Chapter 5.3

Long-term Changes in Water Clarity and Temperature in Maryland's Coastal Bays

Rebecca Raves Golden, Cathy Wazniak, and Carol McCollough
Maryland Department of Natural Resources, Tidewater Ecosystem Assessment, Annapolis, MD 21401

Abstract

The 2013 acreage represents the lowest seagrass coverage documented in the Maryland Coastal Bays since 1991. Seagrasses had been recovering in most embayments after drastic losses in 2005. However, large losses have occurred since 2010 despite local improvements in water quality. Given the lack of seagrass response to suitable habitat conditions, additional environmental factors, including water clarity and temperature, were investigated to determine potential impacts on the recent loss. Overall, both water clarity measurements (Secchi depth and K_d) showed significant improvements from 2003 to 2013. However, current water clarity conditions exceed seagrass thresholds. The relationship between Secchi depth and light extinction (K_d) significantly decreased during the ten year analysis period, suggesting changes in light quality have occurred over time. Because this relationship has changed over time and varies by embayment, a Secchi depth/Kd conversion ratio should be avoided. Exceedance of eelgrass water temperature thresholds was greatest during 2010-2012 and most significant in Chincoteague Bay and St. Martin River. Stress from high water temperatures coupled with water clarity above threshold levels likely inhibited the recovery of eelgrass.

Introduction

Light attenuation is an important factor governing the abundance and distribution of seagrasses (submerged aquatic vegetation or SAV) in coastal ecosystems. Nutrient and sediment pollution can cloud the water and cause algal blooms which block sunlight from reaching seagrasses. Water quality trends in the Coastal Bays show mostly improving conditions for nutrients (Chap. 4.1) and algal blooms (Chap. 4.2). However, seagrasses have been declining in all coastal embayments regardless of improving habitat conditions in recent years.

Long-term declines in water clarity (K_d and Secchi depth) have been documented in the Chesapeake Bay (Gallegos et al., 2011 and the Maryland Department of Natural Resources's (DNR)Tributary Water Quality and Habitat Assessments). It is hypothesized that despite improving nutrient trends (see Chapter 4 of this report); similar long-term water clarity declines are contributing to the lack of seagrass response in Maryland's Coastal Bays. This analysis examines the long-term (2003-2013) temporal and spatial variability in water clarity data (K_d and Secchi depth).

Impacts of high water temperature stress on eelgrass include the disruption of photosynthetic and metabolic processes (Evan et al., 1986; Marsh et al., 1986; Zimmerman et al., 1989; Nejrup and Pedersen, 2008). Water temperatures above 25^{o}C have been shown to stress eelgrass (Rasmussen, 1977) and eelgrass die-backs have been reported when water temperatures exceed

30^{o}C (Orth and Moore, 1986; Moore and Jarvis, 2008). The distribution of eelgrass can shift as a result of reduced water clarity and increased temperature stress. Long-term temperature impacts can lead to seagrass community changes, especially with increases in the frequency and intensity of extreme weather events.

Management Objective: Increase seagrass abundance by improving and maintaining acceptable habitat conditions for seagrass expansion.

Indicator:	K_d and Secchi depth changes over time.	*Indicate changes in water clarity.*
	Temperature >30^{o}C	*Indicates stress to eelgrass.*

Data Sets

Monthly photosynthetically active radiation (PAR), Secchi depth, total suspended solids (TSS) and chlorophyll *a* (chl *a*) data were obtained from 18 National Park Service at Assateague Island (ASIS) water quality stations from 2003-2013, except 2009, and 24 DNR long-term monitoring stations from 2003-2013. Light attenuation, K_d, data was calculated from the PAR data using the 2-point SAV method (Michael et al., 2014). Secchi data was checked to determine if sat on bottom. If the Secchi sat of the bottom it was excluded from the analyses. Secchi depths were then multiplied by the calculated Kd for Secchi*Kd parameter.

Continuous monitoring data for temperature was collected every 15 minutes at four sites in the Coastal Bays (NPC0012 in Newport Bay, XBM8828 in Chincoteague Bay, XDM4486 in the St Martin, XDN6921 in Assawoman Bay) during 2007-2013.

Analyses

Monthly station data was averaged by embayment (Assateague Bay, St. Martin River, Isle of Wight Bay, Sinepuxent Bay, Newport Bay, and Chincoteague Bay) and analyzed by general linear model (GLM), with year as a continuous variable and month as a categorical variable to allow for seasonality (Gallegos et al., 2011).

The amount of time that the temperature was above 30^{o}C was calculated by adding up the number of 15 minute measurements from continuous monitoring sites (measured with YSI 6600 instrument) in the Coastal Bays during the SAV growing season (March-November).

Water Clarity and Temperature exceedances

Assawoman Bay

Significant improvements in both Secchi depth and K_d over time.
Temperature exceedances were second highest in Greys Creek (no SAV).

St. Martin River

Significant improvements in both Secchi depth and K_d over time. Temperature exceedances were highest in Bishopville Prong (no SAV).

Isle of Wight

No significant changes in Secchi depth, K_d or the K_d*Secchi depth product over time in Isle of Wight. No data on temperature exceedances because no continuous monitoring.

Sinepuxent

Significant declines in the K_d*Secchi product over time observed in Sinepuxent Bay. No analyses on temperature exceedances. Analysis was not completed on temperature for this bay.

Newport

Significant improvements in Secchi depth and K_d over time. Temperature exceedances at the Newport Creek continuous monitor were above 400 hours annually from 2010-2012.

Chincoteague

Significant improvements in Secchi depth and K_d over time. Significant decreasing K_d*Secchi product over time observed in Chincoteague. Temperature exceedances at Public Landing were at or exceeded 200 hours a year above 30^oC.

Seagrass Light Model

Trends in Secchi depth, K_d and the K_d*Secchi product varied by coastal embayment. The GLM revealed significant improvements in both Secchi depth and K_d for Assawoman, St. Martin, Newport and Chincoteague. Overall, average Secchi depths in the Coastal Bays have improved by a rate of 0.01meters/year from 2003 to 2013. The greatest rates of Secchi depth improvements were in Assawoman, Newport and St. Martin (Figures 5.3.1-5.3.7). While Secchi depth has improved in recent years, current conditions still exceed the habitat threshold (0.966 m) for eelgrass in most segments (Table 5.3.1 and Chap 5.2).

Overall, the ten-year K_d median observed at the 42 Coastal Bays stations was 1.51 m^{-1}. This slightly exceeds the current light attenuation coefficient requirement (<1.5 m^{-1}) for the polyhaline portion of the Chesapeake Bay (Batiuk et al., 1992). There were significant long-term improvements in K_d in Assawoman, St. Martin, Newport and Chincoteague (Figures 5.3.1 through 5.3.7). However, median K_d values for the 10 year study period exceed the requirement in Assawoman, St. Martin and Newport (Table 5.3.1).

The Coastal Bays wide K_d*Secchi depth product has significantly declined over time (Figures 5.3.1-5.3.7). Significant decreases in the K_d*Secchi product were also observed in Chincoteague and Sinepuxent Bays. Similar decreases in K_d*Secchi depth have also been observed in the mesohaline and polyhaline portions of the Chesapeake Bay (Gallegos et al., 2011) during the same time.

We attempted to explain the changes in the Coastal Bays water clarity by examining associated changes in chlorophyll a and/or total suspended solids. However, no significant relationships between chlorophyll or total suspended solids and Secchi depth, K_d or K_d*Secchi depth were found. Gallegos et al. (2011) suggested that declines in the K_d*Secchi depth product may be accomplished by increasing the relative proportion of organic detritus in the water or increasing the tendency of particulate matter to occur in large aggregates.

Annual median K_d*Secchi products ranged between 1.06 and 1.31, with an overall median of 1.17 (Figures 5.3.1-5.3.7) while the current conversion factor for the Chesapeake Bay is K_d = 1.45/Secchi depth (Batiuk et al., 1992). The Chesapeake Bay ratio declined between 0.20 and 0.33 per year. The values calculated for the Coastal Bays are all below the standard of 1.7 (e.g. Poole and Atkins, 1929) used worldwide and the 1.44 value suggested by Holmes (1970) in turbid waters. We recommend measuring photosynthetically active radiation (PAR) at all stations using a simultaneous, two depth setup in order to calculate K_d directly. Secchi depth should be collected at a minimum if PAR measurements are not available. The use of a Secchi depth to K_d conversion ratio in the Coastal Bays should be avoided as their relationship has changed significantly over time and is lower than current standards.

Temperature Exceedance

Temperature has been shown to also be a habitat stressor to eelgrass in particular (the dominant species in the southern coastal bays). Analyses of the duration of eelgrass temperature above 30^oC showed greatest exceedances occurred during 2010-2012 (Figure 5.3.8). This may be a factor in the continued decline of seagrasses in the Maryland Coastal Bays especially in Chincoteague Bay (see Ch 5.1) which is dominated by eelgrass. In addition, high levels of ammonium may be impacting seagrass distributions (>4μM can be toxic to plants- see chapter 4.1) (van Katwijk et al. 1997; Van der Heide et al. 2008)(see Chapter 4.1 of this document).

Summary

Overall water clarity is improving in the bays, especially Chincoteague, Assawoman and Sinepuxent. The quality of light is changing in Assawoman, Chincoteague and Newport (Kd * Secchi). Multiple factors are believed to be limiting seagrass in the Maryland Coastal Bays. Direct light measurements are best for determining light available to the underwater grasses. Photosynthically available radiation (PAR), Secchi and continuous temperature measurements should continue to be collected in order to provide critical information. Recommend more frequent measurements of PAR be implemented if possible. Measurements near seagrass beds would be most beneficial (most continuous monitors are in tributaries or other areas not designated are seagrass habitat (see Chapter 5.1).

Investigation into why the K_d*Secchi depth product has significantly declined over time is needed. Similar decline in the Chesapeake Bay suggest a regional shift.

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Table 5.3.1 Trends of water clarity indicators, K_d*S, Secchi and K_d during 2003-2013 for the entire Coastal Bays and individual bay segments. Bolded results are significant. Negative Kd and positive Secchi depth slopes indicate improving clarity over time.

	1998-2013			**2003-2013**		
	Kd*S	**Secchi**	**Kd**	**Kd*S**	**Secchi**	**Kd**
All Stations	**-0.01609**	**-0.0102**	-0.00672	**-0.01182**	**0.00985**	**-0.04556**
Assawoman				0.00907	**0.02103**	**-0.04123**
Chincoteague	**-0.02004**	**-0.01413**	-0.00139	**-0.01995**	**0.00802**	**-0.04417**
Isle of Wight				0.00874	0.00626	0.01129
Newport	**-0.02114**	-0.000436	**-0.04087**	-0.00554	**0.02417**	**-0.08641**
Sinepuxent	**-0.02198**	**-0.01208**	-0.01056	**-0.01917**	0.00645	-0.01159
St. Martin				0.000172	**0.02655**	**-0.011049**

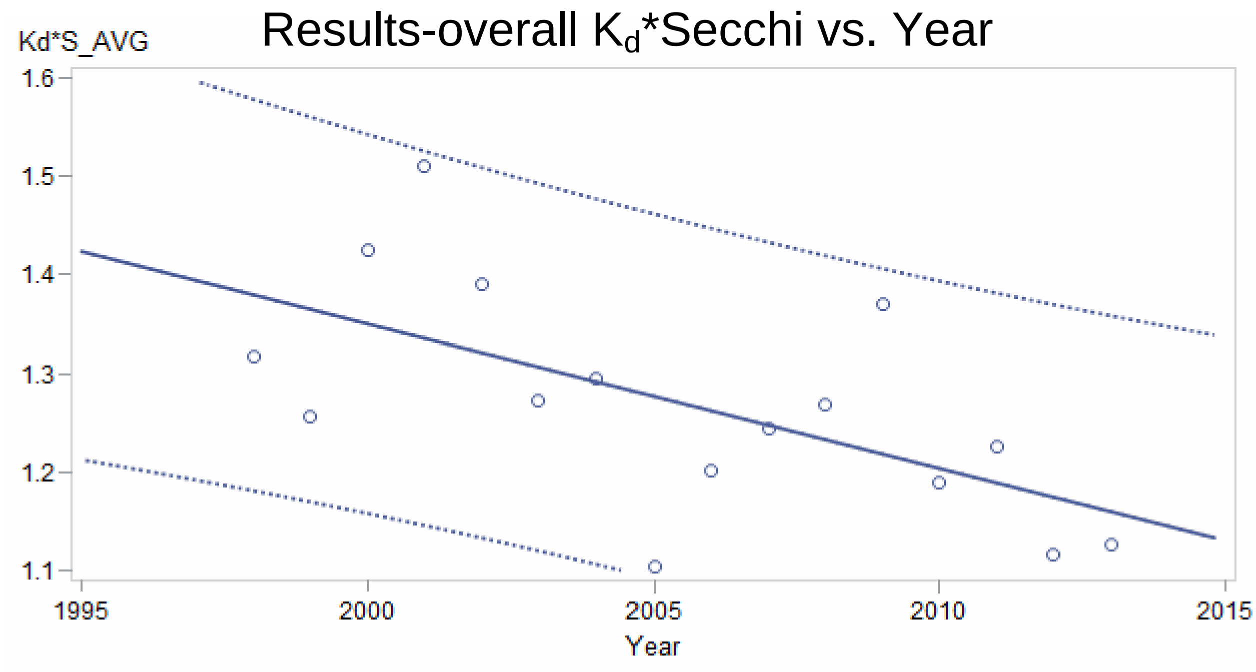

Figure 5.3.1 Maryland Coastal Bays (all bays) water clarity trend of K_d * Secchi.

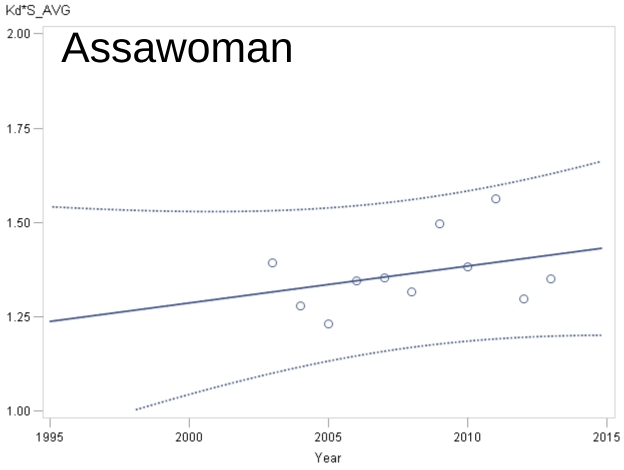

Figure 5.3.2 Assawoman Bay water clarity trend of K_d * Secchi.

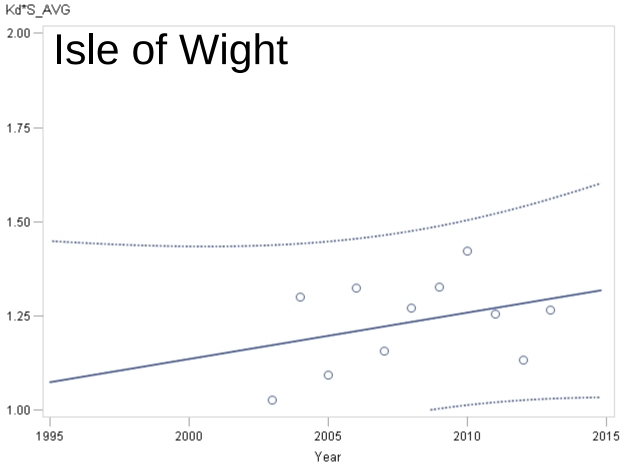

Figure 5.3.3 Isle of Wight Bay water clarity trend of K_d * Secchi.

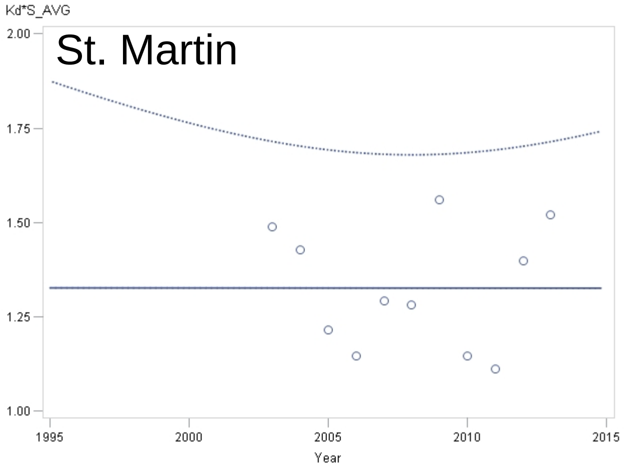

Figure 5.3.4 St. Martin River water clarity trend of K_d * Secchi.

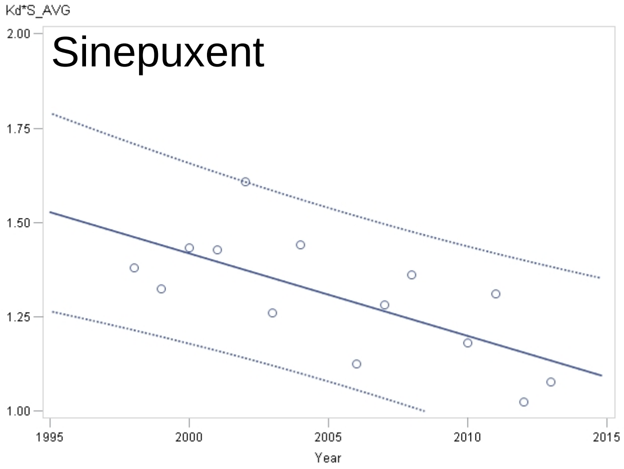

Figure 5.3.5 Sinepuxent Bay water clarity trend of K_d * Secchi.

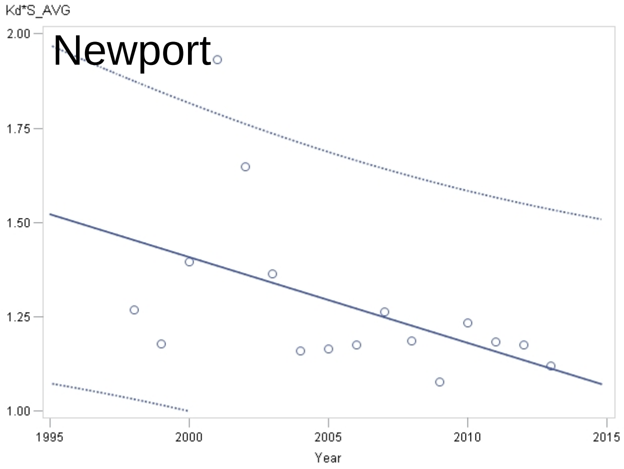

Figure 5.3.6 Newport Bay water clarity trend of K_d * Secchi.

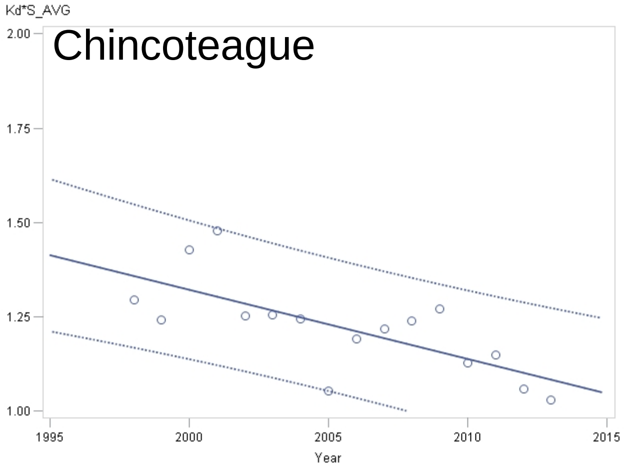

Figure 5.3.7 Chincoteague Bay water clarity trend of K_d * Secchi.

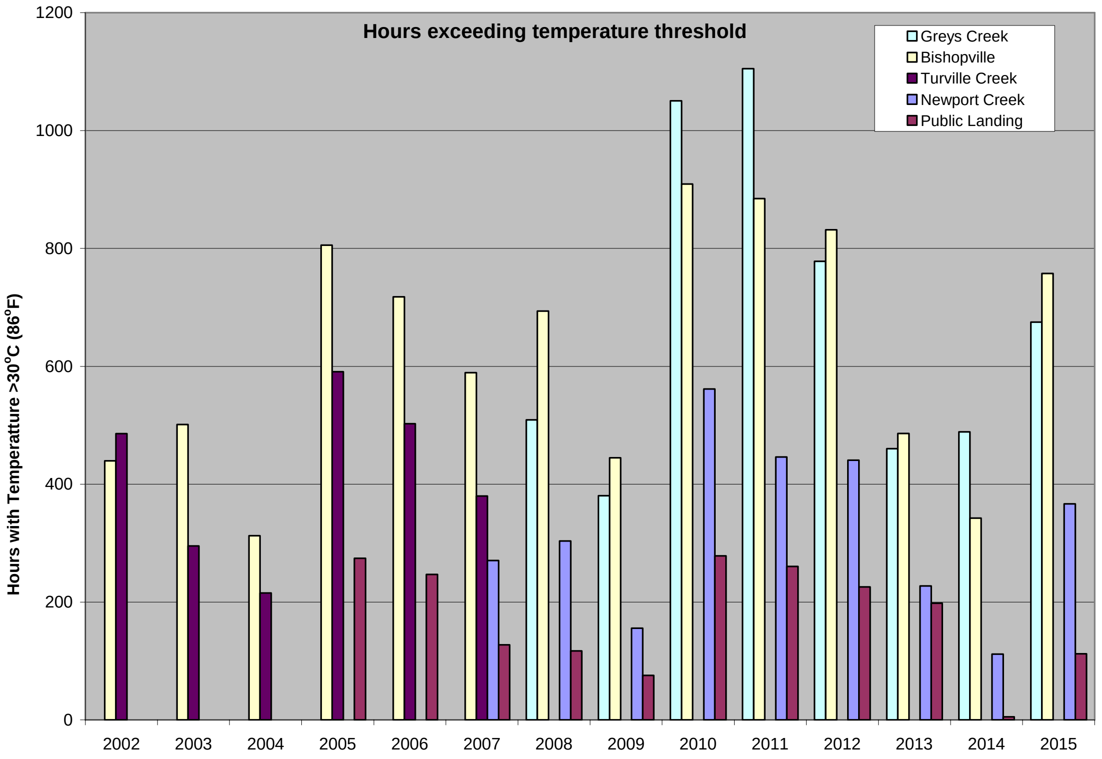

Figure 5.3.8 Duration of eelgrass temperature exceedances (>30°C or 86°F) at four continuous monitoring sites in the Coastal Bays during SAV growing season. Site NPC0012 is in Newport Bay watershed. Site XBM8828 is at Public Landing in the Chincoteague Bay watershed. Site XDM4486 is at Bishopville Prong in the St Martin watershed. Site XDN6921 is at Greys Creek in the Assawoman Bay watershed. Temperature exceedances were greatest in 2010-2012.