ADDENDUM TO THE REPORT:

DEVELOPMENT OF DIAGNOSTIC APPROACHES TO DETERMINE SOURCES OF ANTHROPOGENIC STRESS AFFECTING BENTHIC COMMUNITY CONDITION IN THE CHESAPEAKE BAY

Prepared for:

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1. Introduction

Dauer et al. (2002) submitted a report to the US EPA Chesapeake Bay Program Office on the development of diagnostic approaches to determine sources of anthropogenic stress affecting benthic community condition in the Chesapeake Bay. The objective of the study was to develop analytical tools capable of classifying regions in Chesapeake Bay identified as having degraded benthic communities into categories distinguished by the type of stress experienced by those communities. The tool was successful at identifying regions with high probabilities of sediment contamination. However, prior to implementation, it was recommended that the operational effectiveness of the diagnostic tool be further tested using additional validation data sets.

In this Addendum the results of two additional tasks are presented. First, the linear discriminant function was independently derived to verify the accuracy of the development of the function. Second, two additional putative validation data sets were used to assess the validity of the linear discriminant function.

2. Linear discriminant function

In this task it was discovered that four samples from the original calibration data set were not included in the derivation of the final linear discriminant function originally reported in Dauer et al. 2002. The final validation of the linear discriminant function with these additional four samples was identical to that reported in Table 21 for the Baywide scenario, i.e. using the All Province sediment contaminant classification, namely, with an overall percent correct classification of 75.14%. The new coefficients for this function are given in Table 1 of this Addendum (revised Table 24 of Dauer et al. 2002).

3. Additional validation data sets

Two putative data sets were used for further validation of the Contaminant Discriminant Tool (CDT) as presented in Dauer et al. 2002.

Elizabeth River Watershed

The first putative data set consisted of 125 random samples collected in 1999 from the Elizabeth River watershed (Dauer and Llansó 2003). An additional 100 random samples collected 25 per year from 2000-2003 were also used (Dauer 2001, 2002, 2003, 2004). All samples were analyzed using the CDT function and placed into categories based upon the posterior probability of inclusion into the Contaminant Group. Due to the high levels of contaminants recorded historically in the Elizabeth River watershed (Hall et al., 1992, 1997, 2002; Padma et al. 1998; Conrad et al. 2004), the *a priori* expectation was that a high percentage of samples declared degraded by the Benthic Index of Biotic Integrity would be placed into the Contaminant Group. The results from the Elizabeth River watershed are compared to results from the Virginia

Mainstem that is characterized as having low levels of contaminants and accordingly classified as of no environmental concern (USEPA 1999).

Our *a priori* expectation was that all branches of the Elizabeth River would show a higher percent area placed into the Contaminant Group compared to the Virginia Mainstem. For the Virginia Mainstem the number of sites placed into the Contaminant Group represented 11% of the entire stratum. Consistent with our *a priori* expectation, all strata in the Elizabeth River had higher proportions placed into the Contaminant Group, ranging from 40-92% (Table 2; Figure 1). These results indicate strong support for the CDT.

1996-2002 random data for Chesapeake Bay

The second putative data set consisted of random samples collected as part of the Maryland and Virginia Benthic Monitoring Program from 1996-2002. All samples were analyzed using the CDT function and placed into categories based upon the posterior probability of inclusion into the sediment Contaminant Group. The *a priori* expectation was that more samples collected near highly urbanized or industrialized watersheds would be placed into the Contaminant Group. Results are more difficult to interpret but the pattern of location of samples placed into the Contaminant Group is non-random (Table 3; Figure 2), and can be interpreted to be consistent with known patterns of sediment contaminant distributions for the entire Chesapeake Bay (e.g. see USEPA 1999). GIS maps show patterns of location that agree well with a priori expectations within highly contaminated regions of the Bay such as Baltimore Harbor (Figure 3) and the Elizabeth River (Figure 4). The maps were made with data placed on a 100 m grid and interpolated using a two-dimensional surface fitting algorithm.

4. References

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Table 1. Revised Table 24 of Dauer et al. (2002). Coefficients and cutoff values for the Baywide linear discriminant function for classifying severely degraded and degraded sites into the Contaminant and Other stress groups using "uncorrected" data.

Variable	Coefficient	Variable	Coefficient
Isopoda abundance	2.01518	Nereidae abundance	-0.28511
Isopoda diversity	-3.07226	Nereidae richness	-0.53535
Isopoda proportional abundance	9.45420	Nereidae proportional abundance	12.23099
Amphipoda abundance	0.38084	Oligochaeta abundance	0.43911
Amphipoda richness	-0.32010	Oligochaeta richness	1.37409
Amphipoda proportional abun.	-4.25029	Oligochaeta proportional abundance	-5.05367
Haustoriidae abundance	-3.85522	Tubificidae abundance	0.33669
Haustoriidae diversity	-1.39235	Tubificidae richness	0.96057
Haustoriidae proportional abun.	34.61687	Tubificidae proportional abundance	-2.27273
Ampeliscidae abundance	-1.57316	Deep deposit feeder abundance	-1.07320
Ampeliscidae richness	-1.79716	Deep deposit feeder richness	-2.43057
Ampeliscidae proportional abun.	25.88958	Deep deposit feeder proportional abun.	12.57963
Corophiidae abundance	37.26499	Suspension feeder abundance	1.05255
Corophiidae richness	-18.36548	Suspension feeder richness	-1.25065
Corophiidae proportional abun.	-2329.15377	Suspension feeder proportional abun.	2.17966
Mollusca abundance	2.52241	Interface feeder abundance	0.84134
Mollusca richness	0.74909	Interface feeder richness	-0.47052
Mollusca proportional abundance	-1.43165	Interface feeder proportional abundance	4.50630
Bivalvia abundance	-4.43466	Carnivore-Omnivore abundance	-0.05179
Bivalvia richness	1.28499	Carnivore-Omnivore richness	-0.00602
Bivalvia proportional abundance	-0.27727	Carnivore-Omnivore proportional abun.	3.13784
Gastropoda abundance	-1.23734	Total Abundance	0.18311
Gastropoda richness	-0.15477	Total biomass	4.75310
Gastropoda proportional abun.	-3.82240	Biomass to abundance ratio	-123.97124
Polychaeta abundance	0.05506	Infaunal species richness	-0.04107
Polychaeta richness	0.46294	Infaunal Shannon Wiener diversity	1.22042
Polychaeta proportional abun.	-5.08183	Infaunal species evenness	-2.50732
Spionidae abundance	-0.02286	Epifauna to Infaunal abundance ratio	4.41998
Spionidae richness	-1.89087	Epifauna species richness	-0.96505
Spionidae proportional abundance	4.02486	Epifaunal Shannon Wiener diversity	-1.11725
Capitellidae abundance	0.48588	Epifaunal species evenness	5.85736
Capitellidae richness	2.55550		
Capitellidae proportional abun.	-1.67289		

Cutoff Value = 2.56645

Table 2. Percent of the Elizabeth River 1999 strata placed into the sediment contaminant effect group using the contaminant discriminant function of Dauer et al. 2002 (posterior probability > 0.5). Scuffletown, Gilligan, Jones, and Paradise creeks are subsystems of the Southern Branch. Paradise Creek sampled in 2000. The Elizabeth River strata are compared to the Virginia Mainstem Stratum.

Stratum	Percentage of Stratum in Contaminant Group
Mainstem of the Elizabeth River	40
Lafayette River	60
Eastern Branch	64
Western Branch	72
Southern Branch	64
Scuffletown Creek	60
Gilligan/Jones Creek	68
Paradise Creek (2000)	92
Entire Elizabeth River watershed*	54
Virginia Mainstem	11

* Area weighted value

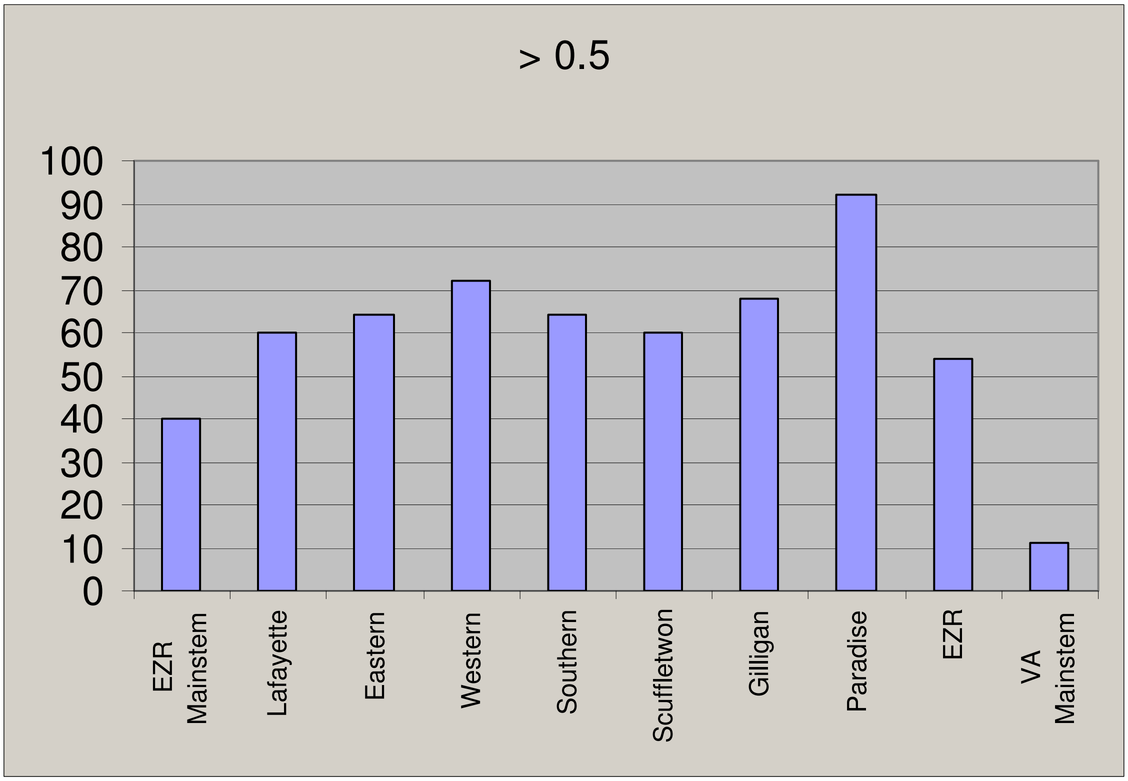

Figure 1. Percentage of stratum with a B-IBI value < 2.7 and placed into the Contaminant Group with a posterior probability > 0.5.

Table 3. Percent of the stratum placed into the sediment contaminant effect group using the contaminant discriminant function of Dauer et al. 2002 (posterior probability > 0.5). Data from 1996-2002. Elizabeth River data includes the intensive 1999 event and 25 random samples of the watershed from 2000-2002.

Stratum	N	Percentage of stratum in Contaminant Group
Lower (VA) Mainstem	175	10.9
Upper Bay Mainstem	175	17.7
MD Eastern Tributaries	175	16.6
Patuxent River	175	20.0
MD Middle Mainstem	175	17.1
MD Western Tributaries	175	24.6
Potomac River	175	31.4
James River	175	30.9
Rappahannock River	175	37.1
York River	175	38.3
Elizabeth River	275	52.4

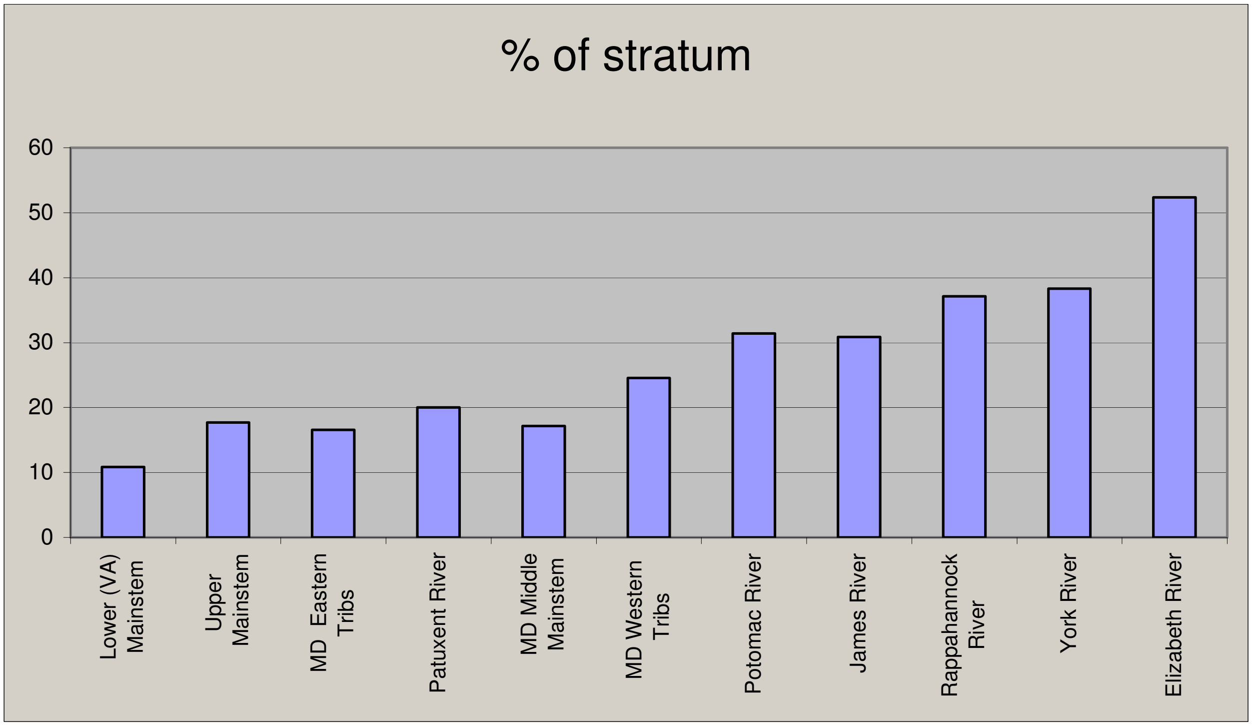

Figure 2. Percentage of stratum with a B-IBI value < 2.7 and placed into the Contaminant Group with a posterior probability > 0.5.

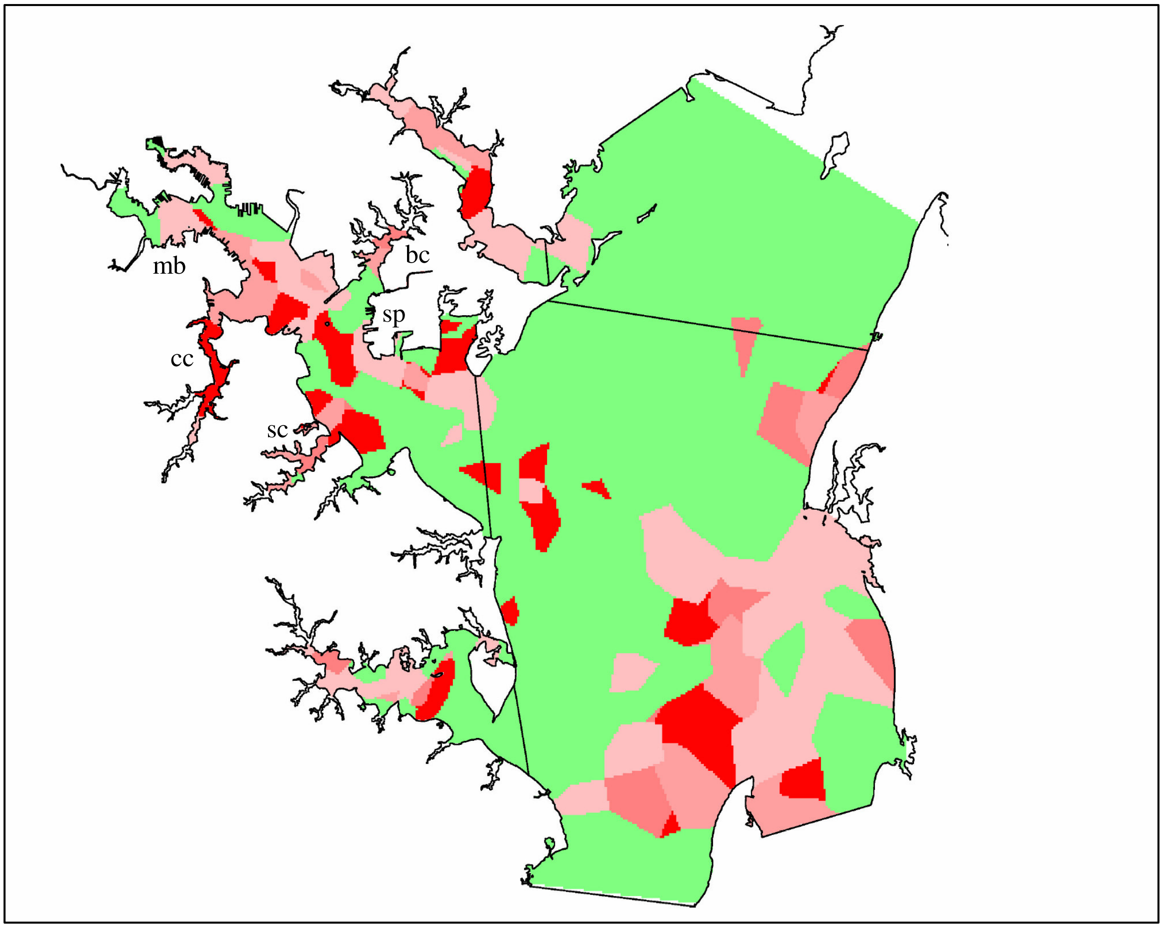

Figure 3. Diagnostic discriminant tool results and an interpolation fitting algorithm were used to classify Baltimore Harbor benthic communities into categories distinguished by the type of stress experienced by those communities. Red shading indicates degraded benthic communities stressed by toxic contamination (posterior probability in Contaminant Group > 0.5), with higher color intensity indicating higher probabilities of contaminant effects (>0.5 to <0.7; >=0.7 to <0.9; >=0.9). Salmon shading indicates degraded benthic communities stressed by other sources, most likely low dissolved oxygen (posterior probability in Contaminant Group <=0.5). Green indicates good benthic community condition. Middle Branch (mb), Curtis Creek (cc), Stony Creek (sc), and Bear Creek (bc) show contamination as likely source of stress. The deep basin north of Curtis Bay and the deep channel southwest of Sparrows Point (sp) shows other stress (low DO) as probable cause of degradation.

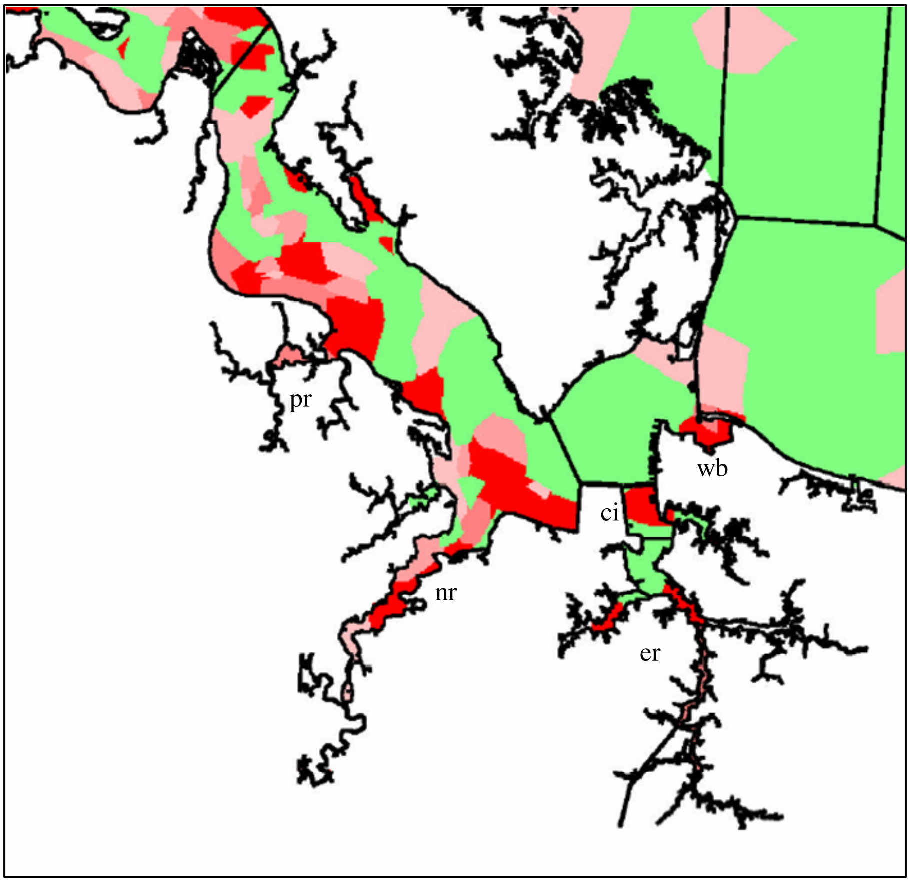

Figure 4. Diagnostic discriminant tool results and an interpolation fitting algorithm used here to classify lower James River benthic communities into categories distinguished by the type of stress experienced by those communities. Red shading indicates degraded benthic communities stressed by toxic contamination (posterior probability in Contaminant Group > 0.5), with higher color intensity indicating higher probabilities of contaminant effects (>0.5 to <0.7; >=0.7 to <0.9; >=0.9). Salmon shading indicates degraded benthic communities stressed by other sources (posterior probability in Contaminant Group <=0.5). Green indicates good benthic community condition. The Elizabeth River (er), Craney Island (ci), Willoughby Bay (wb), Nansemond River (nr), and Pagan River (pr) show contamination as likely source of stress.