Chapter 4.2

Status and trends of phytoplankton abundance in the Maryland Coastal Bays

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Abstract

Planktonic algae are important in coastal ecosystems as producers and, subsequently, as food sources for fish and shellfish. However, high concentrations of planktonic algae can lead to a reduction in water clarity and dissolved oxygen, creating unsuitable conditions for living resources (fish, shellfish, and seagrasses). Planktonic algae were monitored in the Coastal Bays by measuring water column chlorophyll concentrations using fixed station and continuous monitors, as well as intensive spatial mapping. Phytoplankton abundance in the Isle of Wight, Sinepuxent, and Chincoteague Bays were generally low enough to allow for seagrass growth. The St. Martin River and most of Newport Bay demonstrated high chlorophyll levels and failed the thresholds established for seagrass growth. Despite many inshore and river areas failing nutrient thresholds, water column chlorophyll levels were generally low in the open bays but high in those tributaries.

Introduction

Phytoplankton is an important food source to many living resources (shellfish and fish) in the Coastal Bays. However, large algae blooms in the water column can lead to oxygen depletion. High levels of water column algae can also limit the amount of light available to seagrasses.

The concentration of chlorophyll, the green pigment in planktonic algae, is often used to represent the amount of planktonic algae in the water column. Planktonic algae levels are affected by a number of factors including temperature, light, nutrient levels, and grazing by zooplankton and shellfish. Reducing the amount of nutrients entering the bays is expected to reduce chlorophyll levels and improve water clarity and oxygen levels.

Data Sets

A wealth of information is available on phytoplankton abundance through monthly monitoring of water column chlorophyll *a* at fixed stations. The National Park Service at Assateague Island National Seashore (ASIS) conducted monthly chlorophyll *a* monitoring at 18 fixed stations in the southern bays since 1987. The Maryland

Department of Natural Resources (DNR) monitored chlorophyll *a* monthly at 28 fixed sites in the St. Martin River and Newport Bay since 1998 and 17 fixed sites in Assawoman, Isle of Wight, and Chincoteague Bays since 2001. The Maryland Coastal Bays Program (MCBP) implemented a volunteer water quality monitoring program in 1997 and monitors approximately 24 fixed stations. Chlorophyll *a*, along with several other indicators, was measured during this sampling. Samples from these stations were sent to laboratories at the Maryland Department of Health and Mental Hygiene (DNR) or the University of Maryland (ASIS and MCBP) for extractive spectroscopic analysis of chlorophyll *a* concentration.

While monthly sample collections provide important information on patterns of water quality variation, they can often miss events occurring on smaller time scales or during times of the day or year when it is impractical to deploy field personnel. Monthly sampling cannot provide data on the duration of poor water quality events. In order to assess these smaller time scales, DNR has installed two continuous monitors in the northern Coastal Bays (Figure 4.2.1). These monitors measure a suite of water quality parameters every 15 minutes and telemeter the data to a website for near real-time viewing (Maryland Department of Natural Resources 2004). Continuous monitoring data allows scientists to learn more about the ecosystem by tracking daily fluctuations in chlorophyll and linking them to real-time events, such as fish kills or harmful algae blooms. Continuous monitors estimated total chlorophyll *in situ* using a built-in fluorometer. This method cannot discern chlorophyll *a* concentrations, but this is typically the dominant form found in surface water samples. In addition, ASIS conducted temporally intensive surveys in 2003. Field personnel collected chlorophyll samples for extractive laboratory analysis every three hours during three separate ten-day periods in Newport and Chincoteague Bays.

Additionally, DNR, in conjunction with the University of Maryland Center for Environmental Science (UMCES), implemented spatial monitoring between 1999 and 2001 (In-Vitro Fluorescence, IVF) and Water Quality Mapping (DataFlow) in 2003. These methods were employed to provide a more comprehensive spatial analysis of microalgal distribution than can be collected through fixed-station monitoring. Briefly, DataFlow monitoring involved a field crew in a small outboard boat equipped with specialized sensors. These sensors recorded water quality data, including total chlorophyll estimates via fluorometer, on a suite of indicators every three to five seconds as the boat moved along a prescribed track. GPS coordinates were also recorded for each measurement. The paired water quality/GPS data were then used to interpolate chlorophyll concentrations over the entire surface area of the bays. Crews collected data bi-monthly from April through October in all bay segments, though Chincoteague Bay was only partially sampled and was not included in this analysis. Like continuous monitoring, DataFlow instrumentation could only record total chlorophyll concentrations.

Management Objective: Maintain suitable fisheries habitat.

Algae Indicator 1: 50 µg/L for dissolved oxygen effects
Algae Indicator 2: 15 µg/L for effects on seagrasses

Analyses

Fixed stations: A median chlorophyll *a* concentration was determined for the seagrass growing season (March - November) for the three-year period from 2001-2003 for each fixed station monitoring station (Figure 4.2.1). The Maryland Coastal Bays Scientific and Technical Advisory Committee (STAC) developed criteria for threshold categories based on living resources indicators (see under Management Objective above). Based on these criteria, threshold categories were determined (Table 4.2.1). Each median value was compared to each cutoff value from Table 4.2.1 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.

Continuous monitoring: Frequency of threshold failure was determined using temporally intensive continuous monitoring data from 2002 and 2003 (Table 4.2.2). Continuous monitoring data were compared to monthly and biweekly lab data (Tables 4.2.4 and 4.2.5).

Spatial Data: DNR/UMCES water quality mapping median concentration of interpolated chlorophyll data. Intense spatial data were also collected for the National Coastal Assessment during 2002 and 2003. GIS- interpolated water quality maps were created using the bi-monthly DataFlow data from 2003. The 15 µg/L threshold was used to assess whether the area met or did not meet conditions for seagrass growth. Comparison of the maps from each sample date showed the movement of algal bloom events in each bay segment (except Chincoteague Bay, which was only partially sampled). Finally, the percent area of each bay segment passing and failing the threshold was determined (Table 4.2.3).

Table 4.2.1: Threshold category values for chlorophyll *a* 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 (is median significantly different in threshold category). Bolded values are living resources and dissolved oxygen indicator values as imposed by STAC (see text above).

Threshold criteria category	Chlorophyll *a* cutoff values for threshold category
Better than SAV (seagrass) objective	< 7.5 µg/L
Meets SAV (seagrass) objective	**< 15 µg/L**
Does not meet SAV (seagrass) objective	< 30 µg/L
Dissolved oxygen concentration threatened	**< 50 µg/L**
Threatened - does not meet any objectives	> 50 µg/L

Table 4.2.2: Summary of florescence/chlorophyll continuous monitoring data for 2002 and 2003 in Bishopville Prong and Turville Creek.

Site	Indicator and Threshold Level	2002 results	2003 results
Bishopville Prong	Chl >50	84%	46%
	Chl >30	94%	68%
	Chl >15	98%	88%
Turville Creek	Chl >50	34%	7%
	Chl >30	70%	36%
	Chl >15	94%	75%

Table 4.2.3: Summary of percent areas failing seagrass chlorophyll thresholds (15 µg/L) during 2003 water quality mapping. The medians were calculated based on interpolated water quality mapping data collected from April through October.

Bay segment	Percent area failing
Assawoman Bay	3
St. Martin River	73
Isle of Wight Bay	2
Sinepuxent Bay	0
Newport Bay	96

Status of Algae Abundance

The status of chlorophyll concentrations in each Coastal Bays segment is discussed below. Please review Figure 4.2.1 for place names and station locations.

Assawoman Bay

The five upper bay sites did not meet seagrass thresholds while two stations in the open bay (XDN4851 and XDN3445) did meet the seagrass objective. All stations passed the 50 µg/L threshold (Figure 4.2.2). Chlorophyll thresholds were not applicable to a non-tidal station in upper Grey's Creek (GET0005). Spatially intensive data suggested that the fixed stations probably missed the chlorophyll maximum in this creek.

Spatial monitoring showed more than three percent of Assawoman Bay failed the 15 µg/L threshold in 2003 between April and October. Most of the failing area was in the northern and western parts of the bay (Table 4.2.3 and Figure 4.2.3). Bi-weekly intensive spatial monitoring also showed a small bloom in the early season (May) in Grey's Creek and the area behind northern Ocean City and the Assawoman Ditch (northern passage into Delaware) (Figure 4.2.4). The peak bloom occurred in late July and early August throughout the bay.

St. Martin River

All sites failed the seagrass threshold of 15 µg/L. One Bishopville Prong site (XDM4486) did not pass the 50 µg/L threshold and was therefore considered eutrophic. As with Grey's Creek in Assawoman Bay, the chlorophyll thresholds were not applicable to non-tidal sites on Bishopville and Shingle Landing Prongs (Figure 4.2.2).

The Bishopville Creek continuous monitor showed that total chlorophyll concentrations failed two thresholds 84 and 94 percent of the time (50 and 30 µg/L thresholds respectively) from March through November in 2002 (Table 4.2.2). In 2003, the 50 and 30 µg/L chlorophyll thresholds were exceeded 46 and 68 percent of the time (Table 4.2.2). Table 4.2.4 shows monthly data compared to more temporally intense sampling.

Spatial monitoring results indicated that 73.2 percent of the river area failed the 15 µg/L threshold between April and October in 2003 (Table 4.2.3 and Figure 4.2.5). Bi-weekly intensive spatial monitoring also showed this segment to have two bloom periods in 2003. The first bloom occurred in late April to early May and the second bloom lasted two months, from late July into September. The first blooms coincided with more than 75 percent of the river area failing the seagrass threshold, while the second bloom appeared more intense, with up to 100 percent of the river area failing the threshold (Figure 4.2.6).

Isle of Wight Bay

All fixed stations met or exceeded seagrass thresholds except upper Turville Creek, TUV0019 (Figure 4.2.1). Spatial monitoring data suggest this may be the chlorophyll maximum area for this creek. Sites nearest the inlet had the lowest chlorophyll concentrations (likely influenced by clear water coming in from the ocean). Again, chlorophyll criteria were not applicable to non-tidal sites in the headwaters of Turville Creek.

Continuous monitoring on Turville Creek show the seagrass threshold failed 94 percent of the time from March – November in 2002 (33.8 percent and 70.1 percent for 50 and 30 µg/L thresholds, respectively) and 75 percent in 2003 (7 percent and 36 percent for 50 and 30 µg/L thresholds, respectively) (Table 4.2.2). Table 4.2.5 indicates monthly data underestimate chlorophyll in May, June, and July (compared to more temporally intensive samples).

Spatial monitoring shows two percent bay segment area, in upper Turville Creek, failed the 15 µg/L in 2003 (Table 4.2.3 and Figure 4.2.7). Bi-weekly intensive spatial monitoring showed late July/August to have the peak distribution of areas failing seagrass threshold with up to 60 and 50 percent of the area, respectively (Figure 4.2.8). Turville Creek continually had some areas failing the threshold; however, the July bloom indicates a pulse from St. Martin River made it to the open Isle of Wight Bay as well.

Sinepuxent Bay

All fixed stations exceeded seagrass thresholds (Figure 4.2.2).

Spatial monitoring indicated all areas were less than the 15 µg/L threshold in 2003 (Table 4.2.3 and Figure 4.2.9). Bi-weekly intensive spatial monitoring also shows June to have the peak distribution of area failing the seagrass threshold; however, blooms seem to be more sporadic in this bay and are likely a factor of tidal cycle (Figure 4.2.10).

Newport Bay

Seagrass thresholds were only met at two sites in the lower bay (Not applicable to non-tidal sites on upper of Trappe, Ayer, and Newport Creeks). The Trappe Creek station (TRC0043) was eutrophic and Ayer (AYR0017, MCBP 33) and Marshall Creeks (MSL0011, MCBP 12) were more polluted than other areas (Figure 4.2.2).

Intensive temporal monitoring from a short term study initiated by ASIS in 2003 collected chlorophyll data every three hours during three separate ten day periods. Chlorophyll values were above seagrass threshold levels values 90 percent of the time in June (Figure 4.2.11). During the July/August sampling period, there was more variation between sampling times with all values above seagrass habitat criteria. Approximately 10 percent of samples were above TMDL threshold of 50 µg/L.

Spatial monitoring in Newport Bay shows 96 percent area failed the 15 µg/L threshold in 2003 (Table 4.2.3 and Figure 4.2.12). Bi-weekly intensive spatial monitoring also showed two bloom periods. The first bloom in May/June lasted two months (90 –100 percent of area failing seagrass threshold) and the second in late July/August lasted one month with nearly 100 percent of areas failing seagrass threshold (Figure 4.2.13). Blooms in Newport extend from the upper tributaries throughout bay and often down into Chincoteague Bay. Blooms were most persistent in the tributaries and along the western shore in most months.

Chincoteague Bay

All sites met seagrass thresholds with almost all sites better than seagrass threshold (e.g., less than 7.5 µg/l) (Figure 4.2.2).

Two stations were monitored in 2003 as part of ASIS short-term study in Chincoteague Bay at Public and Taylor Landings. The **Public Landing** site showed 85 percent of chlorophyll values were at or below seagrass habitat thresholds in June (15 µg/L)(Figure 4.2.14). During the final two days of the June deployment at Public Landing, there was a marked increase in chlorophyll concentration. Examination of ancillary data revealed that this was probably due to re-suspension of benthic algae as this occurred during a strong wind event prior to a storm and there was no increase in nutrients before or during the event. These results suggest that benthic micro algae concentrations may be as high or higher than phytoplankton and an important primary producer in this system. The July/August period exhibited higher chlorophyll levels than the earlier June time frame with 90 percent of the values above seagrass thresholds. At **Taylor Landing**, 90 percent of the chlorophyll samples were at or above seagrass habitat criteria during June (Figure 4.2.15). Average chlorophyll levels during July/August were lower overall than the June values with 50 percent of the values being above seagrass threshold levels.

Comparison of Sample Frequency

Table 4.2.4: Comparison of 2002 results from varying temporal frequencies of monitoring in Bishopville Prong. Continuous data were collected every 15 minutes by an *in situ* hydrolab sonde using a fluorescence probe (total chlorophyll) while weekly and monthly data were collected as surface grab samples that were filtered and analyzed by UMD (extractive method for chl *a*). Values presented are means, with standard deviations in parentheses, except monthly data that consisted of a single sample. Periods indicate no or missing data.

Parameter	**Month**	**Continuous Data (t chl)**	**Weekly data (chl *a*)**	**Monthly Data (chl *a*)**
Chlorophyll	June	81.53 (20.48)	100.57 (32.32)	53.83
	July	106.68 (18.45)	93.22 (13.21)	109.10
	August	119.99 (35.27)	111.39 (20.41)	131.60
	September	67.29 (21.46)	52.99 (16.54)	49.34
	October	71.35 (31.66)	42.79 (10.22)	47.10
	November	90.30 (107.55)	.	0.748
	December	22.99 (13.66)	.	5.79
Total Nitrogen	June	.	3.045 (0.25)	2.50
	July	.	3.106 (0.30)	3.420
	August	.	3.643 (0.13)	3.550
	September	.	2.265 (0.36)	2.020
	October	.	2.290 (1.24)	2.020
	November	.	.	6.739
	December	.	.	2.462
Total Phosphorus	June	.	0.270	0.231
	July	.	0.254	0.278
	August	.	0.303	0.313
	September	.	0.151	0.153
	October	.	0.120	0.093
	November	.	.	0.141
	December	.	.	0.086
Salinity	June	23.89	.	23.42
	July	27.02	.	26.23
	August	30.41	.	29.8
	September	25.57	.	24.59
	October	25.71	.	24.91
	November	20.57	.	
	December	22.63	.	20.65

Table 4.2.5: Comparison of 2002 results from varying temporal frequency of monitoring in Turville Creek. Continuous data were collected every 15 minutes by an *in situ* hydrolab sonde using a fluorescence probe (total chlorophyll) while weekly and monthly data were collected as surface grab samples that were filtered and analyzed by UMD (extractive method for chl *a*).Values presented are means, with standard deviations in parentheses, except monthly data which consisted of a single sample. Periods indicate no or missing data.

Parameter	**Month**	**Continuous Data (T chl)**	**Weekly data (chl *a*)**	**Monthly Data (chl *a*)**
Chlorophyll a	May	72.54	60.8	20.93
	June	58.19	48.17	5.48
	July	48.71	43.27	26.91
	August	51.32	46.00	45.70
	September	30.56	27.60	19.70
	October	24.48	20.98	18.20
	November	26.16	.	25.60
	December	32.37	.	8.40
Total Nitrogen	May	.	1.68	1.34
	June	.	2.64	2.0
	July	.	1.95	2.09
	August	.	2.31	2.25
	September	.	1.59	1.28
	October	.	1.30	1.82
	November	.	.	1.43
	December	.	.	1.10
Total Phosphorus	May	.	0.140	0.110
	June	.	0.178	0.144
	July	.	0.165	0.145
	August	.	0.195	0.156
	September	.	0.010	0.081
	October	.	0.075	0.095
	November	.	.	0.120
	December	.	.	0.048
Salinity	May	23.55	.	26.77
	June	28.57	.	28.03
	July	31.37	.	31.51
	August	33.92	.	32.6
	September	25.79	.	27.79
	October	26.65	.	27.23
	November	19.49	.	6.2
	December	19.15	.	21.95

Trends in algae abundance

Sinepuxent Bay

Improving chlorophyll trends were found in the southern part of the bay while no significant trends were detected in northern areas (Figures 4.2.16 and 4.2.17).

Newport Bay

No significant trends in chlorophyll were present at two sites in the open bay (Figures 4.2.16 and 4.2.17).

Chincoteague Bay

A significantly improving trend in chlorophyll was found at Public Landing (ASIS 5) and a degrading chlorophyll trend was found in Johnson Bay (ASIS 7) (Figures 4.2.16 and 4.2.17). No significant trends were detected at eight other sites in Chincoteague Bay.

Table 4.2.6: Medians, Sen slopes, and percentage change (slope as percentage of median by year) for significant chlorophyll *a* (CHLA) trends. Chlorophyll *a* was recorded in µg/L. Positive slopes indicate a declining trend; negative slopes indicate an improving trend. The algorithm for percent change is: ((slope*n years)/initial median)*100 (Ebersole et al. 2002).

Station	Segment	Indicator	Median	Slope	N Years	Percent Change
ASIS 2	Sinepuxent	CHLA	4.797	-0.2831	16	-95
ASIS 7	Chincoteague	CHLA	5.438	0.3195	13	76
ASIS 16	Chincoteague	CHLA	5.38	-0.03784	16	-11
ASIS 18	Chincoteague	CHLA	4.742	-0.02425	16	-8

Summary

The seagrass chlorophyll threshold was met in Isle of Wight, Sinepuxent and Chincoteague Bays; while the St. Martin River and upper Newport Bay failed. STAC chlorophyll threshold showed eutrophic conditions are present in Bishopville Prong and Trappe Creek.

Intensive temporal monitoring shows the duration of blooms can be very long in these areas. Even Chincoteague Bay showed intense blooms when 90 percent of samples were greater than 15 µg/L at Public Landing in July/Aug and Taylor Landing in June. Recommend continuous monitors be put in all bay segments to better understand duration of blooms.

Spatial monitoring gives better resolution of blooms and shows large scale 'pulses' in some bays. Overall, 24% of the bay area (minus Chincoteague) failed seagrass chlorophyll threshold**.**

Trend analyses show significantly improving trends at 5 out of 18 sites, all in lower Sinepuxent and middle Chincoteague Bays. A single significantly degrading chlorophyll trend was found in Johnson Bay (ASIS 7).

Despite many areas failing nutrient thresholds in the Coastal Bays, chlorophyll values were generally good in the open bays. This could be because much of the algal biomass (organic matter) produced in the tributaries is deposited within these areas (see Chapter 5.1). Another explanation may be that nutrients are sequestered in or utilized by other forms such as benthic planktonic algae, benthic macroalgae, and seagrasses instead of water column phytoplankton. We recommend that all primary producers be monitored in a coordinated program in order to best understand the total impacts of nutrient inputs.

Chlorophyll criteria for Total Maximum Daily Load (TMDL) analyses that have been approved by the EPA for the St. Martin River, Herring and Turville Creeks, Manklin and Greys Creeks, and Newport Bay use a different metric than those reported here for chlorophyll (Maryland Department of the Environment 2002, 2001). The Maryland Department of the Environment, MDE, applies a mean summer (June-September) chlorophyll value and a 50 µg/L threshold in TMDL models. Applying the same dataset used in the analyses above to the MDE model season, a different picture emerges of areas meeting or failing objectives (Figure 4.2.18). This analysis seems to relate better to areas with oxygen problems (see Chapter 4.3).

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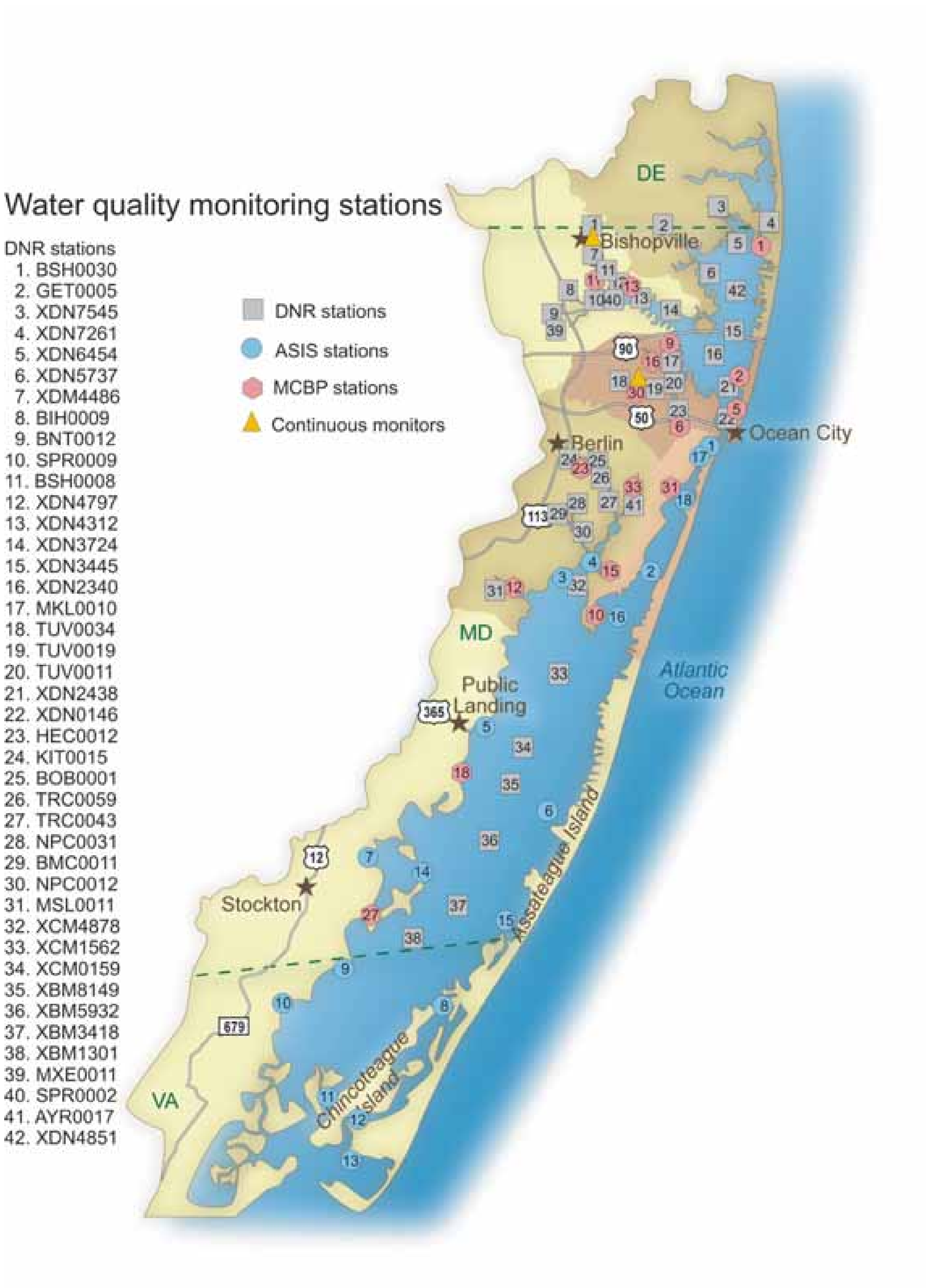

Figure 4.2.1: Map showing water quality monitoring stations for the Maryland Department of Natural Resources (DNR), the National Park Service, Assateague Island National Seashore (ASIS), and the Maryland Coastal Bays Program volunteers (MCBP). DNR stations are listed by DNR code; ASIS and MCBP stations are referred to as ASIS or MCBP and the station number (for example, ASIS 1).

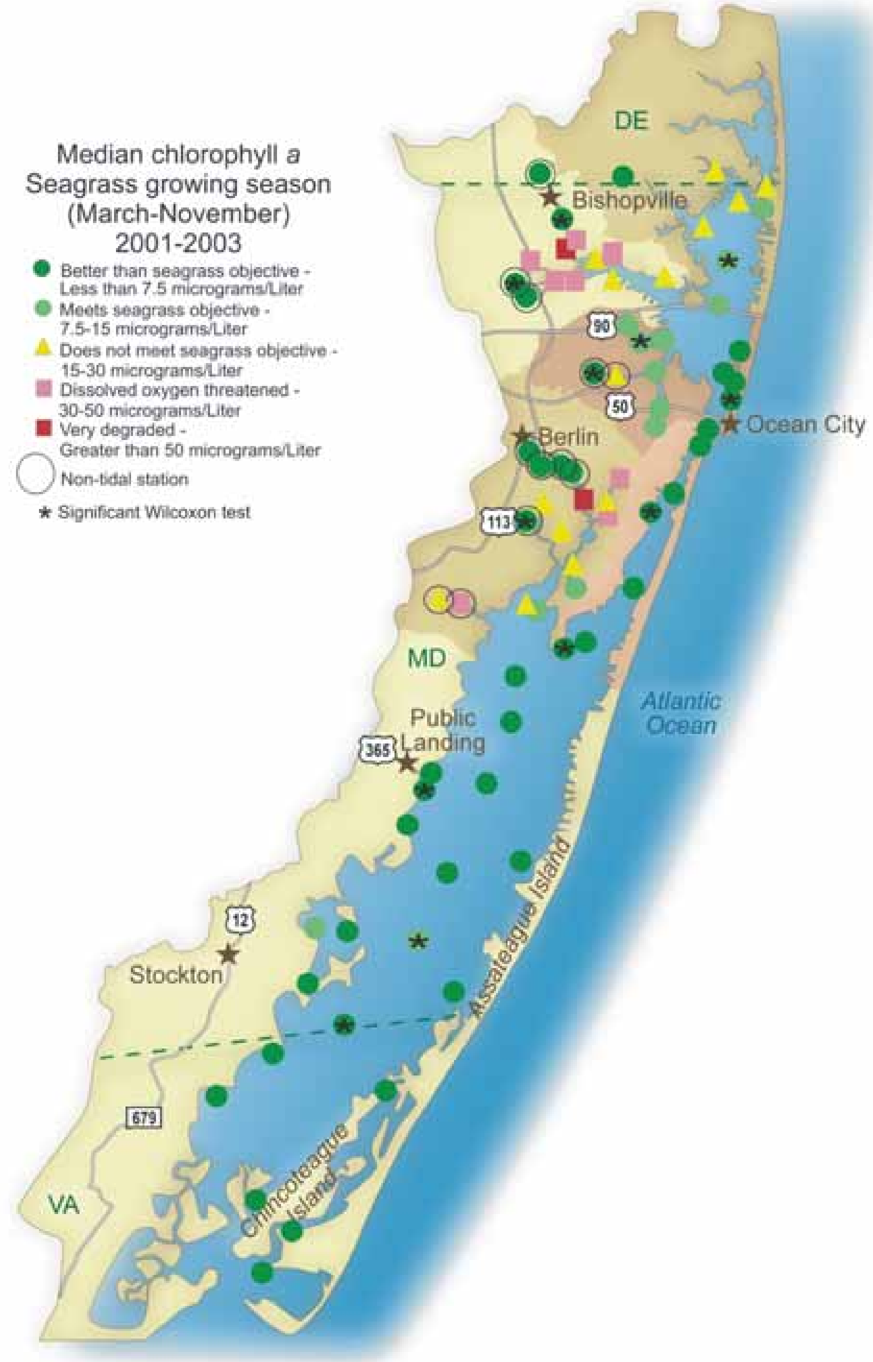

Figure 4.2.2: Median concentrations of chlorophyll *a* in Coastal Bays fixed monitoring stations between 2001 and 2003. Circled stations are non-tidal. Status categories are based on threshold values described in the text.

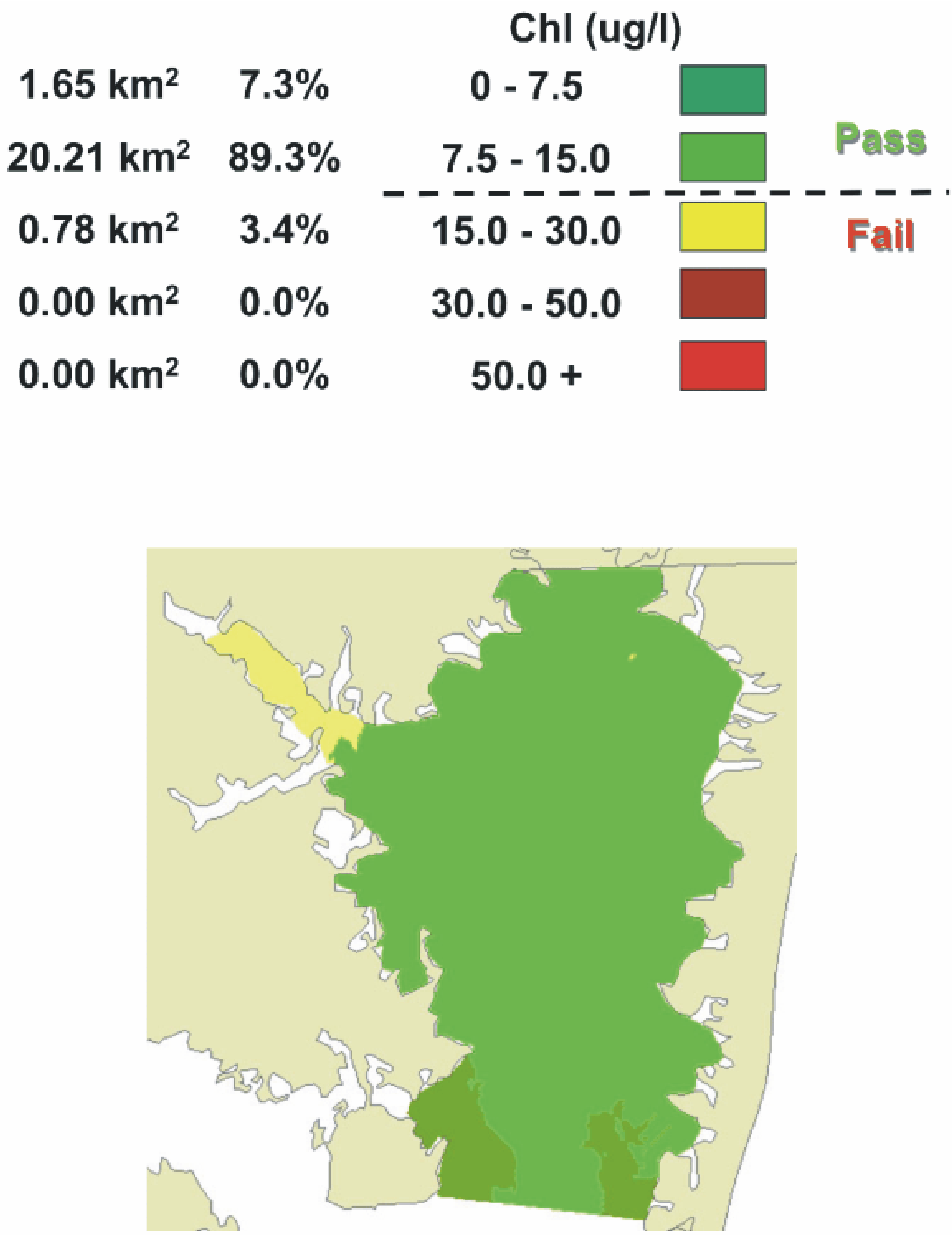

Figure 4.2.3: 2003 DataFlow chlorophyll median results for Assawoman Bay.

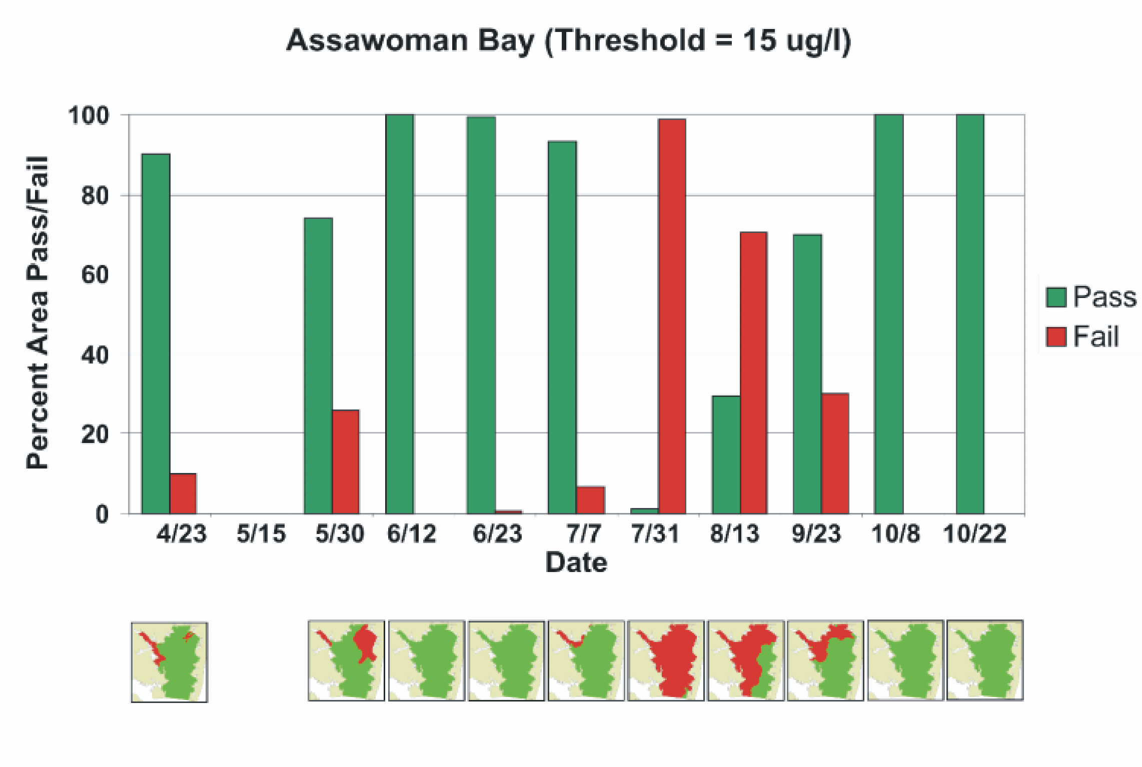

Figure 4.2.4: 2003 DataFlow bi-weekly chlorophyll in Assawoman Bay.

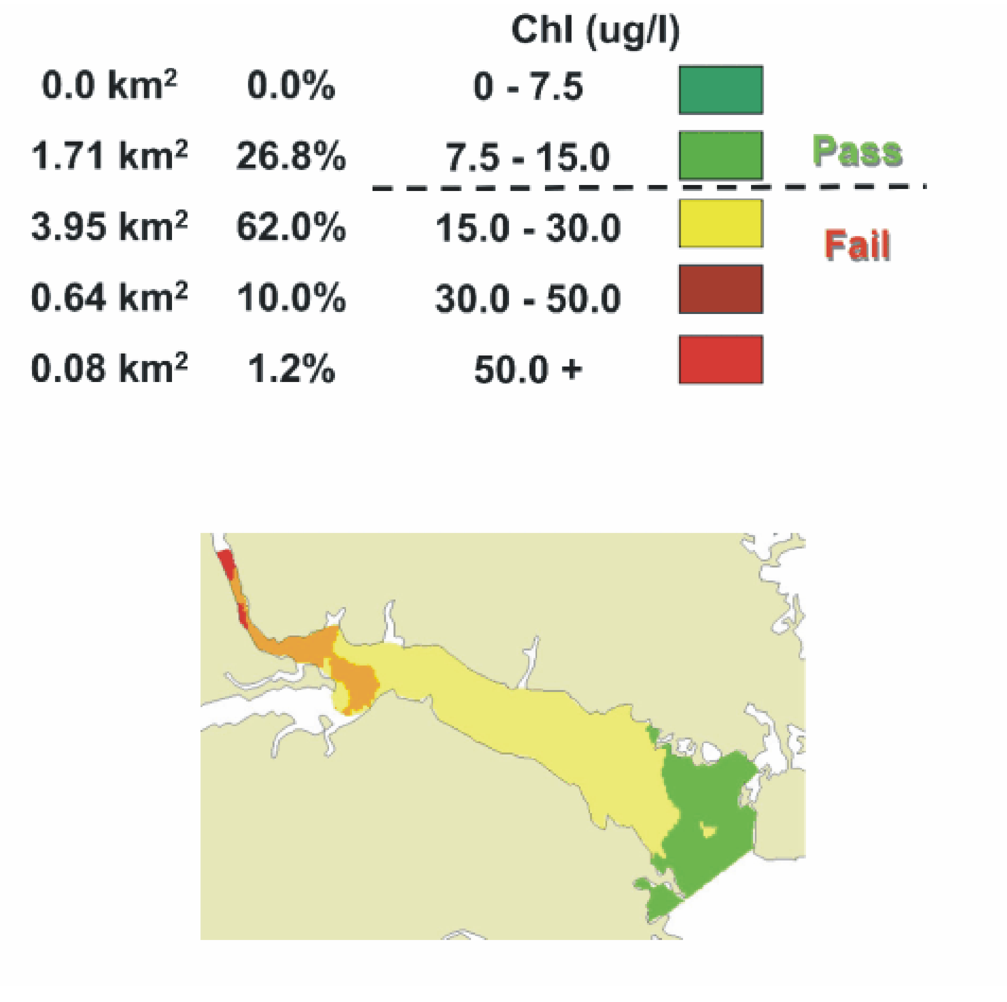

Figure 4.2.5: 2003 DataFlow chlorophyll median results for St. Martin River.

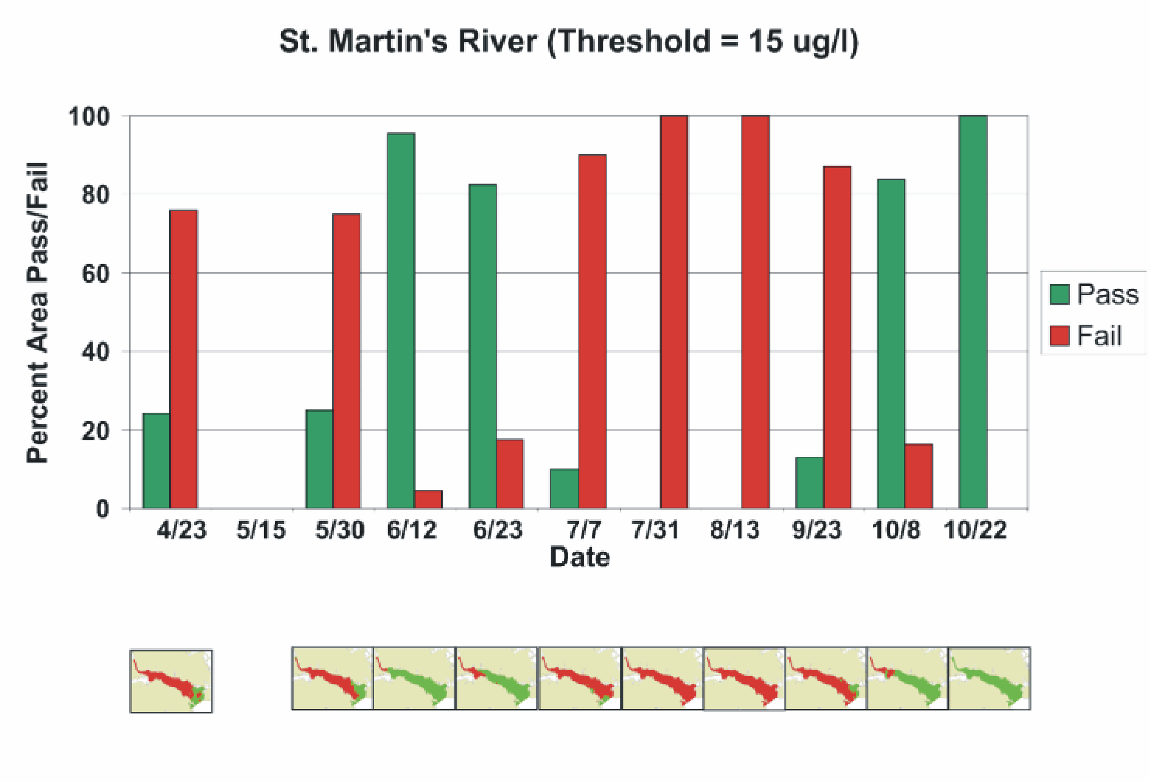

Figure 4.2.6: 2003 DataFlow bi-weekly chlorophyll in St. Martin River.

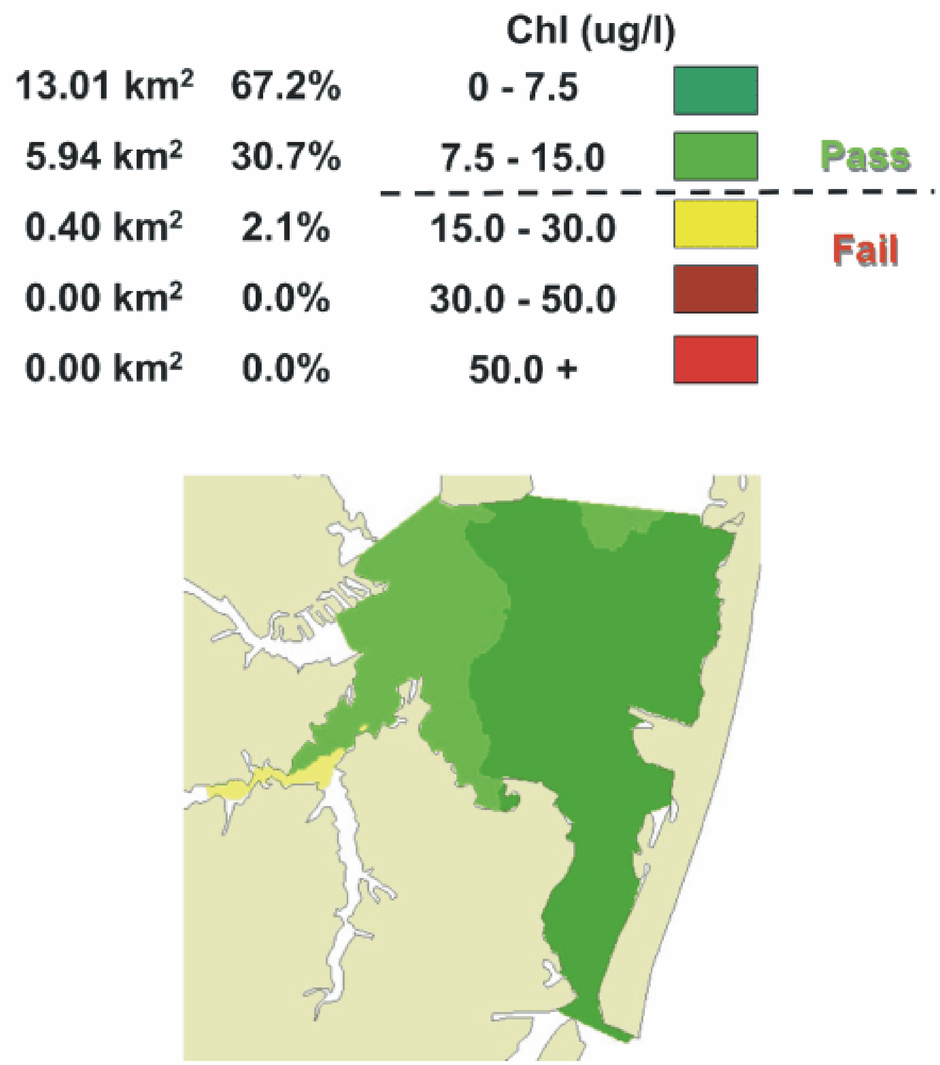

Figure 4.2.7: 2003 DataFlow chlorophyll median results for Isle of Wight Bay.

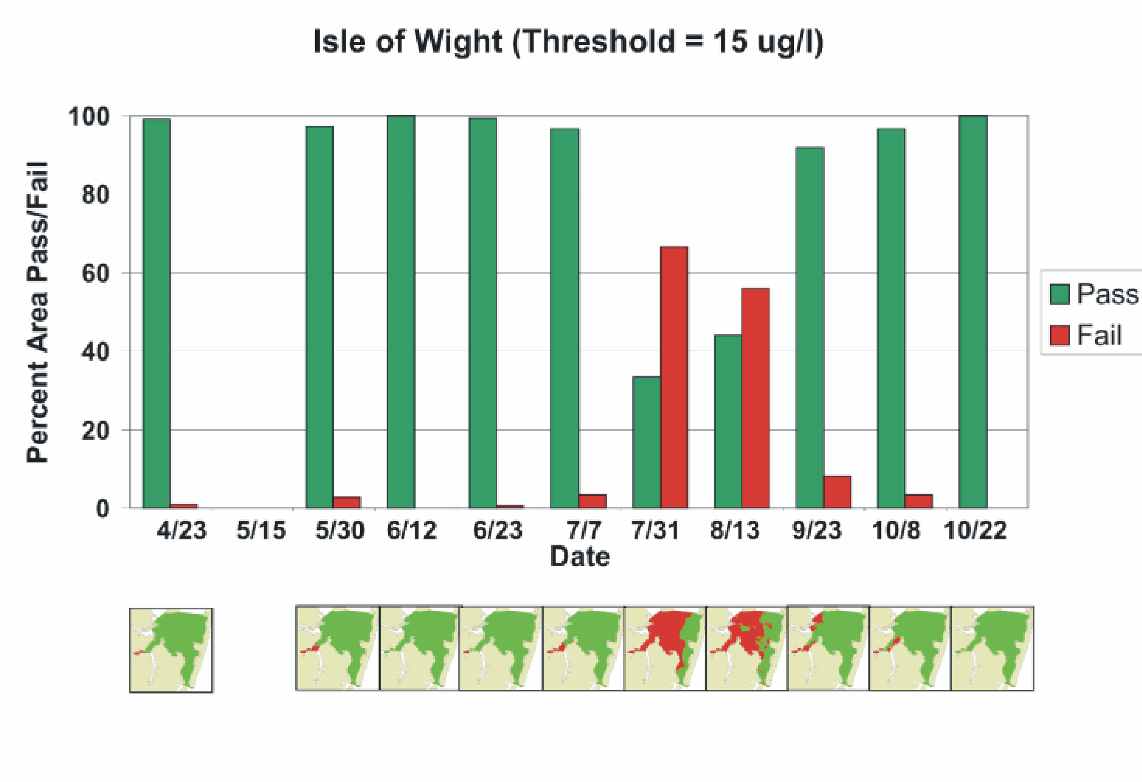

Figure 4.2.8: 2003 DataFlow bi-weekly chlorophyll in Isle of Wight Bay.

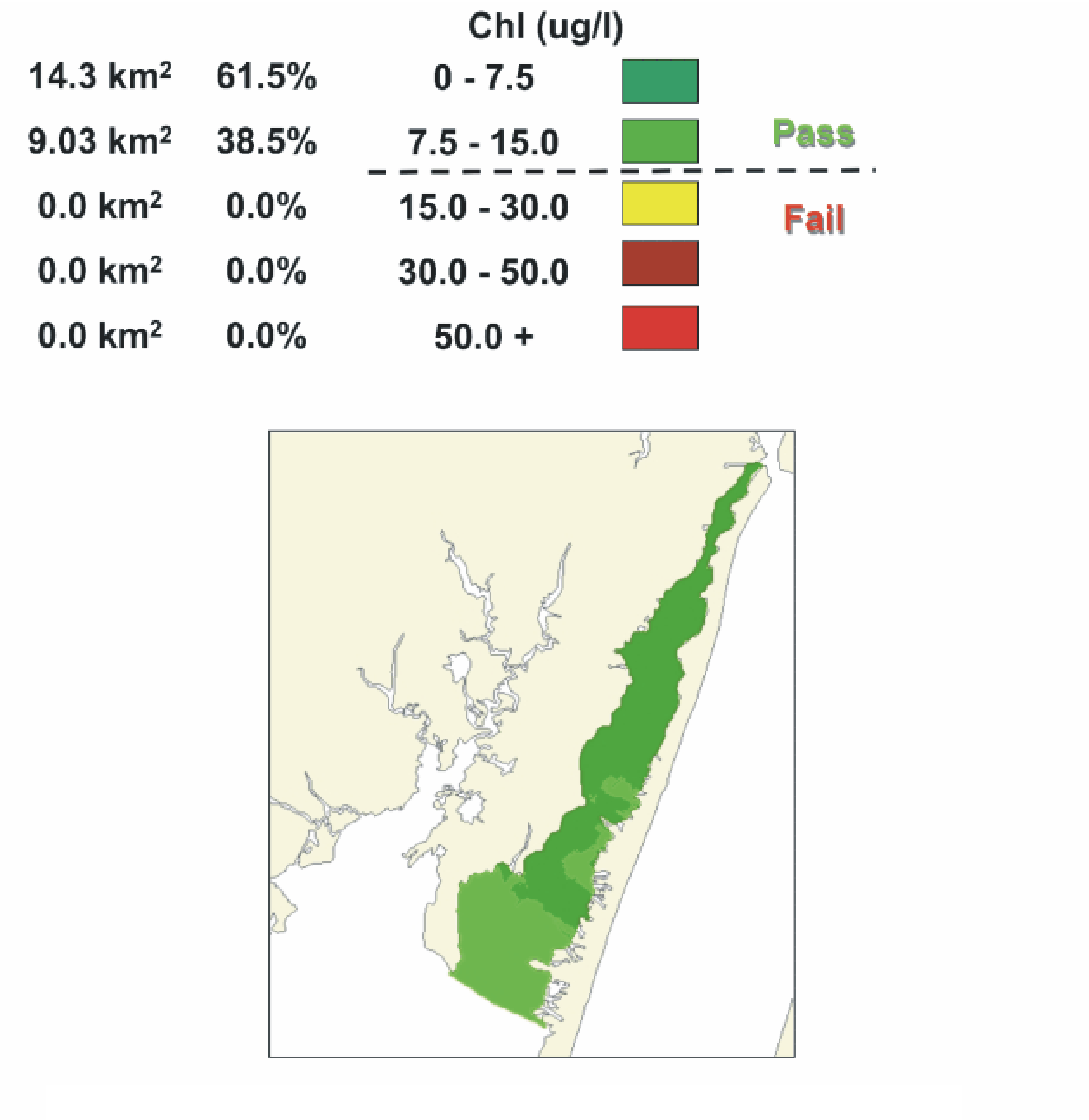

Figure 4.2.9: 2003 DataFlow chlorophyll median results for Sinepuxent Bay.

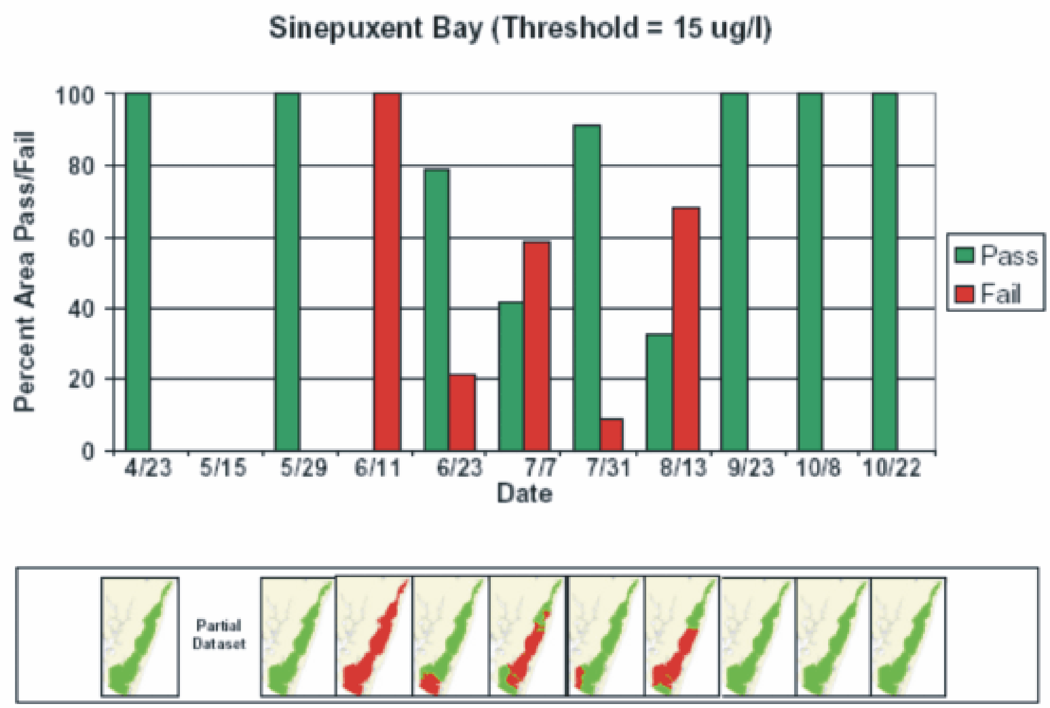

Figure 4.2.10: 2003 DataFlow bi-weekly chlorophyll in Sinepuxent Bay.

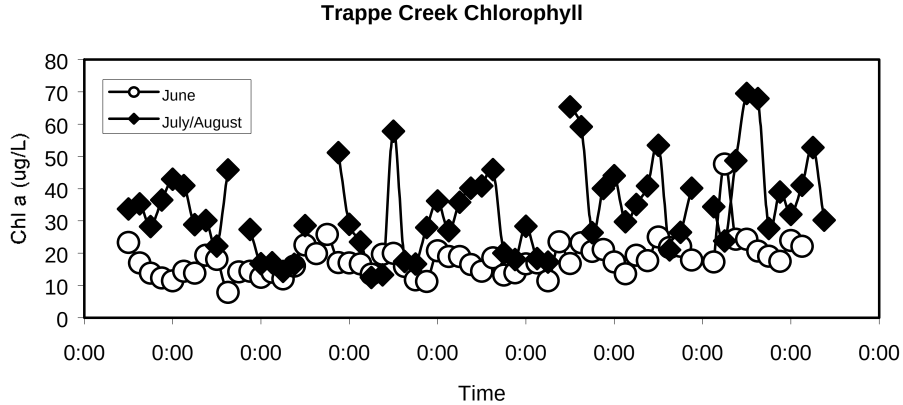

Figure 4.2.11: Chlorophyll *a* concentrations (extractive method) recorded during intensive sampling by Assateague Island National Seashore (ASIS) personnel. Samples were collected every three hours during two separate nine-day periods in Trappe Creek, a tributary of Newport Bay. The times on the x-axis represent midnight of alternative days, or the transition between consecutive two-day periods. Sample dates were June 10 through June 18, 2003 and July 29 through August 6, 2003.

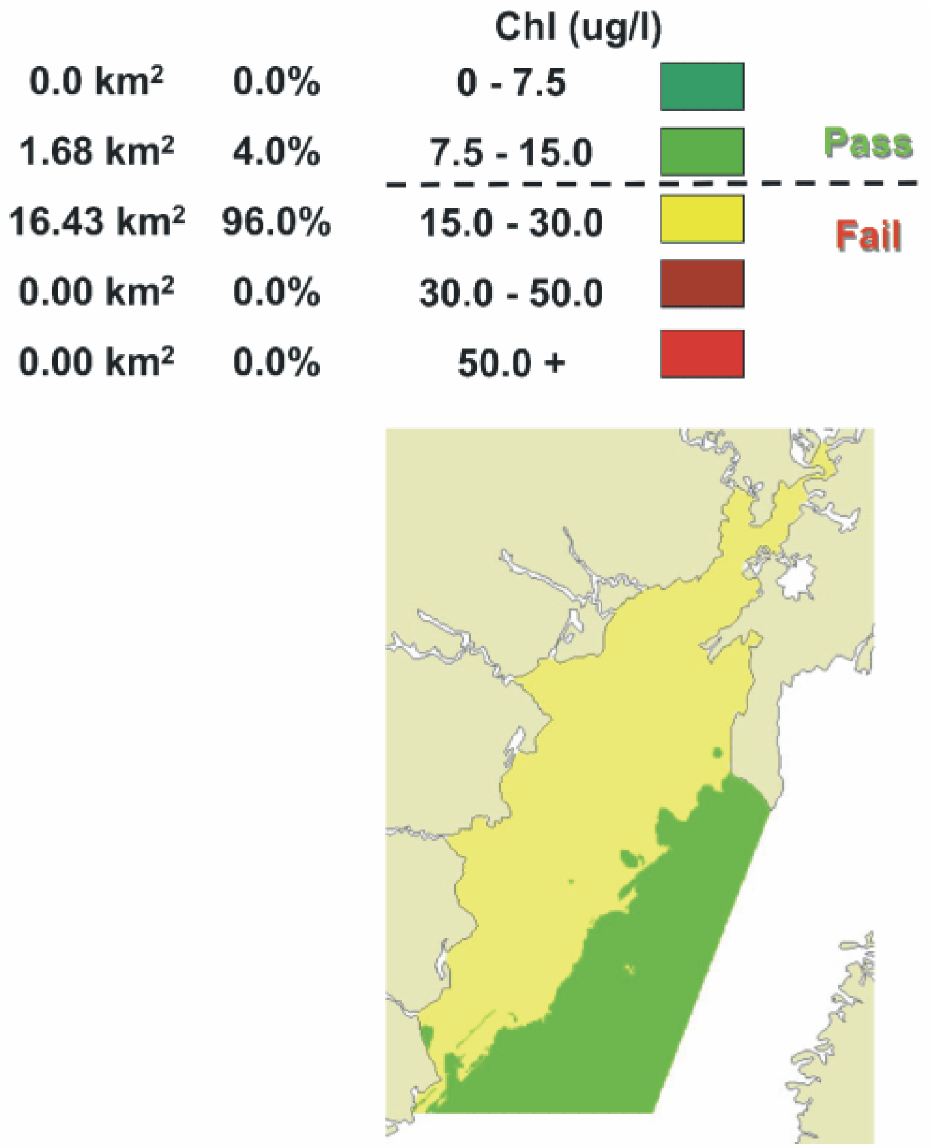

Figure 4.2.12: 2003 DataFlow chlorophyll median results for Newport Bay.

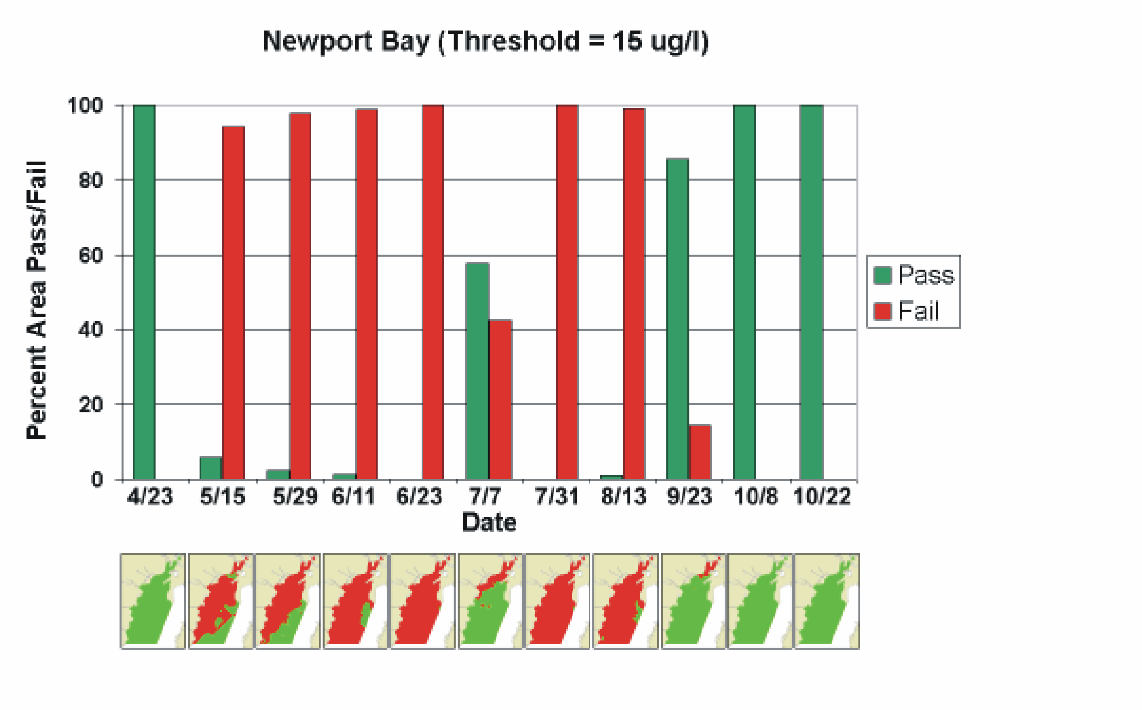

Figure 4.2.13: 2003 DataFlow bi-weekly chlorophyll in Newport Bay.

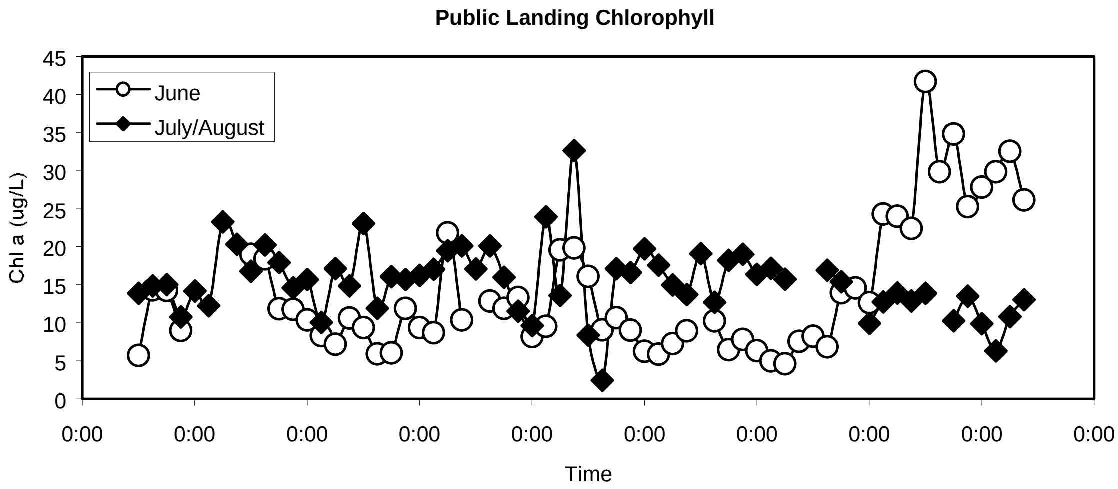

Figure 4.2.14: Chlorophyll *a* concentrations (extractive method) recorded during intensive sampling by Assateague Island National Seashore (ASIS) personnel. Samples were collected every three hours during two separate nine-day periods at Public Landing in northern Chincoteague Bay. The times on the x-axis represent midnight of alternative days, or the transition between consecutive two-day periods. Sample dates were June 10 through June 18, 2003 and July 29 through August 6, 2003.

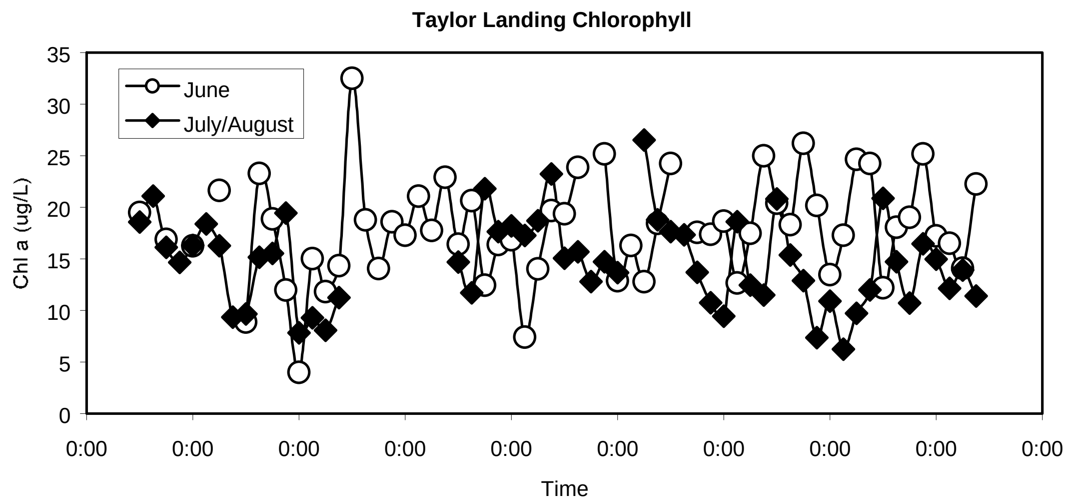

Figure 4.2.15: Chlorophyll *a* concentrations (extractive method) recorded during intensive sampling by Assateague Island National Seashore (ASIS) personnel. Samples were collected every three hours during two separate nine-day periods at Public Landing in northern Chincoteague Bay. The times on the x-axis represent midnight of alternative days, or the transition between consecutive two-day periods. Sample dates were June 10 through June 18, 2003 and July 29 through August 6, 2003.

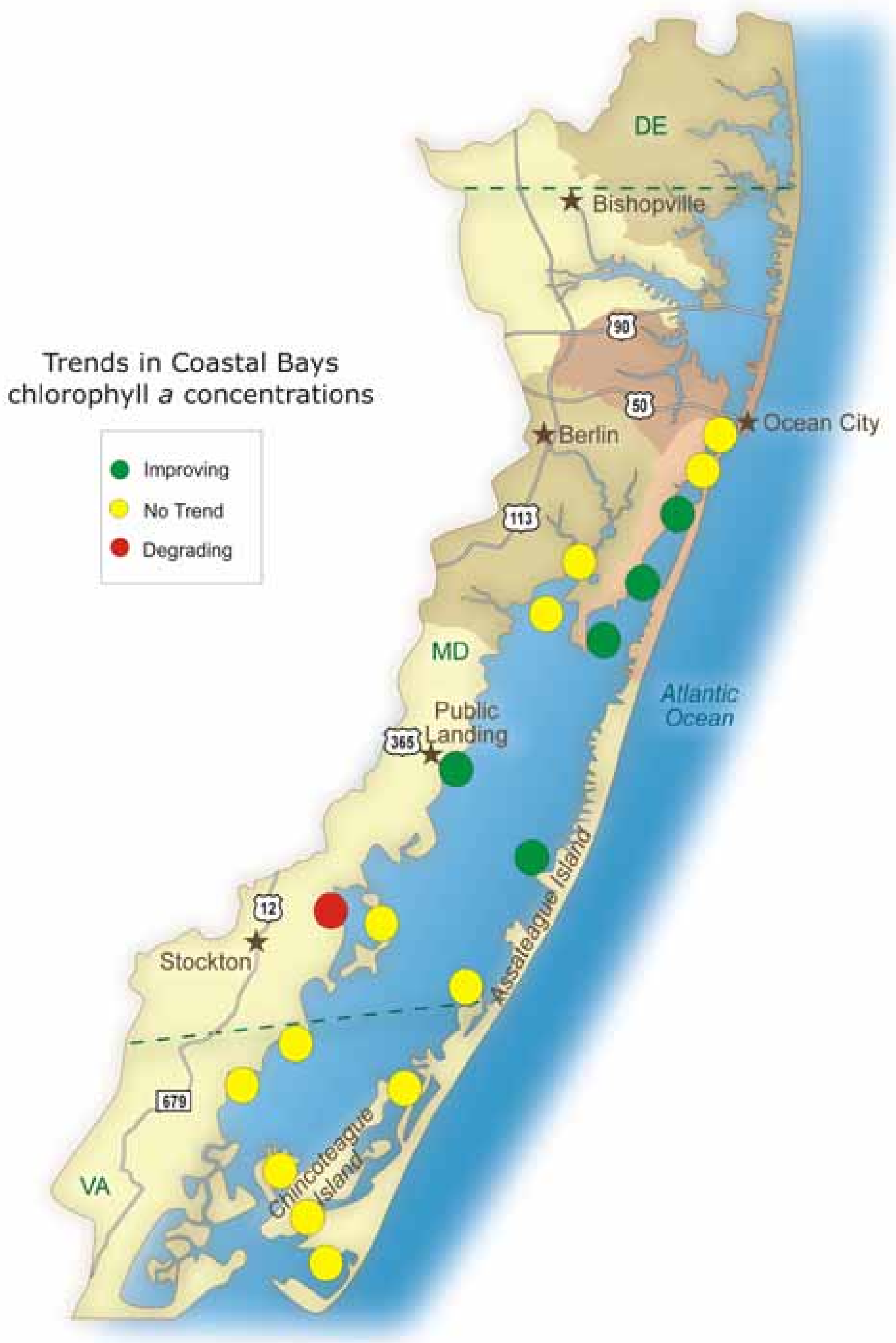

Figure 4.2.16: Chlorophyll *a* trend analysis of southern Coastal Bays National Park Service fixed water monitoring stations. Trends are based on between 12 and 16 years of data, depending on the station. Significance in trends was calculated using the seasonal Kendall's tau statistic and directionality (improving or degrading) condition for significant trends was determined by linear regression (p=0.01).

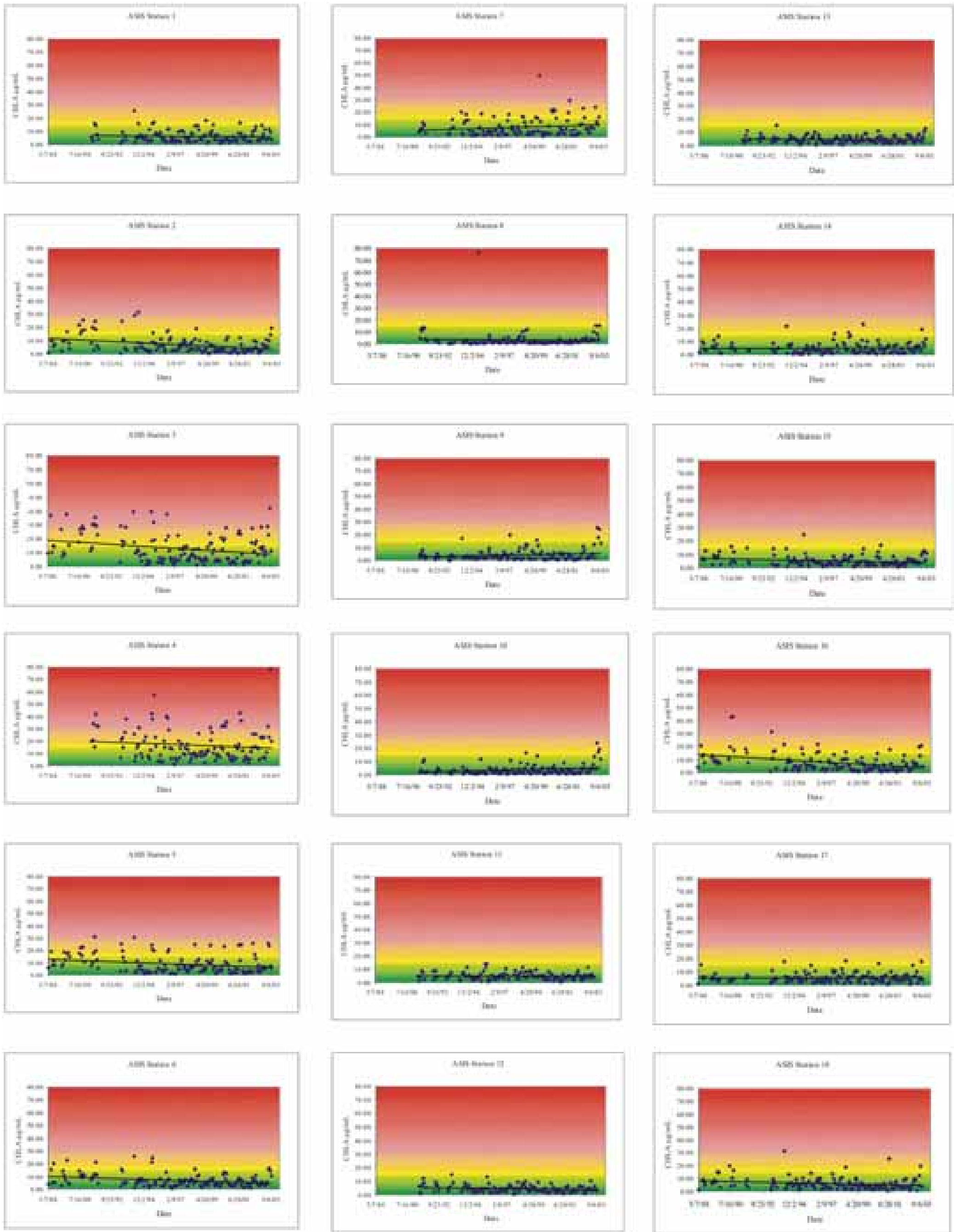

Figure 4.2.17: Chlorophyll *a* trend analysis at ASIS stations. Trend lines indicate directionality; underlying colors indicate status threshold categories (see Figure 4.2.2). Data are monthly medians and are uncensored. Stations 2, 5, 6, 16, and 18 all had significant improving trends (decreasing chlorophyll); station 7 had a significantly degrading trend (increasing chlorophyll), despite values remaining mostly within acceptable status threshold levels. Significance was based on the seasonal Kendall tau test (see text).

Figure 4.2.18: Mean summer (June-September) concentrations of Chlorophyll *a* 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. This analysis is analogous to those conducted in the determination of TMDLs for Newport Bay and the St. Martin River. TMDL status categories were matched to STAC threshold values (see Figure 4.2.2); hence the duplicate "Meets TMDL goal" categories.