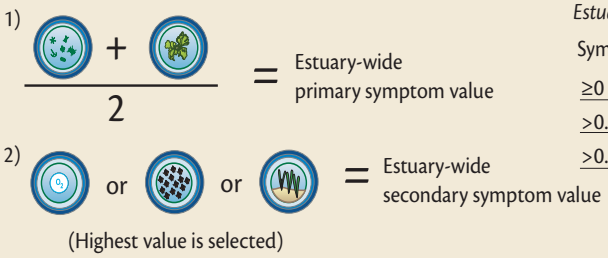
The expression values are then used to calculate estuary-wide symptom expressions for each symptom. First, each expression value is multiplied by the area of the salinity zone and divided by the entire area of the system to establish the weighted value. Then, the weighted expression values in the tidal fresh, mixing, and seawater zone for each symptom are totaled to calculate the estuary-wide symptom expression value. This process is repeated for all five eutrophic symptoms. Note that "no problem" is the rating assigned if the value is 0, but that "no problem" and low are combined for discussion and tabulation throughout the report.



Step 3: Assign categories for primary and secondary symptoms.

The average of the primary symptoms is calculated to represent the estuary-wide primary symptom value. The highest of the secondary symptom values is chosen to represent the estuary-wide secondary symptom expression value and rating. The highest value is chosen because an average might obscure the severity of a symptom if the other two have very low values (a precautionary approach).

Primary and secondary estuary-wide symptom expression values are determined in a two step process:



Estuary-wide symptom rating is determined:

Symptom expression value	Symptom rating
≥0 to ≤ 0.3	Low
>0.3 to ≤ 0.6	Medium
>0.6 to ≤ 1	High

Step 4: Determine overall eutrophic condition.

A matrix is used to combine the estuary-wide primary and secondary symptom values into an overall eutrophic condition rating according to the categories at right. Thresholds between rating categories were agreed on by the scientific advisory committee and participants from the 1999 assessment (Bricker et al. 1999).

	Low Secondary (0 – 0.3)	Moderate Secondary (0.3 – 0.6)	High Secondary (0.6 – 1.0)
High Primary (0.6 – 1.0)	Moderate	Moderate high	High
Moderate Primary (0.3 – 0.6)	Moderate low	Moderate	High
Low Primary (0 – 0.3)	Low	Moderate low	Moderate high

*Flags are used to identify components for which data were inadequate or unknown. In these cases, assumptions were made based on conservative estimates that unknown spatial coverage is at least 10% of a zone, frequency at least episodic, and duration at least days.

Determining overall eutrophic condition

To help facilitate the determination of overall eutrophic condition, the range of scores assigned to eutrophic symptoms are divided into categories of high, moderate, and low (Figure 2.3). Primary and secondary ratings are then compared in a matrix so that an overall eutrophic condition rating can be assigned to the estuaries.

Estuaries having high scores for both primary and secondary conditions are considered to have an overall high level of eutrophication (Figure 2.3). Likewise, estuaries with low primary and secondary values are assigned an overall low level of eutrophication. Estuaries with other combinations are interpreted and assigned a rating using the matrix as a guide (Figure 2.4). Those with few primary symptoms (and low numeric ratings) are considered to be relatively unaffected by nutrient-related conditions. Most estuaries show varying degrees of both primary and secondary symptoms, so that the meaning of the rating may be more difficult to determine:

South Florida Water Management District

Epiphytes, such as the ones shown here growing on submerged aquatic vegetation in Biscayne Bay, Florida, can also serve as further evidence of eutrophication.

Moderate to high primary symptoms and low secondary symptoms

Estuaries with well-developed problems associated with elevated chlorophyll *a* and/or macroalgal blooms are in the early stages of eutrophication and may be on the edge of developing more serious conditions.

Low primary symptoms and moderate to high secondary symptoms

There are a few possible interpretations for estuaries with advanced secondary symptoms but less developed primary symptoms (*see box below*).

Advanced secondary eutrophic symptoms in the absence of primary symptoms

Researchers have determined several reasons for the occurrence of secondary eutrophic symptoms in the absence of primary symptoms. For some estuaries, secondary symptoms (e.g., nuisance/toxic blooms) can be transported from offshore coastal areas rather than originating within the estuary (many North Atlantic estuaries function in this way). In addition, some blooms have no relation to nutrient conditions. As a result, this assessment provides a lower rating for blooms when it is clear that they originate offshore and are therefore not related to nutrient loads.

Alternatively, it is possible that nutrient-related water quality conditions have recently improved, but that the response time to reduce secondary symptoms is longer than for the primary symptoms. The secondary symptoms that remain may be residual conditions that also may improve as nutrient concentrations continue to decrease.

Finally, it is possible that the secondary conditions may occur without being necessarily related to nutrient enrichment. Some submerged aquatic vegetation losses in Chincoteague Bay, Maryland, for example, are related to dredging operations rather than to nutrient conditions. Also, in warmer climates, dissolved oxygen concentrations may be lower on average than cooler systems due to decreased oxygen solubility as water temperature rises.

National Oceanic and Atmospheric Administration

Nuisance/toxic blooms, such as the cyanobacterial bloom above, is a secondary symptom of eutrophication.

Figure 2.4. Descriptions of the ratings used in the NEEA update.

Symptom	Parameters	Expression: Low	Expression: Moderate	Expression: High
Chlorophyll *a* (phytoplankton) Typical high concentration (µg L^{-1}) in an annual cycle determined as the 90th percentile value.	*Spatial coverage:* High >50% Moderate 25–50% Low 10–25% Very low 0–10% *Frequency:* Episodic Periodic Persistent *Concentration:* High >20 µg L^{-1} Medium 5–20 µg L^{-1} Low 0–5 µg L^{-1}	*Low symptom expression:* *Conc.* / *Coverage* / *Frequency* low / any / any medium / mod. - v. low / episodic high / low - v. low / episodic	*Moderate symptom expression:* *Conc.* / *Coverage* / *Frequency* medium / high / episodic medium / moderate / periodic high / low - v. low / periodic high / moderate / episodic	*High symptom expression:* *Conc.* / *Coverage* / *Frequency* medium / high / periodic high / mod. - high / periodic high / high / episodic
Macroalgae Causes a detrimental impact on any natural resource.	*Frequency of problem:* Episodic (occasional/random) Periodic (seasonal, annual, predictable) Persistent (always/continuous)	No macroalgal bloom problems have been observed.	Episodic macroalgal bloom problems have been observed.	Periodic or persistent macroalgal bloom problems have been observed.
Dissolved oxygen Typical low concentration (determined as the 10th percentile value) in an annual cycle.	*Spatial coverage:* High >50% Moderate 25–50% Low 10–25% Very low 0–10% *Frequency:* Episodic Periodic Persistent *State:* Anoxia 0 mg L^{-1} Hypoxia 0–2 mg L^{-1} Biol. stress 2–5 mg L^{-1}	*Low symptom expression:* *State* / *Coverage* / *Frequency* anoxia / mod. - low / episodic anoxia / very low / periodic hypoxia / low - v. low / periodic hypoxia / moderate / episodic stress / any / episodic stress / mod. - v. low / periodic	*Moderate symptom expression:* *State* / *Coverage* / *Frequency* anoxia / high / episodic anoxia / low / periodic hypoxia / moderate / periodic hypoxia / high / episodic stress / high / periodic	*High symptom expression:* *State* / *Coverage* / *Frequency* anoxia / moderate - high / periodic hypoxia / high / periodic
Submerged aquatic vegetation A change in SAV spatial area observed since 1990.	*Magnitude of change:* High >50% Moderate 25–50% Low 10–25% Very low 0–10%	The magnitude of SAV loss is low to very low.	The magnitude of SAV loss is moderate.	The magnitude of SAV loss is high.
Nuisance/toxic blooms Causes detrimental impact on any natural resources.	*Duration:* Persistent, seasonal, months, variable, weeks, days, weeks to seasonal, weeks to months, or days to weeks *Frequency:* Episodic, periodic, or persistent	Blooms are either a) short in duration (days) and periodic in frequency; or b) moderate in duration (days to weeks) and episodic in frequency.	Blooms are either a) moderate in duration (days to weeks) and periodic in frequency; or b) long in duration (weeks to months) and episodic in frequency.	Blooms are long in duration (weeks, months, seasonal) and periodic in frequency.

*For further technical documentation of the methods, refer to Bricker et al. 1999 and Bricker et al. 2003.

Through the use of a simple model, the current framework was established to help understand the sequence, processes, and symptoms associated with nutrient enrichment. Despite its limitations, it represents an attempt to synthesize enormous volumes of data and derive a single value for eutrophication in each estuary, essentially representing a complex process in a simple way. Furthermore, modifications are in progress to improve the method (*Chapter 6: Improvements to the assessment*). With this foundation, the next step is to better understand the negative impacts on the human uses of estuaries and to provide insight for the development of a holistic approach to management with future outlook in mind.

Use impairments

In the original 1999 report, use impairments were evaluated to try to capture the cost that eutrophic symptoms impose on the human dimension of estuaries. These impacts may include, but are not limited to, recreational activities such as swimming, fishing and boating, commercial operations, and tourism. A list of possible impairments was developed from state 305b reporting requirements (see text box, top right). Expert judgment from the participants was used to evaluate local use impairments.

State 305b reporting requirements

Under section 305b, the Clean Water Act requires each state to prepare a biennial report on the health of their streams, rivers, lakes, and estuaries. These reports are reviewed by Congress to determine how far each state has progressed toward making the Nation's water bodies fishable and swimmable.

State 305b reports are submitted to the Environmental Protection Agency (EPA), which also provides reporting guidelines to the states during each reporting period. Then, the EPA compiles and summarizes the information that will be presented to Congress. These reports are an important tool because they are the main vehicle for evaluating current water quality conditions and the progress that has been made toward improving water quality nationwide.

Source: www.epa.gov/Region8/water/monitoring/

In addition to investigating use impairments, this update also includes information about living resource impairments. This additional information was collected in an attempt to link more directly the causes and manifestations of use impairments and to provide a stronger basis for the development of management plans.

Jane Hawkey, University of Maryland Center for Env. Science

Eutrophic symptoms can lead to use impairments such as restricted commercial and recreational fishing and closed waterways.

DETERMINING FUTURE OUTLOOK

How is the future outlook for an estuary evaluated?

Like influencing factors and overall eutrophic condition, the future outlook for an estuary is ultimately determined by a matrix. This matrix combines two factors:

- System susceptibility
- Predicted future loads to the system

The future outlook is designed to estimate future changes in eutrophic condition based on expected changes in nutrient inputs to a system.

Similar to influencing factors and eutrophic conditions, future outlook is determined by a matrix that combines the susceptibility of a system with expected changes in nutrient loads. Predictions of nutrient loading (categorized as increase, decrease, or no change) are based on predicted population increase, planned and/or recently implemented management actions, and expected changes in watershed use. Results from the 2004 update will show whether conditions predicted by the 1999 report have yet been realized (predictions are for year 2020).

National Oceanic and Atmospheric Administration

An American bittern in Narragansett Bay, Rhode Island. These birds are very sensitive to changes in estuarine health. Future outlook in this study attempts to project which estuaries will remain healthy enough to support such sensitive organisms.

Calculating future outlook

The analysis for future outlook is an attempt to determine whether conditions in an estuary will worsen, improve, or remain unchanged over the next 20 years.

In this analysis, expected nutrient input changes were used to predict whether eutrophic conditions will improve or worsen. The system's susceptibility to nutrients is then used to determine the magnitude of this change. Population projections are used as a primary indicator of the level of future nutrient input changes. However, population projections are unpredictable. Therefore, experts at the NEEA update workshop were asked to predict changes in nutrient load, based on their knowledge of likely changes in land use, management measures, and other activities that affect nutrient loading.

Determination of the future outlook

Susceptibility *(flushing and dilution)*	decreasing nitrogen load	no change	increasing nitrogen load
low susceptibility	Improve high Symptoms likely to improve substantially	No change Symptoms will most likely remain unchanged	Worsen low Symptoms likely to worsen only minimally
moderate susceptibility	Improve low Symptoms likely to improve	No change Symptoms will most likely remain unchanged	Worsen high Symptoms are likely to substantially worsen
high susceptibility	Improve low Symptoms likely to improve somewhat	No change Symptoms will most likely remain unchanged	Worsen high Symptoms are likely to substantially worsen

Expected future load *(nitrogen input)*

ASSESSMENT OF ESTUARINE TROPHIC STATUS (ASSETS)

How is an ASSETS rating evaluated?*

The ASSETS rating is a combination of the following three components:

- Influencing factors
- Overall eutrophic condition
- Future outlook

More information about ASSETS may be found at http://eutro.org/

In an effort to simplify the comparison of the status of systems, the last step is to combine the influencing factor, overall eutrophic condition, and future outlook components into a single overall score for each system. The ratings for influencing factors, overall eutrophic condition, and future outlook are combined in a matrix to provide an overall grade or score which may fall into one of five categories: High, good, moderate, poor, or bad. These categories are color coded following international convention and provide a scale for setting reference conditions for different types of systems (Bricker et al. 2003).

The high grade will not be assigned if the expected future outlook is for worsening conditions, but a system may be rated as good based on high or good eutrophic condition and influencing factors, even if the expectation is that it will worsen in the future. Poor and bad grades reflect a range of undesirable pressure and state conditions, even if there are management plans for recovery.

Data completeness and reliability

In order to evaluate the reliability of the assessment, a measurement of data completeness and reliability (DCR) of the dataset was calculated. This is important because the assessment uses a combination of symptom indicator data, which are derived from a variety of sources and levels of certainty. Additionally, data for all indicators were not available for all systems. The robustness of the assessment is affected by missing data (e.g., spatially or temporally limited), and data that are judged to be based upon speculative inference.

The DCR is defined as the percent of the total estuarine area for which data are considered highly certain for all or most indicators. A DCR rating is made for each of the five symptom variables, incorporating scores for both completeness (whether data is entered for symptoms [e.g., concentration] and symptom characteristics [e.g., spatial coverage, frequency]), and the level of confidence of data used for the assessment. The symptom DCR values are averaged for an overall eutrophic condition DCR rating. A score of 76–100%, or high DCR, means that there are complete data of high certainty for the majority of the estuary. A system with moderate DCR has complete, high certainty data in 51–75% of its area and a low DCR means that there are complete, high certainty data in 50% of the system or less.

National Oceanic and Atmospheric Administration

Participants at the National Estuarine Eutrophication Assessment Update workshop held in Maryland in May 2006.