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NORTH CAROLINA
Environmental Quality

CRC-21-02

February 1, 2021

MEMORANDUM

TO: Coastal Resources Commission

FROM: Ken Richardson, *Shoreline Management Specialist*

SUBJECT: Inlet Hazard Area Boundary Update & Rule Amendments: Additional Public C

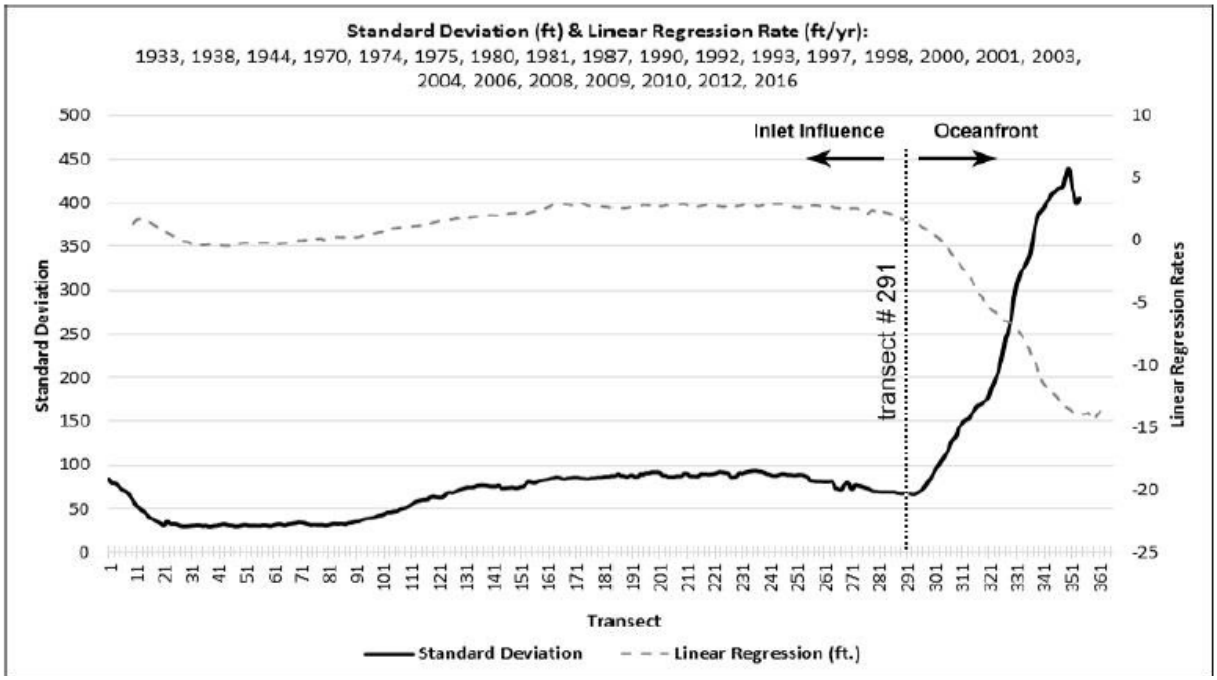
At the Coastal Resources Commission's February 2019 meeting in Manteo, the Commission approved the updated Inlet Hazard Area (IHA) boundaries as recommended in the CRC's Science Panel's report, "*Inlet Hazard Area Boundary, 2019 Update: Science Panel Recommendations to the North Carolina Coastal Resources Commission,*" and the IHA erosion rate setback factors report prepared by the Division of Coastal Management, "*2019 Inlet Setback Factors*," which are associated with rule amendments to 15A 7H .0304, 07H .0306, 07H. 0309 and 07H .0310. On August 30, 2019, the NC State of Office of Budget and Management (OSBM) approved the fiscal analysis.

As part of the rule making process, the Division of Coastal Management held seven public hearings (Brunswick, New Hanover, Pender, Onslow, Carteret, Hyde, and Dare Counties) for the purpose of presenting updated IHA boundaries, proposed rule amendments, and collecting public comments (download public comments). Five additional workshops (Ocean Isle Beach, Holden Beach, Carolina Beach, Topsail Beach, and North Topsail Beach) were held to allow additional opportunities to address questions from public officials and the general public.

At the Coastal Resources Commission's November 2020 meeting, Mr. Bill Birkemeier (CRC's Science Panel Chair) presented a detailed response to questions and comments specific to the Inlet Hazard Area Methodology (IHAM) used by the Panel to delineate the proposed new IHA boundaries. In addition, the CRC was also provided access to the full packet of comments received during the public comment period.

Since the November 2020 meeting, DCM has received follow up comments from Mr. Smith at Ocean Isle (attached). In reference to Figure 17 (see below) in the IHA boundary update report, Mr. Smith asked why transect #291 was identified at Ocean Isle (Shallotte Inlet) by the Science Panel to be the location where inlet related processes start to have a dominate influence on the shoreline and suggested that transect #295 appears to be a more accurate location since that seems to more closely reflect where the standard deviation curve (solid black line) starts to increase. Mr. Smith also pointed out a labeling error on the graph where "Inlet Influence" and "Oceanfront" should be reversed.

Figure 17. Based on the standard deviation of shoreline position at Shallotte Inlet-Ocean Isle Beach, transect-291 is recommended as the inlet-ocean transition boundary along the shoreline. Negative Linear Regression rates indicate erosion, while positive values represent accretion (right axis).



To address Mr. Smith's concern, DCM Staff consulted with the Science Panel to reaffirm that transect #291 was identified intentionally and correctly. After further consideration, it was agreed that #291 is correct; however, it was noticed that the identification of #291 was also influenced by the linear regression curve (dashed gray line) where shoreline accretion influenced by beach nourishment ends, and the shoreline change rate begins a rapid transition to erosion approaching the Shallotte Inlet. While this detail was not included in the report, the Science Panel is recommending an amendment be made to record this consideration, in addition to correcting the graph labels. Mr. Smith's second submission contains additional comments; however, Staff believe these were adequately address by the Science Panel Chair at the November 2020 Commission meeting.

Attachment A: IHA Comments from Mr. Wilson Earl Smith at Ocean Isle

Additional Comments Regarding 2019 Inlet Hazard Area Boundary Update – Science Panel Responses to Public Comments

WILSON EARL SMITH – OCEAN ISLE BEACH
JANUARY 4, 2021

On November 18, 2020, Chairman Cahoon and the CRC members heard the Science Panel responses to 140 pages of public comments regarding the document entitled "Inlet Hazard Area Boundary, 2019 Update" that is the reference document for proposed Inlet Hazard Area Boundaries and Regulations. Included in those comments on pages 95-113 were detailed findings from the analysis that I performed of the contents of that document and information obtained at the Ocean Isle Beach public meeting. I included a brief biography to describe my credentials to perform such a peer review, not of the oceanography but of the application of computational, statistical and graph theory to the tasks assigned by the CRC and as executed by the Science Panel. Where possible, I used quotes from the Science Panel document and provided extensive explanations including some diagrams to aid the Science Panel in understanding the problems that I cited. I described the responses that I considered to be necessary to close each issue.

At the conclusion of Bill Birkemeier's presentation and subsequent discussion, action was postponed to the February, 2021 meeting awaiting any further public comments. I have reviewed the Science Panel wri8en response to comments. The Science Panel specifically deferred to the CRC on the topic of peer reviews as requested in other comments.

I am submitting these follow-up comments for consideration by the Science Panel and CRC to address the following topics that need to be addressed before taking action on regulations.

1. Inadequate Responses to Issues Raised in My Peer Review of February 8, 2020
2. Need to Address Serious Open Technical and Methodology Questions 3. Necessity of Peer Reviews

1. Inadequate Responses to Issues Raised in My Peer Review of February 8, 2020:

Direct Responses were not provided to my comments. Instead, responses to some of my issues appear sca8ered throughout the Science Panel response document distributed at the November, 2020 CRC meeting. In the following, I review the 5 issues that I raised, the responses that I found, and my objections to those responses.

a. Issue 1 – Multiple Errors, Omissions, Misstatements and Contradictions

The document as wri8en delivers recommendations that deviate from the (CRC) assigned task, states multiple differing and conflicting versions of the alongshore IHA boundary definition, omits methodology details and fundamental explanations and makes erroneous statements.

My objection: I see nothing in the Science Panel response that even hints at fixing these problems found in the Science Panel "Inlet Hazard Area Boundary: 2019 Update" document. Instead, the Science Panel responses to other issues suggest that even more updates are needed. This Science Panel Recommendations document is the reference for the regulations and for the 5 year or other updates to follow. It must be corrected.

b. Issue 2 – IHAM Is Built on an Unstable Foundation

Here, I provide nearly 5 pages of detail showing 2 things:

1. The Science Panel could not se8le on a definition for the alongshore boundary of the IHA in their recommendation. This is disappointing given that the CRC only told them to find the point of dominance. Shoreline variability as indicated by standard deviation seems to have expanded the IHA beyond what point of dominance would require. Their inability to stick with the definition given in the Executive Summary as "The alongshore boundary of the IHA is identified by an increase in shoreline change variability compared to adjacent shoreline that is not influenced by the inlets." and the lack of any precise definition acceptable to the panel undermines the effectiveness of the entire IHAM.
2. Section 2.4 in the Science Panel recommendation clearly states "Figure 6, which plots the alongshore variation in the Standard Deviation and the LRR, illustrates the methodology that was used." The reader would assume that this is supposed to be explanation by example of how it ***correctly*** works in light of the boundary definition articulated in the executive summary. In their response to comments, the Science Panel insists that standard deviation

identified the correct boundary 64% of the time. This, being the illustrative example, should have been one of those that worked. Upon examination, the illustration of that methodology did not work at all. In fact, the alongshore boundary at transect-291 meets none of the stated definitions or criteria.

While transect-295 appears to be the correct and logical location. Section 3.2a simply says "Inlet transect-291 is the boundary along the oceanfront shoreline where inlet processes start to affect the shoreline's position" making reference to Figure 17 where the directions of the inlet and oceanfront are incorrectly shown. Transect-291 only works without
intervention by the Science Panel if the erroneous inlet location in Figure 17 is used. In the Science Panel recommendation document in bullet #6 on page 20, the IHAM process specifically calls out this item for an explanation if the Science Panel made professional knowledge adjustments. There is no explanation given in Section 3.2a as to how transect-291 became that boundary location, another indication that they used the incorrect inlet location and thought that standard deviation worked without modification.

I challenged the Science Panel to correct what appears to be an error or to defend their work and explain how they arrived at transect-291, as promised in the IHAM. In their October 29 response, the Science Panel states "Changes to the initial IHAM computation were not quickly adopted as, in meeting aKer meeting, the panel analyzed and discussed each inlet boundaries based on their collective expertise. The decisions were unanimous and are explained in the report." Yet, there is no explanation found on page 30 of the Recommendation Document for this inlet location.

My objection: It is reasonable to expect the Science Panel to directly address my points of disagreement on transect-291 as the boundary as they are based solely on information and lack thereof from their recommendation document. That has not occurred. As both a reviewer and an affected property owner, I am again requesting either a correction to the boundary location or a detailed explanation for transect 291 as the alongshore boundary.

c. Issue 3 – IHAM Does Not Work As Claimed

At the end of the methodology section 2, page 20, the claim was "*"The IHAM as described above worked well at most of the inlets, requiring no additional modification."*. Again, drawing from their document, I presented tables of what the document said and discounted for locations where the IHA encompassed a full barrier island.

It seems irrelevant whether the number is 50% or 64%. Either represents some degree of success and skill. However, I would not expect to pass a course with either average and I would not purchase a product, trust a vaccine or fly in any

aircraft that, at best, worked 64% of the time. In situations such as this, simplifying assumptions are commonly employed in practice to provide interim solutions that do work effectively, even if less efficiently.

My Objection: The Recommendation document from February, 2019 is woefully inaccurate in the descriptions of how the methodology is employed and in its claims about how well it worked. At a minimum, this document needs to be updated to accurately describe the IHAM effectiveness, to update Section 2 to more accurately explain how the alongshore boundary recommendations were derived and to ensure that all necessary explanations are provided in the inlet discussions.

d. Issue 4 – Hybrid Vegetation Line

In the local meeting at Ocean Isle Beach, we were told that the Hybrid Vegetation Line (HVL) was only being used for siting the landward extent of the IHA. This issue requested that this limitation be documented.

The following statement was provided in the response to comments. "Although the Science Panel found the HVL to be a robust and useful feature, which works on both eroding and accreting sides of an inlet, DCM has decided not to incorporate the HVL nor the risk lines in any of the proposed IHA rule documents or maps presented to the CRC or to the public."

My Objection: The above statement stops well short of the verbal statement made at the public meeting. Perhaps that is because in my earlier comments, I cited a statement on p.43 of the Science Panel recommendation showed that the verbal statement was untrue. It now appears that the HVL is a primary element in many decisions such as alongshore boundary locations that affect the regulations. So, while it is not shown in the regulations, it is still there. The Science Panel must completely disclose all of these instances of use in the recommendations document so that they can be understood and accepted now and then revisited in the 5-year updates.

e. Issue 5 – Recommendation for Updating Inlet Hazard Boundaries
The Science Panel recommended 5-year updates to the Inlet Hazard Areas.

My additional comment: This is a recommendation that I fully supported. The Science Panel acknowledges the underlying linearity of data assumption of Linear Regression. This assumption likely does not hold near inlets. Updates every 5 years are essential to correct for the nonlinearity of shoreline change near inlets and even those updates will not necessarily be sufficient to contemporaneously react to rapid changes such as those at the Sunset Beach side of Tubbs Inlet which is described on page 21 of the Science Panel document. "The northeastward migrating spit on Sunset Beach retreated 1100 feet around 2013 but was quickly

recovering by 2017." This all occurred within a 5-year time span and contributes to the first open question below.

2. Need to Address Serious Open Technical and Methodology Questions:

Open Questions Relative to Shoreline Change Rates

Section 2.3 describes the use of Linear Regression to satisfy the first task assigned to them. "Develop an inlet change rate calculation methodology". The Linear Regression Rates from those models became the transect erosion or accretion rates. That section closes with the statement: "Once computed, the linear regression rate was then smoothed as described previously for the HVL (Figure 2); but instead of averaging 5 transects, a 17-transect running-average alongshore was used. This follows the DCM blocking computation used for the OEA shoreline rates and further smooths the alongshore variation in the shoreline change rate."

In his comments, Spencer Rogers, Coastal Construction and Erosion Specialist, North Carolina Sea Grant noted that "Erosion Rate Blocking Underestimates Inlet Erosion Rates". While blocking can result in lower setback factors than the LRR might justify, it is the smoothing algorithm that additionally suppresses the erosion rates at the most seriously eroding locations in the throat of the inlet. It also affects the area at the other end of the inlet hazard area at the alongshore boundary except there, it tends to overestimate the erosion rate near the alongshore boundary. The problem, which I refer to as data skewing, is most acute in the vicinity of sharp changes in the standard deviation (see Issue #1, item 7 on page 6 of my comments and page 100 of the IHA_Public_comments_ALL_20200302.pdf).

However, Murray from the Science Panel in his review on page 30 of the response to public comments seemingly did not recognize the data skewing problem that I highlighted in my comments. He noted "The Linear Regression Rates (LRR) is used in the IHAM as a secondary criterion for delineating IHAs." This is shown to be a flawed procedure in my comments and should be reviewed at every inlet where this procedure was applied. Both standard deviation and LRR are calculated from the same shoreline position data. They should point to the same location as the alongshore boundary and should confirm one another but do not. My comments expose the fallacy of using LRR for delineating IHAs.

The Science Panel knows that use of running averages is an open question. In their recommendations found in Section 4 on page 96 of their document, they list evaluation of "the effect of various running averages in smoothing transect points alongshore;" as something for the next update.

The problem is larger than just the smoothing algorithm and various running averages. There is a second reason that inlet erosion rates could be underestimated (or also overestimated). In fact, the Science Panel acknowledged that Linear Regression "tends to underestimate the rate of change relative to other statistics, …" on page 18 of their

document. The problem is that Linear Regression is based on an underlying assumption that the shoreline data is changing in a linear manner. This is a particularly serious problem for locations near inlets where shoreline movement can accelerate or decelerate as in the Tubbs Inlet example cited earlier. In these cases, LRR is a lagging prediction that will take time to adjust. The more rapid the change, the more acute the problem will be. This is a perfect example of how linear regression can lead to inefficient or biased models. McNinch in his review states "Use of linear regression versus end-point for shoreline behavior is a no-brainer." and my comments should not be taken as a suggestion that a higher order polynomial should be used but a brain must be used. A piecewise linear approach can suffice. However, the Science Panel should have a strategy that looks at both the short-term and long-term shoreline movement so that 5-year updates can compensate properly for both accelerating and decelerating movement, especially those that appear suddenly.

The task needs to be completed and documented. The above problems are not hard problems to identify and to characterize and are too important to be relegated to some future update.

Open Questions Regarding Location of the Alongshore Boundary.

The Science Panel has not found a satisfactory way to complete their second assigned task from July, 2016 (Re-evaluate points along the oceanfront shoreline where inlet processes are the dominant influence over shoreline position.). The problems are highlighted in detailed comments for my issues 1 and 2 (pages 98-105 of the DCM comments document) where even a descriptive definition of the feature of interest, the alongshore boundary could not be se8led.

That boundary is not only the alongshore boundary of the inlet hazard area, it is also the alongshore boundary of the ocean erodible area. What are the boundary conditions that separate the two areas? When is a property sufficiently different from one in the ocean erodible area to be regulated differently? If you cannot answer that question, then you must ask if such a location really exists. As it stands, that boundary is completely arbitrary as the use of standard deviation as presented in the methodology section of the Science Panel recommendation document is now acknowledged as not the process but only a starting point.

On page 8 of the panel response to comments, it is stated "Changes to the initial IHAM computation were not quickly adopted as, in meeting after meeting, the panel analyzed and discussed each inlet boundaries based on their collective expertise. The decisions were unanimous…" Unfortunately, this can be taken that there was no common agreement on this definition before they began trying to locate those boundaries. It is not clear what it took to obtain unanimous agreement or what that really means. Is it a multi-dimensional problem because you have 10 different opinions to satisfy?

What criteria did they satisfy to get to that point of unanimous agreement? If that can be stated, then you have the beginnings of a definition. In most any case, it is preferable for the observed data to speak and reveal the location of the alongshore boundary and that would form a logical and repeatable process. But, without a definition of what that location looks like and how it differs from the ocean erodible area, it is an illogical and impossible task. There is no basis for any data driven placement and maybe no boundary at all.

In the sub-panel peer review summary (Appendix B, page 28) is the following statement: "We recommend exploring additional metrics at a later date that may be used in concert with shoreline variability to make establishing IHA boundaries less arbitrary and repeatable across the state." While this seems like a nice gesture, it confirms the arbitrary and non-repeatable nature of what the Science Panel has proposed. Suggestions to consider future work to fix the boundaries once they have already been imposed seem pre8y empty. It just confirms that the task is not completed.
The Science Panel rejected the criteria in the task as given to them by the CRC. If they need to delay this work, then less aggressive alongshore boundaries, ones with precise definitions, should be implemented now. Then, let the Science Panel explore those additional metrics at a later date and tighten the boundaries in concert with a quantifiable risk to life and property that justifies that tightening. Those changes can be part of a future 5-year update that completes this task.

3. Necessity of Peer Reviews:

When you consider the task at hand, defining Inlet Hazard Areas, you must realize that there are at least two components. The first is the pure science component, the physical aspects of the sea and the inlet behaviors that experts in this discipline can observe and explain. If the behavior is completely deterministic, future behavior is known. If not, as is the case here, a second component, the applied science aspect, one that utilizes other disciplines to measure observable phenomena and make predictions about future behavior of interest comes into play. Simplifications and approximations such as Linear Regression may be used but those must be applied with care as models are developed that are, at best, approximations of the system behavior. Peer reviews should be viewed as a positive step towards validating both the scientific content and the application of other disciplines, in this case to predict areas with elevated risk due to inlet behaviors.

Peers are experts in any discipline utilized that are independent of the work under review. They can draw on either expertise in the field or other fields and experiences in similar endeavors to highlight concerns or issues. This is going to raise questions and, in so doing, they reveal things that need a8ention.

Independent peer reviewers each have a unique perspective from which they form their individual responses. The new Science Panel members who reviewed the document have theirs. I have a different background, one based in another field but very much applicable use of statistical methods in the identification of inlet hazard areas as is done here. Peer

reviews should not be limited to the pure science aspect. In ground breaking work, a review by experts in related disciplines can be hugely beneficial. In those instances, a peer review focuses on two major themes. The first is analysis of the body of work in the context of the reviewer's primary field of expertise, things like probability and statistics or model construction, the mapping of observed phenomena to abstract models. The other theme is to verify that the scientist describes adequately and completely what he did and that he correctly executed what he claimed to have done. I noted deficiencies of that nature in my review.

Reviewers do not always agree. For instance, one of the new Science Panel members, McNinch wrote "Overall, the 2019 Inlet Hazard Area Boundary Report is well wri8en – concise, logically-organized, and the methodology (IHAM) is sound." In my peer review, pages 95-113 of the
IHA_Public_Comments_ALL_20200302.pdf that was delivered at the November meeting, my assessment was that the problems with the February 2019 version of the Science Panel Recommendation document, one that will be the reference work for the proposed regulations, "are severe enough that the Science Panel Recommendation document must be revised and updated. In its present form, it is not suitable as a reference document for any regulatory purpose." It is important that these and all peer review issues are addressed and differences resolved as that only serves to strengthen the outcome, add credibility to the entire piece of work, and most importantly here, to provide valid reference documentation.

Page 17 of the Science Panel response to comments includes the following statement. "The IHA report presents a new procedure, the IHAM, which along with the accompanying regulations will be of interest to coastal managers around the nation and across the world. We encourage DCM to take the lead in drafting a paper for peer review that will publicize North Carolina's approach to inlets."
The reference document for proposed regulations is not some future paper. The one referenced in the regulations is currently the 2019 Science Panel Recommendations document. That one has substantial flaws. The one referenced in the regulations must be a corrected version as what is stated there will be the basis from which the next 5-year and future updates to the inlet hazard area boundaries are performed.

The Science Panel seems to have missed the point of peer reviews. Additional formal peer reviews, besides the one that I provided, are needed to ensure that the work is recognized by independent experts as adequately documented, technically correct and complete enough to support the proposed regulations. In the 2019 IHA Recommendations document, one of the issues to evaluate in the next update is "the effect of various running averages in smoothing transect points alongshore; ". As noted above, my review exposed problems that resulted from the smoothing that should be addressed now.

Peer reviews should be ingrained in the fabric of what the Science Panel is doing. As such, there could be a standing set of experts that voluntarily and routinely read and review

pre-release versions of the Science Panel's work at appropriate times and certainly before publication for public comments.

An updated Recommendations document is needed and that one should become the one referenced in the regulations. Peer reviews are best completed and corrections made to the recommendations document before any additional publication of the nature recommended in the Science Panel response to comments is undertaken.