Chapter 4.1

Nutrient status and trends in the Maryland Coastal Bays

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Abstract

Total nitrogen (TN) and total phosphorus (TP) concentration data from the 2001 through 2003 Coastal Bays water quality monitoring program (Maryland Department of Natural Resources and Assateague Island National Seashore) were analyzed for status. TN and TP concentration data from Assateague Island National Seashore only were analyzed for trends (DNR data sets were not of long enough duration). Results indicated that the upper tributaries, mostly in the northern Coastal Bays, and Newport Bay were severely enriched with nitrogen. The southern Coastal Bays, Sinepuxent and Chincoteague, had the lowest TN concentrations. Phosphorus enrichment appeared to be more widespread. The only segments demonstrating phosphorus levels suitable for seagrass growth were Sinepuxent and Chincoteague Bays.

Introduction

Nutrient over-enrichment is a major threat to the Coastal Bays. Nutrients can enter the water column from a wide range of point and non-point sources. However, nutrient inputs are often sporadic or ephemeral, as when a storm event causes large amounts of run-off. Non-point nutrient inputs are the major sources of nutrients, nitrogen and phosphorus, to the Coastal Bays. Point sources are estimated to account for only 4% of the total nutrient inputs (Boynton 1993). Non-point sources include agriculture (fertilizer and animal waste), atmospheric deposition, septic systems, and natural sources (wetlands, marshes, and forests). Total nitrogen (TN) and total phosphorus (TP) were used as indicators to reduce variability associated when measuring dissolved nutrients only.

Nutrient concentrations can be affected by inputs from a sewage treatment plant, agricultural run-off, and atmospheric deposition, the latter of which brings in nutrients from outside the watershed.

Data Sets

Several water quality monitoring programs were implemented in the Coastal Bays (see Chapter 1.1). Those conducted by the Maryland Department of Natural Resources (DNR) and the National Park Service at Assateague Island National Seashore (ASIS) were used for nutrient analysis in this report (the Maryland Coastal Bays Program volunteer monitors did not collect TN or TP data). Figure 4.1.1 shows the locations of

each DNR and ASIS station monitored between 2001 and 2003. A full list of nutrient parameters monitored by ASIS and DNR is reported in the Maryland Coastal Bays Program Eutrophication Monitoring Plan (Wazniak 1999).

Management Objective: To reduce bay water concentrations of nitrogen and phosphorus.

Nitrogen Indicators: TN = 0.65 mg/L seagrass health
TN = 1.0 mg/L eutrophic

Phosphorus Indicators: TP = 0.037 mg/L seagrass health
TP = 0.1 mg/L eutrophic

Analyses

Status

Median concentrations of TN and TP were determined for the three-year period between 2001-2003 for each monitoring station (Figure 4.1.1). The Maryland Coastal Bays Scientific and Technical Advisory Committee (STAC) developed criteria for threshold categories based on living resources indicators, most notably seagrass (see under Management Objective above). Based on these criteria, threshold categories were determined (Table 4.1.1). Each median value was compared to each cutoff value from Table 4.1.1 by non-parametric Wilcoxon test. Those medians that were significantly different at p=0.01 from the two cutoffs between which they fell were considered statistically significant overall.

Table 4.1.1: Threshold category values for TN and TP in the Maryland Coastal Bays. Upper cutoff values are shown; lower cutoff values are the values from the previous category, forming category bounds for hypothesis testing. Bolded values are living resources indicator values as suggested by STAC.

Threshold criteria category	TN cutoff values for threshold category	TP cutoff values for threshold category
Better than seagrass objective	< 0.55 mg/L	< 0.025 mg/L
Meets seagrass objective	**< 0.64 mg/L**	**< 0.037 mg/L**
Does not meet seagrass objective	**< 1 mg/L**	< 0.043 mg/L
Does not meet STAC objectives	< 2 mg/L	**< 0.1 mg/L**
Does not meet any objectives	> 2 mg/L	> 0.1 mg/L

Trends

Trend analyses were utilized to compare the effect of time on water quality parameters. Only ASIS stations were used because DNR stations did not have a long enough data record for a robust trend analysis and MCBP stations were not analyzed for TN or TP. The Seasonal Kendall test was used to identify trends, and Sen's slope estimator was used to estimate the magnitude of change over time when a significant trend was present (Ebersole et al. 2002, Hirsch et al. 1982; Van Belle and Hughes 1984). For all trend tests, a significance level of 0.01 was used to reduce the chance of type I error.

Status of nutrient concentrations

The status of TN and TP concentrations in each Coastal Bays segment are discussed below. Please refer to Figure 4.1.1 for individual stations mentioned in the text.

Assawoman Bay

None of the seven stations met TN or TP seagrass thresholds. One station at the headwaters of Grey's Creek (GET0005) did not meet the STAC TN threshold and was classified as eutrophic (Figures 4.1.2 and 4.1.3).

St. Martin River

None of the eleven stations met TN or TP seagrass thresholds. Most stations did not meet the STAC TN or TP thresholds and were classified as eutrophic (Figures 4.1.2 and 4.1.3).

Isle of Wight Bay

Stations in the open bay met the TN seagrass threshold. Five stations on Manklin, Turville, and Herring Creeks (MKL0010, TUV0034, TUV0019, TUV0011, and HEC0012) failed the TN seagrass threshold (Figure 4.1.2). No stations were located in the seagrass beds behind Ocean City.

No station met the TP seagrass threshold; one station at the headwater of Turville Creek (TUV0034) did not meet the STAC TP threshold and was considered eutrophic (Figure 4.1.3).

Sinepuxent Bay

All five stations were below the TN seagrass threshold (Figure 4.1.2).

Three stations in the northern part of the bay were above the TP seagrass thresholds, while the two southern stations (ASIS 2 and ASIS 16) met the TP seagrass threshold (Figure 4.1.3).

Newport Bay

All twelve stations except one in the lower bay (ASIS 3) were above the TN seagrass threshold. Trappe, Ayers, Marshall, and upper Newport Creeks (KIT0015, BOB0001, TRC0059, TRC0043, AYR0017, and BMC0011) failed the STAC TN threshold and were classified as eutrophic (Figure 4.1.2).

All stations except one in the lower bay (ASIS 3) were above TP seagrass thresholds. Four stations on Trappe Creek (TRC0043, TRC0059, BOB0001, and KIT0015) failed the STAC TP threshold and were classified as eutrophic (Figure 4.1.3).

Chincoteague Bay

Four northern mainstem stations (XCM1562, XCM0159, XBM5932, and XBM8149) did not meet TN seagrass thresholds, while the other 13 stations on the eastern side of the Bay (behind Assateague) and the Virginia portion of the Bay met TN seagrass thresholds (Figure 4.1.2).

Four stations (ASIS 6, 9, 12, and 14) met the TP seagrass threshold. Mainstem and western shore stations (except ASIS 9 and 14) did not meet TP seagrass thresholds, while Public Landing (ASIS 5), Johnson Bay (ASIS 7), and the site north of Chincoteague Island (ASIS 8) had the highest TP concentrations (Figure 4.1.3).

Trends in nutrient concentration

Overall, there were few significant trends at the ASIS stations in Sinepuxent, Newport, and Chincoteague Bays since sampling began in 1987 (1991 at ASIS stations 4,7,8,12, and 13) (Table 4.1.2). No ASIS stations were present in Isle of Wight Bay, the St. Martin River, or Assawoman Bay. The results of trend analyses are shown in Figures 4.1.4, 4.1.5, and 4.1.6. Descriptions of results by embayment follow (refer to Figure 4.1.1. for stations mentioned in the text):

Table 4.1.2: Medians, Sen slopes, and percentage change (slope as percentage of median by year) for indicators with significant trends. TN and TP medians were recorded in µM concentrations here, but were converted to mg/L for status analysis. Negative slopes indicate an improving trend; positive slopes indicate a declining trend. The algorithm for percent change is: ((slope*n years)/median)*100 (Ebersole et al. 2002).

Station	Segment	Indicator	Median	Slope	N Years	Percent Change
ASIS 2	Sinepuxent	TN	23	-0.918	16	-64
ASIS 2	Sinepuxent	TP	1.33	-0.0602	16	-72
ASIS 3	Newport	TP	1.975	-0.0632	16	-51
ASIS 4	Newport	TP	2.36	-0.078	13	-43
ASIS 5	Chincoteague	TP	1.725	-0.0482	16	-45
ASIS 6	Chincoteague	TP	1.57	-0.0482	16	-49
ASIS 7	Chincoteague	TN	37.15	1.5066	13	53
ASIS 7	Chincoteague	TP	1.645	0.04	13	32
ASIS 8	Chincoteague	TP	1.135	0.0784	13	90
ASIS 12	Chincoteague	TP	1.33	-0.0241	13	-24
ASIS 13	Chincoteague	TP	1.345	-0.0349	13	-34
ASIS 16	Chincoteague	TP	1.35	-0.0468	16	-56
ASIS 18	Chincoteague	TP	1.39	-0.0301	16	-35

Sinepuxent Bay

Improving trends were found at both stations in the southern part of this bay (ASIS 2 and ASIS 16). In the mid-portions of the bay, in the vicinity of the Route 611 Bridge only, TN concentrations exhibited no trend (ASIS 18). No significant trends were found in the northern part of Sinepuxent Bay (ASIS 1 and ASIS 17).

Newport Bay

Both stations in Newport Bay showed significantly improving trends in TP concentration (ASIS 3 and ASIS 4).

Chincoteague Bay

The most noticeable trends in Chincoteague Bay were found in Johnson Bay (ASIS 7). Here both nutrient indicators were significantly degrading. TP was also degrading at Wildcat Point in Virginia north of Chincoteague Island (ASIS 8). On the other hand, TP was significantly improving in the central stations of Chincoteague Bay (ASIS 5 and ASIS 6).

Summary

Upper tributaries of the St. Martin River, Assawoman Bay, Newport Bay, and Isle of Wight Bay were found to be severely nutrient enriched. The mainstem St. Martin River, northern Assawoman Bay and tributaries, and Herring Creek (HEC0012) were also highly enriched. Sinepuxent Bay, southern Chincoteague Bay, and open Isle of Wight Bay had the lowest TN concentrations. Phosphorus enrichment appeared to be more widespread with few stations in the Coastal Bays meeting the seagrass threshold for TP.

Many areas failed seagrass thresholds for TN and TP. One possible explanation is the use of median concentrations based on annual TN and TP and not on seagrass growing season. Another explanation may be that the Coastal Bays system is known to have high dissolved organic nutrients. Higher TN and TP concentrations may result from this, especially when compared to the Choptank River in the Chesapeake Bay system where thresholds were developed (Stevenson et al. 1993). However, studies have shown that TN and TP may be better than dissolved inorganic nutrients as indicators of relative nutrient availability in systems known to have high organic inputs (Glibert et al. 2001). Further research on the applicability of seagrass thresholds in the Coastal Bays is recommended.

Another concern is the route that nutrients take to enter the Coastal Bays. If nutrients are delivered via direct groundwater upwelling, which may be occurring in some areas of the bays (Dillow et al. 2002), they may be sequestered by benthic micro- and macroalgae or macroscopic plant material (e.g., seagrasses) and never enter the sampled water column. Therefore, nutrient concentrations derived from routine water column samples may underestimate the quantity of nutrient entering the Coastal Bays. The relationships between nutrient loading pathways and subsequent biological uptake warrant further study.

Improving trends in nutrients indicators are a good sign. However, Chincoteague Bay, initially thought to be the least impacted of the embayments, had some disturbing status and trend indicators. Degrading TP trends occurred in Johnson Bay (ASIS 7) and Wildcat Point (ASIS 8), and a degrading TN trend was also found in Johnson Bay. These degrading trends should be further investigated.

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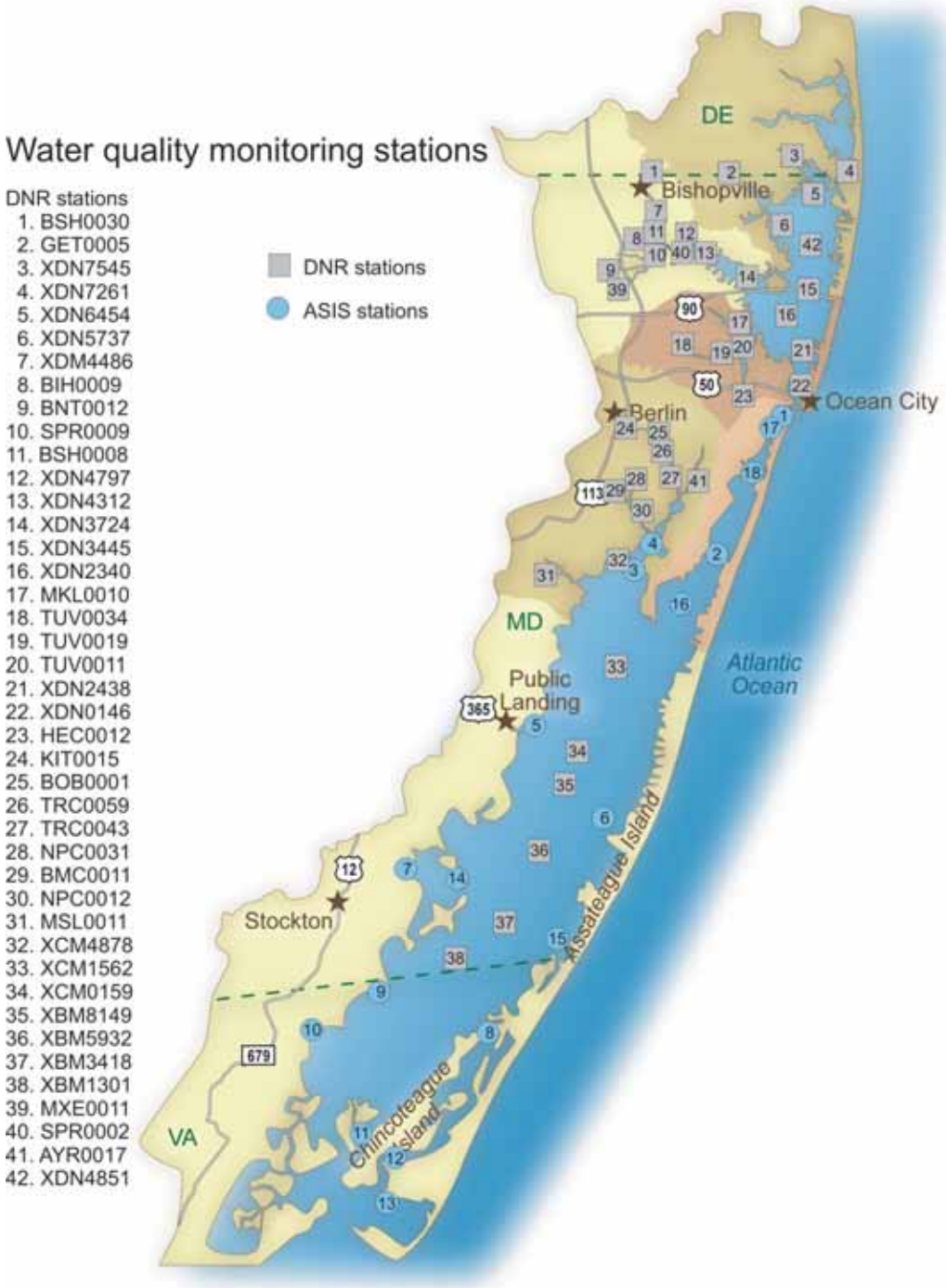

Figure 4.1.1: Map showing water quality monitoring stations for both Maryland Department of Natural Resources (DNR) and the National Park Service, Assateague Island National Seashore (ASIS). DNR stations are listed by DNR code; ASIS stations are referred to as ASIS and the station number (for example, ASIS 1).

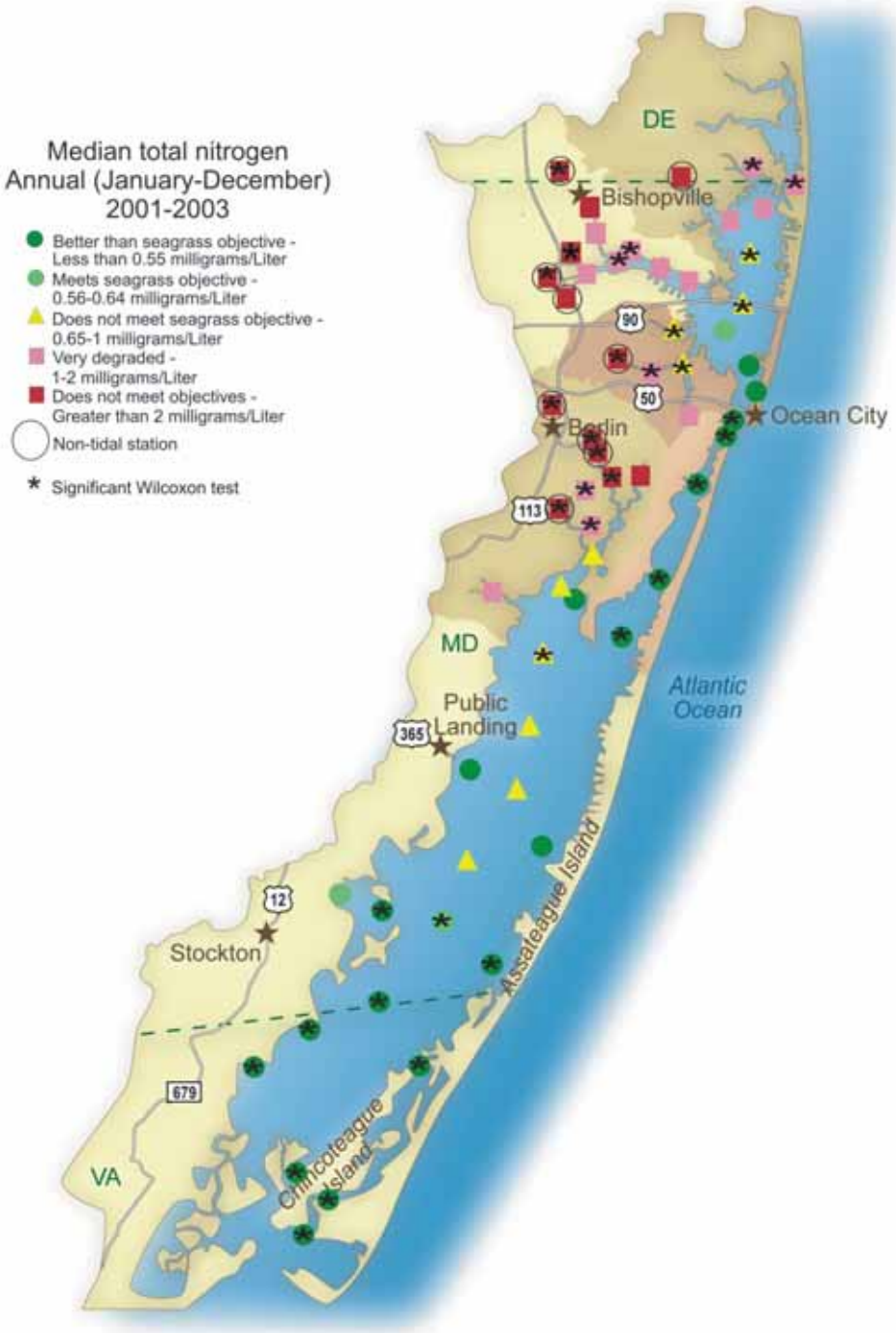

Figure 4.1.2: Median concentrations of total nitrogen in Coastal Bays fixed monitoring stations between 2001 and 2003. Circled stations are non-tidal. Status categories are based on threshold values described in the text.

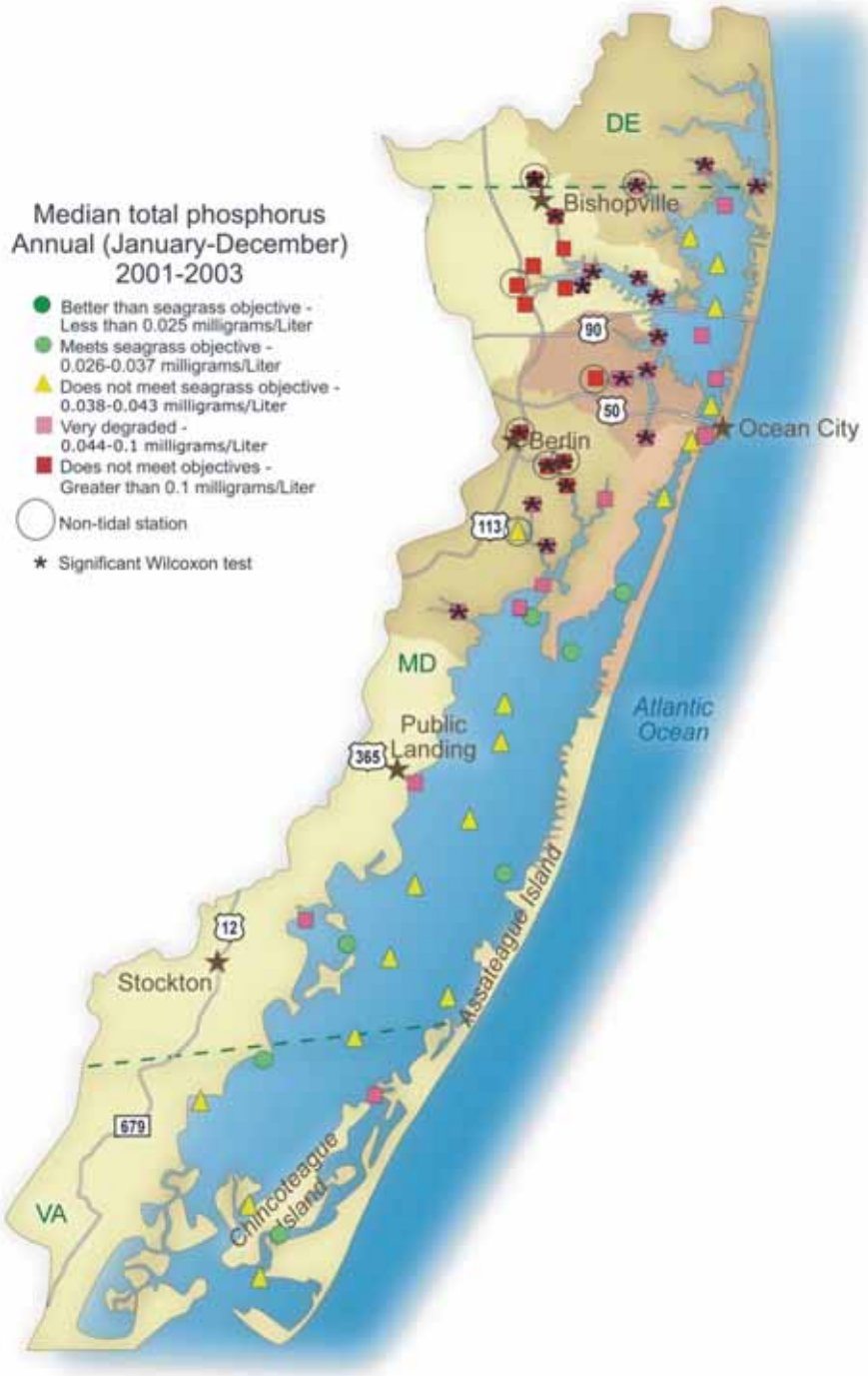

Figure 4.1.3: Median concentrations of total phosphorus in Coastal Bays fixed monitoring stations between 2001 and 2003. Circled stations are non-tidal. Status categories are based on threshold values described in the text.

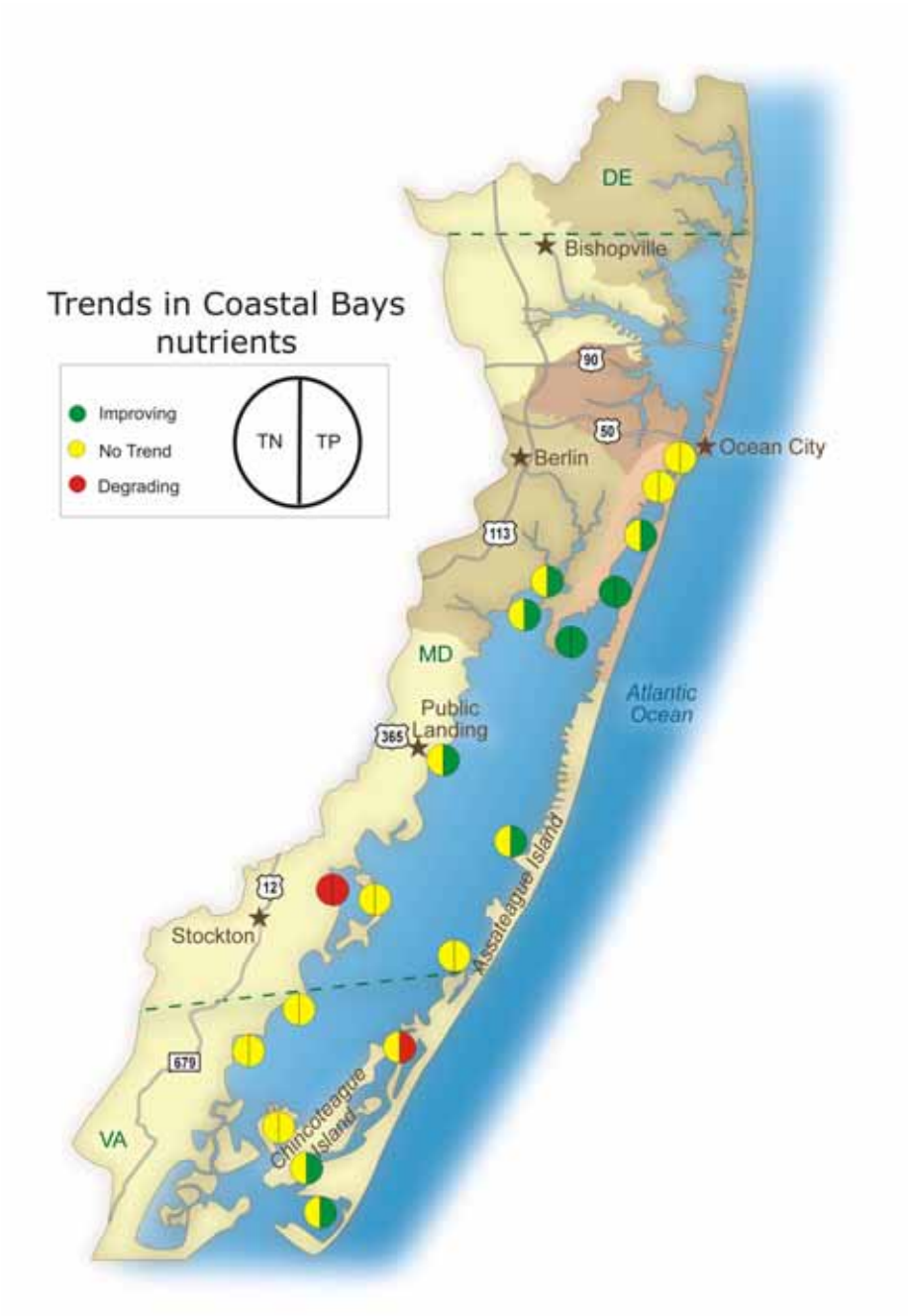

Figure 4.1.4: Nutrient trend analysis of southern Coastal Bays National Park Service fixed water monitoring stations. Trends were based on between 12 and 16 years of data, depending on the station. Significance in trends was calculated using the seasonal Kendall's tau statistic, and directionality (improving or degrading) condition for significant trends was determined by linear regression ($p = 0.01$).

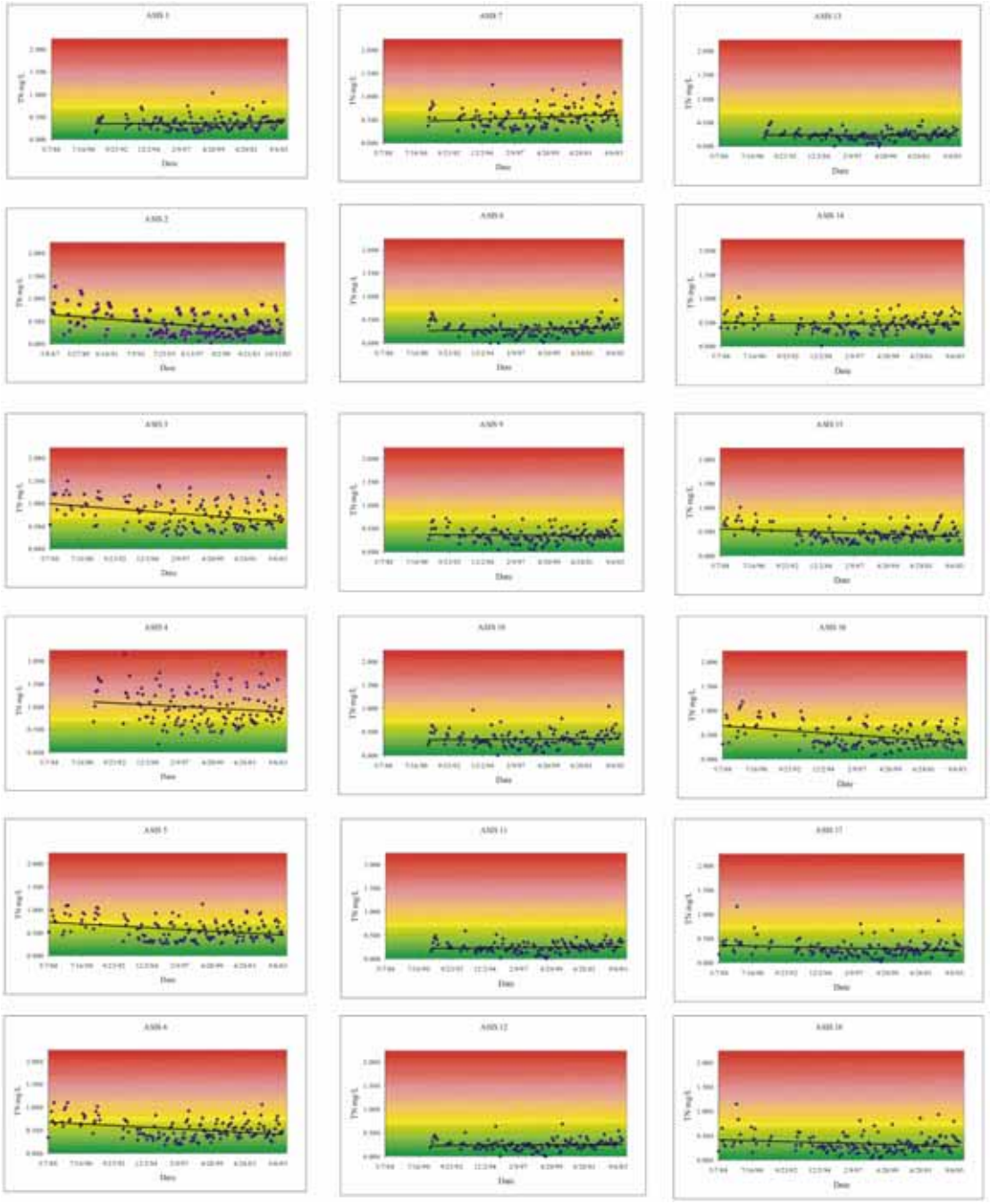

Figure 4.1.5: Total nitrogen trend analysis at ASIS stations. Trend lines indicate directionality; underlying colors indicate status threshold categories (see Figure 4.1.2). Data are monthly medians and are uncensored. Stations 2 and 16 had significant improving trends (decreasing total nitrogen concentration); station 7 had a significantly degrading trend (increasing total nitrogen concentration), despite values remaining mostly within acceptable status threshold levels. Significance was based on the seasonal Kendall tau test (see text).

Figure 4.1.6: Total phosphorus trend analysis at ASIS stations. Trend lines indicate directionality; underlying colors indicate status threshold categories (see Figure 4.1.3). Data are monthly medians and are uncensored. Stations 2, 3, 4, 5, 6, 12, 13, 16, and 18 had significant improving trends (decreasing total phosphorus concentration); stations 7 and 8 had significantly degrading trends (increasing total phosphorus concentration). Significance was based on the seasonal Kendall tau test (see text).