

Chapter 4.4

Development of a Water Quality Index for the Maryland Coastal Bays

Tim Carruthers¹ and Catherine Wazniak²

¹Integration and Application Network, University of Maryland Center for Environmental Science, Cambridge, MD 21613

²Maryland Department of Natural Resources, Tidewater Ecosystem Assessment, Annapolis, MD 21401

Abstract

The Water Quality Index synthesizes the status of the four water quality indicators; chlorophyll *a* (algae: Chl *a*), total nitrogen (TN), total phosphorus (TP), and dissolved oxygen (DO) into a single indicator of water quality. This indicator is similar to the Dow Jones Index, which compiles information on multiple stocks and provides a simple number to track over time. The Water Quality Index compares measured variables to values known to maintain fisheries (DO) and submerged aquatic grasses (Chl *a*, TN, and TP). The Index joins these together into one number between zero and one. A score of one indicates habitat suitable for fish and aquatic grass survival, while a value of zero indicates unsuitable habitat for either fish or aquatic grasses. Intermediate values indicate the system is variable and that some ecosystem functions (grass beds or fish) may be expected to be present some of the time. Currently, the tributaries generally show poor to very degraded water quality largely due to high nutrient inputs, while the open bays have good to excellent water quality.

Introduction

The Water Quality Index was designed to synthesize the status of chlorophyll *a*, total nitrogen, total phosphorus and dissolved oxygen into a single parameter. Three year median values of these variables (see previous water quality chapters) are compared to criteria based on ecosystem function, such as maintaining fisheries (DO threshold) and maintaining submerged aquatic grasses (Chl *a*, TN and TP threshold). The Index is unitless and is scaled between zero and one, such that a WQI of one indicates habitat suitable for fish and aquatic grass survival, while a value of zero indicates relatively unsuitable habitat for either fish or aquatic grasses. Intermediate values indicate a system in flux, where it might be expected that some ecosystem functions (grass beds or fish) may be present some of the time. This approach of summarizing compliance of water quality variables with threshold values has previously been carried out to compare US mid-Atlantic estuaries as well as tributaries within the Chesapeake Bay (Kiddon et al., 2003; Jones *et al.*, 2003).

Management Objective: Maintain suitable fisheries and seagrass habitat.

Draft Indicator: Water quality Index >0.6

Data Analyses

For the 64 sampling sites with at least 10 records for all variables between 2001 and 2003, median values for each variable were calculated. Median values were then compared to established threshold values (Table 4.4.1) and scored as one (meets criteria) or zero (fails to meet criteria). These scores were summed for all four variables and divided by the number of variables to result in an index value ranging from zero to one for each sampling location. An index value of zero indicated that a site met none of the habitat suitability criteria, while a score of one indicated a site that met all habitat suitability criteria. Once an index value had been calculated for each site, the index value for all sites within several reporting regions were averaged and these values are presented by measured variable (Table 4.4.1) and combined regional index values (Table 4.4.3). Standard error associated with mean index values in these cases represents spatial variation between sites, within a reporting region and does not include temporal variability.

Table 4.4.1: Variables and threshold values used in the calculation of the Water Quality index for Maryland Coastal Bays (1: Dennison et al. 1993; 2: Stevenson et al. 1993; 3: Anonymous 2000, 4: Stevenson et al. 1993).

Variable	Threshold value	Reference
WQI		
Chl a	< 15 $\mu\text{g L}^{-1}$	1, 2
Total nitrogen	< 0.65 mg L^{-1} (46 μM)	4
Total phosphorus	< 0.037 mg L^{-1} (1.2 μM)	4
Dissolved oxygen	> 5 mg L^{-1}	3

Results

Status of the Water Quality Index

Water quality index values in upstream stations that show a better rating than downstream were due to lower chlorophyll values in these areas (above chlorophyll max for stream, not really improved water quality in these areas).

Assawoman Bay

Within Assawoman Bay, four sites were degraded and another two sites had poor water quality condition (Figure 4.4.1). This is largely due to high nutrient inputs as no sites passed TN or TP thresholds, while currently, all sites passed DO threshold (Table 4.4.2).

St. Martin River

Two sites in St. Martin River were very degraded, five degraded, and the remaining six sites had poor water quality (Figure 4.4.1). All sites failed TN and TP thresholds suggesting that high nutrient loading to these regions is reducing water quality. Broader impacts of these nutrients are becoming evident in this region, with half the sites failing chlorophyll thresholds and the two very degraded sites also failing to meet the DO threshold (Table 4.4.2). There is a slight improvement from degraded to poor water quality upstream. This was largely driven by lower chlorophyll values upstream, resulting from the lower salinity as these upstream sites had some of the highest nutrient concentrations (Table 4.4.2).

Isle of Wight Bay

Within the Isle of Wight region, a clear distinction occurred between open bay sites and tributary sites. The three open bay sites all had good water quality; while three tributary sites had poor and two (Manklin and Turville Creeks) had degraded water quality conditions (Figure 4.4.1). No sites passed the TP threshold and while the three open bay sites passed the TN threshold, all tributary sites exceeded the TN threshold (Table 4.4.2).

Sinepuxent Bay

Overall Sinepuxent Bay had good water quality (Figure 26). All stations passed the thresholds for chlorophyll, DO and TN. The slightly reduced water quality in the north resulted from failure to meet the TP threshold in these three sites (Table 4.4.2, Figure 4.4.1).

Newport Bay

Most sites in Newport Bay were degraded or very degraded, while one lower bay site had excellent condition (Figure 4.4.1). Only the southern bay sites passed TN or TP thresholds and half of all sites failed the chlorophyll threshold (Table 4.4.2). Upper tributary sites categorized as poor, instead of degraded, generally due to chlorophyll and/or oxygen meeting criteria (chlorophyll not always applicable and DO may be saturated in headwaters).

Chincoteague Bay

Mainstem sites in northern Chincoteague Bay (public landing and north) had poor water quality (due to nutrients), while other sites had good to excellent water quality (Figure 4.4.1). Northern Chincoteague failed TN and TP thresholds but many sites in the southern region of Chincoteague also failed to meet the TP threshold (Table 4.4.2). All sites passed chlorophyll and DO thresholds.

Table 4.4.2: Breakdown of WQI variables by region (mean_(se))

Bay Segment	Chl	TN	TP	DO
Assawoman	0.33 _(0.21)	0.00 _(0.00)	0.00 _(0.00)	1.00 _(0.00)
St. Martin	0.46 _(0.14)	0.00 _(0.00)	0.00 _(0.00)	0.85 _(0.10)
Isle of Wight	0.89 _(0.11)	0.33 _(0.17)	0.00 _(0.00)	0.89 _(0.11)
Sinepuxent	1.00 _(0.00)	1.00 _(0.00)	0.40 _(0.24)	1.00 _(0.00)
Newport	0.43 _(0.14)	0.14 _(0.10)	0.14 _(0.10)	0.86 _(0.10)
Nth Chincoteague	1.00 _(0.00)	0.33 _(0.21)	0.17 _(0.17)	1.00 _(0.00)
Sth Chincoteague	1.00 _(0.00)	1.00 _(0.00)	0.27 _(0.14)	1.00 _(0.00)

NB: (0: all sites failed to meet threshold, 1: all sites met threshold)

Summary

Overall, the Coastal Bays show generally poor or degraded water quality in or close to tributaries and good or excellent water quality in well-flushed open bay regions. Sinepuxent and south Chincoteague exhibited excellent water quality, north Chincoteague had good water quality, Isle of Wight had poor water quality, and Assawoman, St Martin and Newport all displayed degraded water quality (Table 4.4.3; Figure 4.4.2). Variations in water quality between regions reflects variation in nutrient concentrations, however many sites throughout the system display effects of high phytoplankton and reduced dissolved oxygen. This has implications for aquatic communities, suggesting that many regions within the Coastal Bays do not provide suitable habitat for submerged grasses and/or fish.

Table 4.4.3: Summary of Water Quality Index by Region

Region	n (sites)	WQI _(se)	Health
Assawoman	6	0.33 _(0.05)	Degraded
St Martin	13	0.33 _(0.05)	Degraded
Isle of Wight	9	0.53 _(0.07)	Poor
Sinepuxent	5	0.85 _(0.06)	Excellent
Newport	14	0.39 _(0.08)	Degraded
Nth Chincoteague	6	0.63 _(0.09)	Good
Sth Chincoteague	11	0.82 _(0.04)	Excellent

References

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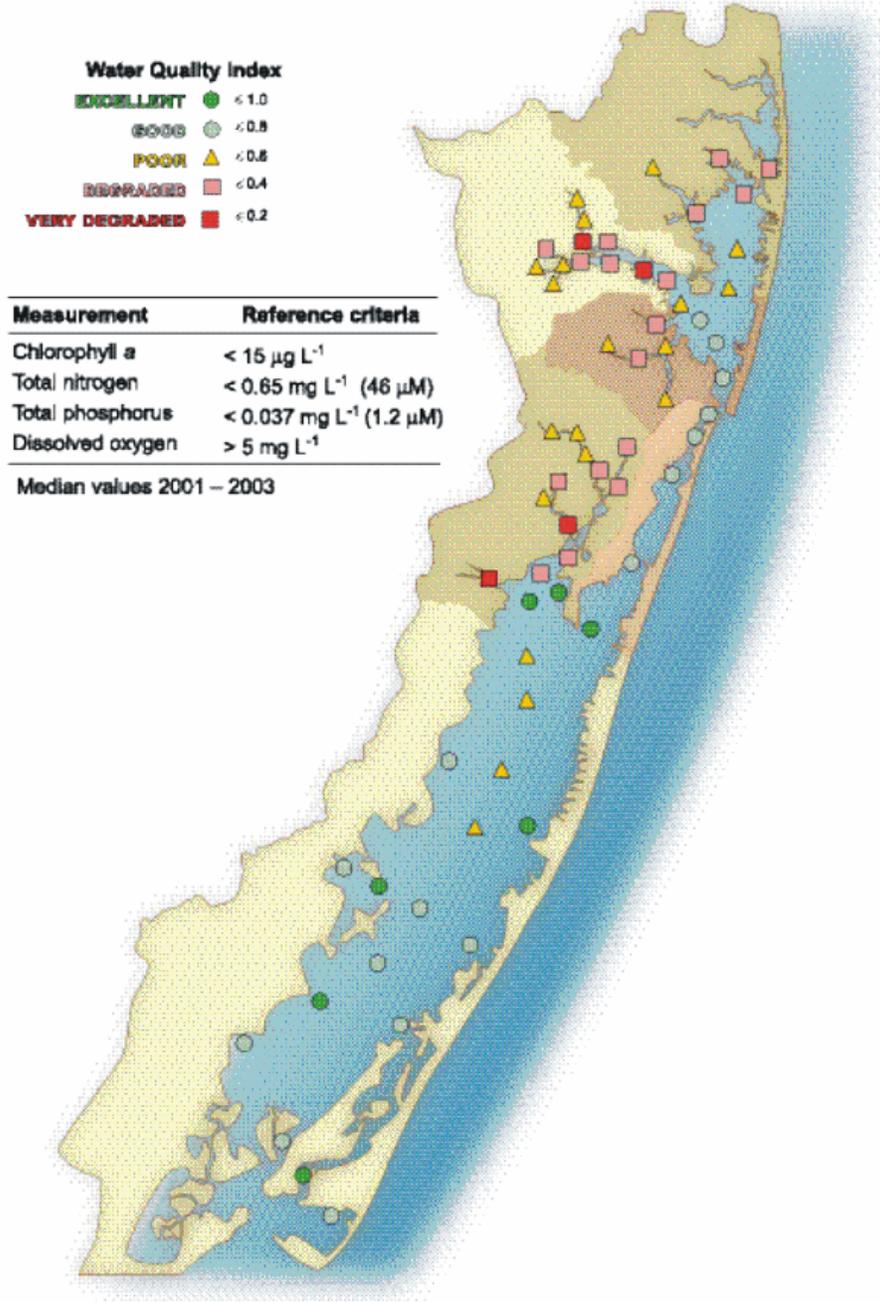


Figure 4.4.1: Water Quality Index values for all fixed sampling stations based on amalgamated median indicator values.

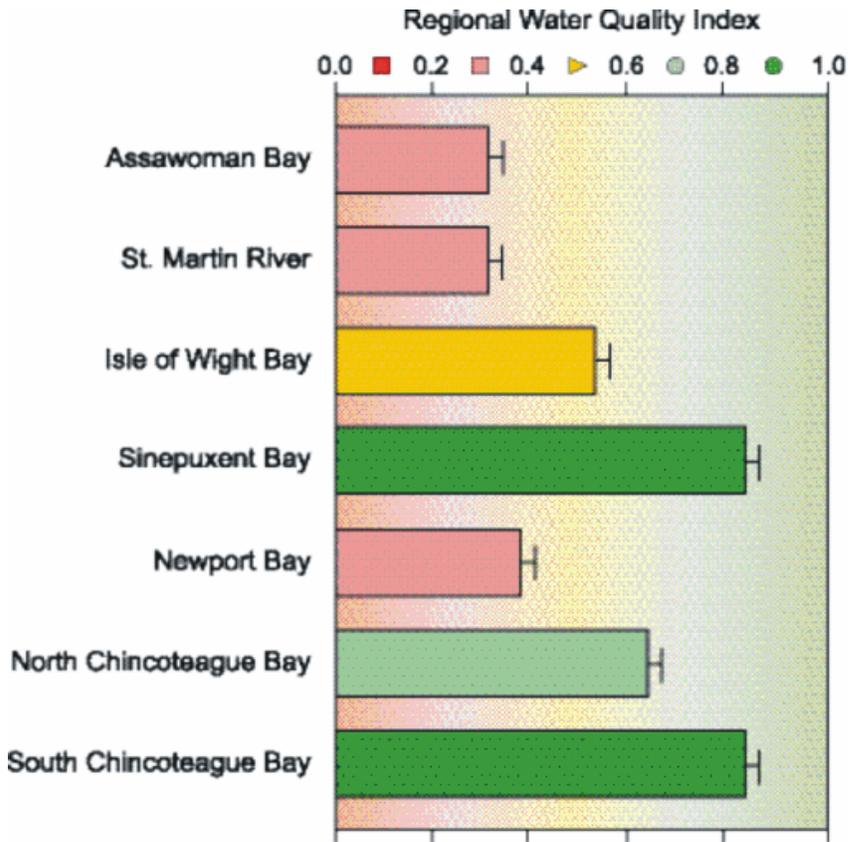


Figure 4.4.2: Overall Water Quality Index values for each of the Coastal Bays.