NORTH CAROLINA
Environmental Quality

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CRC-20-33

November 6, 2020

MEMORANDUM

TO: Coastal Resources Commission

FROM: Bill Birkemeier (CRC Science Panel on Coastal Hazards Chair) & Ken Richardson (NC DCM Staff)

SUBJECT: Inlet Hazard Area Boundary Update and Rule Amendments: Public Comment

(Download Public Comments)

Summary of Public Comments:

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, 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.

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Public commits submitted to the Division of Coastal Management could generally be categorized into the following categories:

1) **Concerns with the process of updating Inlet Hazard Areas**
2) **Concerns with public hearing notices and scheduling**
3) **Concerns with the Inlet Hazard Area Methodology (IHAM)**

Both DCM Staff and the Science Panel are providing responses (below) to common questions/comments expressed during the public hearing period. First are DCM Staff responses to questions/comments regarding the overall process associated with updating the Inlet Hazard Area. While there were additional comments related to the fiscal analysis and proposed IHA use standards, Staff has acknowledge previously that there will be additional amendments related to grandfathering and setbacks, that will necessitate additional hearings and update to the fiscal analysis. Secondly, the NC CRC's Science Panel has provided responses to public comments pertaining to the Inlet Hazard Area Methodology.

DCM Staff:
Questions/Comments with the Process of Updating Inlet Hazard Areas: (NC DCM Staff)

During public hearings and workshops, questions were raised with the general procedures and process of defining Inlet Hazard Areas and rules and with why the boundaries are needed. The following are summarized themes:

1. Why is it necessary to define IHA boundaries?
2. Would like to have seen more public involvement from the start.
3. Not all inlets present a current hazard and do not have erosion problems. Would rather IHA's be called something different, such as "*inlet areas*," "*areas of inlet influence*" or "*inlet management areas*."

DCM Staff Response: The Coastal Area Management Act (CAMA) of 1974 requires the Coastal Resources Commission to periodically review all Areas of Environmental Concern (AEC) to evaluate if they are still needed, or require updating (§ 113A-115(4)(c)). Although the IHA boundaries themselves have remained static since 1979, much of the land area within them has continued to be in a constant state of flux (eroding and accreting) to varying degrees due to ocean inlet-related processes, storm events, and engineering practices (dredging, realignment, and erosion control structures). In some cases, the inlet has migrated out of the IHA boundary altogether. Given that the current boundaries were anticipated to be reassessed in the late 1980's, and inlet areas continuing to change, the need to update IHA boundaries has not diminished.

The Coastal Resources Commission (CRC), Coastal Resources Advisory Council (CRAC), and CRC Science Panel meetings must be publicly noticed and are open to the public, and while members of each have changed over the course of time, the topic of updating Inlet Hazard Areas has been discussed for 22 years, when in 1998 the CRC's Science Panel first identified the need to change the methodology for defining inlet hazard areas (October 21, 1998 meeting minutes). In 2000, the Science Panel formally recommended to the CRC that the IHAs needed to be re-delineated (memo CRC-01-14February 2000). In 2004, the Division of Coastal Management began the process of collecting and digitizing inlet shoreline data, and at the request of the CRC, began working the Science Panel through 2010, and most recently from 2014 to 2019, on the development of shoreline erosion rates at inlets, updating the methodology for defining IHAs, and proposing new boundaries (memos CRC 14-23, 16-24, 18-24, & 19-05).

It is also worth noting that in 2012, the NC General Assembly directed the CRC to consider the unique coastal morphologies and hydrographic conditions at the Cape Fear region, and to determine if action is necessary to preserve, protect, and balance the economic and natural resources of this region through the elimination of current overlapping Areas of Environmental Concern (AEC) by incorporating appropriate development standards into one single AEC (Session Law 2012-202). During that effort, the CRC found that while the Cape Fear River Inlet did present a unique set of challenges, other inlets may have similar, but unique issues. In 2014, the CRC held four regional inlet management workshops (Beaufort, Buxton, Ocean Isle, & Wilmington) to seek input on inlet management from a wide array of stakeholders that included sand managers, engineers, dredging industry representatives, the USACE, and those with an interest in environmental impacts associated with inlet management. One of the recommendations from this effort was that the Science Panel should complete their technical study of Inlet Hazard Areas (memo CRC-14-33, October 2014). That effort also led to the establishment of the new State Port Inlet Management AEC.

Questions regardingPublic Hearing Notices and Scheduling: (NC DCM Staff)

Concerns were expressed with regards to the timing of public hearings, and generally that the notification procedures were insufficient and did not allow for enough time for the public to submit comments.

DCM Staff General Response: The process of notifying the public of proposed new rules, or amendments to existing rules is defined in the North Carolina Administrative Procedures Act, Chapter 150B of the General Statutes (150B.21.2). In addition to information being made available on agency websites, the proposed rules must be published in the North Carolina Register and followed by public hearings to be held no sooner than 15 days after the proposed rules have been published in the Register. The comment period is to remain open for 60 days after publication in the Register, or when the last public hearing is held, whichever period is longer. The following is a two-year timeline from when the updated IHAs were presented to the CRC and the public:

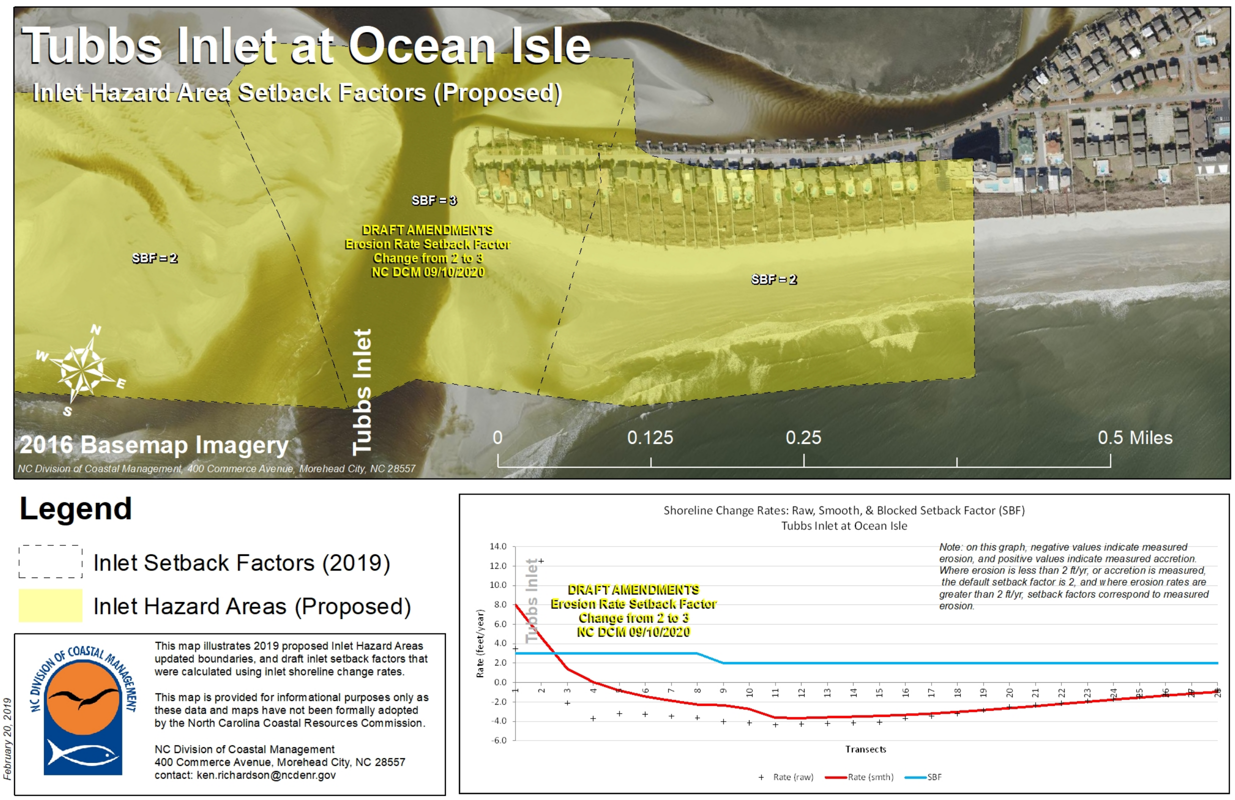
- **November 29, 2018** – CRC's Science Panel Chair, Bill Birkemeier presented the IHA methodology to the CRC
- **February 28, 2019** – CRC approved the Science Panel's IHA update report and proposed rule amendments
- **September 18, 2019** - CRC approved fiscal analysis associated with proposed rule amendments.
- **December 2, 2019** - proposed rule amendments were published in N.C Register.
- **December 17, 2019** – first public hearings were held (15 days after publication in Register).
- **December 20, 2019** – at CRC meeting, there were public concerns expressed to the CRC regarding the public hearing notification process, schedule and timing with holidays. As a result, the CRC extended the comment period to March 2, 2020.
- **January 14, 2020** - last public hearing.
- December 17, 2019 – January 28, 2020 – An additional five local government workshops were held (North Topsail Beach, Holden Beach, Ocean Isle, Carolina Beach, and Topsail Beach) to explain the IHA delineation process and to take additional public comment.
- **January 22, 2020** - public comment period extended to March 2, 2020. Although the public comments period ended on March 2, 2020, Staff did include comments for the CRC to consider that were received after March 2, 2020.
- **January 31, 2020** – close of initial public comment period.

Although the timeline has been influenced by the COVID-19 pandemic, the opportunity to express comments and concerns with the updated IHAs and rule amendments is about to enter its third year.

DCM Staff Note with Regards to the Inlet Erosion Rate Setback Factors (Required Amendment):

While preparing a summary of public comments, DCM Staff noticed that approximately five transects and their associated erosion rates values were not exported into the erosion rate setback factor analysis at Tubbs Inlet on the Ocean Isle side of the inlet. This was not a factor in the boundary analysis but did require one amendment to the blocked erosion rate value resulting in a change from 2 to 3 at the west end of Ocean Isle and adjacent to Tubbs Inlet (see Figure 1).

Figure 1. *This is a revised map illustrating the erosion rate setback factor amendment at Ocean Isle (Tubbs Inlet), where the factor was changed from 2 to 3 (area adjacent to inlet) due to missing data points in the original analysis at this location.*



FROM: NC CRC's Science Panel

Inlet Hazard Area Methodology (IHAM): Science Panel Response, October 29, 2020

Introduction

After a nearly 16-year effort, the Science Panel on Coastal Hazards completed work on updating the Inlet Hazard Area (IHA) boundaries for the 10 developed inlets. After the report was published February 12, 2019, the Division of Coastal Management (DCM) held seven public hearings and five workshops along the coast and public comments were invited. DCM consolidated and summarized the public comments and requested that the panel develop a response. The Panel reviewed both the individual public comments as well as the DCM summary. This document is the Panel's response to the summarized comments.

Only three existing Panel members (Birkemeier, Rogers, Rudolph) worked on the final report and they developed this response. Mr. Tom Jarrett and Dr. Bill Clearly, two major contributors to the IHA report, but no longer on the Panel provided comments on our response which have been incorporated.

Considering that the original boundaries were established over 40 years ago, the comments are relatively few. Not surprisingly, most of the comments are related to inlets where the proposed boundaries have changed significantly.

In recommending the IHA boundaries, the Science Panel, chose to take the long view. We are temporary stewards of the coast, mindful of the fact that change at the coast may be slow and persistent (i.e. long-term shoreline erosion) or rapid and dramatic (i.e. an inlet opening during a storm event), with profound long-term impact. Each inlet has its own, complex story. For example, New Topsail Inlet was first reported in 1726, but over the next 294 years has migrated southwest at an average rate of 125 feet per year. At Shallotte Inlet, oscillations in the near inlet oceanfront shorelines on each side of the inlet have had gains and losses over 500 feet over 30-year periods. North Carolina's tidal inlets are our most dynamic coastal feature. As presented in the report, they either migrate, consistently moving in one direction, or oscillate left and right. They may even close or new inlets may open.

Living at the coast entails an element of risk; the establishment of the IHA boundaries recognizes that risk increases with proximity to an inlet. Equally important to managing that risk, is establishing what is allowed within the IHA.

The IHA report on this is quite clear. The usual use of the existing vegetation line for establishing construction setbacks, which works well in the Oceanfront Erodible Area (OEA), does not work within the IHA. The IHA report recommends 30- and 90-Year Risk Lines, which were developed to be as similar as possible to the 30- and 90-year vegetation line setback provisions used elsewhere in the OEA. The Risk Lines are based on a Hybrid-Vegetation Line, or HVL. The HVL is computed based on the most landward limits of all vegetation lines during the time period being considered, appropriate for each inlet shoreline.

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. Most importantly, neither the CRC nor the public have been shown the potential adverse consequences of using the stable vegetation line for setbacks within the IHA—consequences that the HVL and risk lines were intended to avoid.

Before addressing the public comments specifically, it's useful to provide some general, over-arching comments:

1) **The Inlet Hazard Area Method (IHAM):** A number of comments questioned the use of the IHAM which uses a combination of objective steps based on the standard deviation of shoreline position, modified with a subjective step to determine if the computed result was reasonable, based on the combined inlet expertise of panel members.

   As a result, the method combines quantitative shoreline rate date with the with unique inlet expertise of the Panel. Notably Jarrett, Cleary, Benton, Rogers and Rudolph have personal experience with these inlets (researching, mapping, dredging). In actuality, the panel would have preferred a completely objective method, and many different ones were tested and rejected.
   The IHAM was found to have the most predictive skill, providing the best initial IHA boundary estimate. Of the 10 inlets considered with 14 adjacent, developed beaches, the IHAM-defined point separating inlet from oceanfront was used at nine and only modified at five beaches. Of these, two were moved toward the inlet and three further away. 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 and are explained in the report.
   The fact that we did not find a truly objective measure should not be surprising. Inlets are complex, 3-dimensional coastal features with ebb and flood shoals, multiple channels, engineering activities, changing currents and varying geology. The historical shoreline and vegetation lines used by the IHAM, while useful and indicative, do not completely represent inlet dynamics.
   Even so, it's worth noting that the historic shoreline and vegetation data provide a readily available, consistent, temporally-rich database covering all of North Carolina's inlets, which when combined with the IHAM method provides a robust, skillful method for determining IHA boundaries
2) **Accreting shorelines:** Several comments questioned including accreting sides of an oscillating inlet within the defined IHA, suggesting that accreting shorelines are protective and lower risk. In fact, to be useful the IHA should include the entire area influenced by the inlet, distinctive from the adjacent oceanfront. One way to think about this is to imagine the

shoreline without the inlet. For example, without Shallotte Inlet, the accretionary bulge at Holden Beach would not exist.

It's important to take the long view and to recognize these accretionary features as being ephemeral, which we know from their history. An inlet shoreline may appear stable for years or decades; dredging or nourishment projects may have an impact—but we need to recognize and acknowledge that conditions may suddenly change on one or both sides of the inlet. For example, the ocean shoreline on the southwest end of Oak Island near Lockwood Folly Inlet experienced a period of severe erosion in the late 1970s. Many houses were threatened, some collapsed, and some were moved. Multiple erosion control efforts failed along with the loss of the loop road at the end of the island. The episode was followed by at least 30 years of accreting shoreline until 2014 when erosion driven by inlet changes again threatened both previously surviving houses as well as recent replacement houses where previous failures and relocations had occurred.
What differentiates each side of the inlet is a highly variable erosion/accretion rate, which is well-represented by the HVL. The HVL can be used as a powerful tool in managing the risk inside the IHA.

3) **IHA Semantics:** One of the public suggestions was to change the wording of *Inlet Hazard Area* and instead refer to it as something less scary, like *Inlet Influence Area*. The panel does not support doing this. The IHAs include what are expected to be the most rapidly eroding shorelines in the state in the future. Renaming would not reduce the risk, but it would likely reduce the public's awareness of the risk.

4) **IHA Messaging:** It is challenging to convey the dynamic realities of inlets to the public. They generally evolve slowly; storm and erosion episodes, which may be catastrophic, quickly fade from memory. While historic shoreline change maps and inlet atlases are informative, inlet animations are visual and much more effective at illustrating just how these inlets evolve. We suggest that DCM develop time-lapse animations for each inlet and make them widely accessible to the public (website, interactive map, CRC meetings, public meetings, etc.). The better the public understands the dynamic nature of inlets, the more accepting they will be of the IHA management program.

   The Science Panel has created draft inlet animations for Tubbs, Shallotte, Lockwood Folly and Bogue Inlets which can be viewed and downloaded at this link. Reviewing the Shallotte Inlet animation will be useful in understanding the discussion that follows on that inlet.

Detailed Public Comment Reponses:

1. **Shallotte Inlet at Holden Beach**: Public comments were concerned with the size of the proposed Inlet Hazard Area boundary on the western end of Holden Beach (at Shallotte Inlet), and questioned why the boundary is so large given that this area has a very wide and healthy beach/dune system, and the island has been accreting for many years (since the 1960s). Relative to the boundary proposed on the eastern end of the Holden Beach (at Lockwood Folly Inlet), and others where erosion has been a problem, this boundary is much larger in

comparison. This section of beach has not required beach nourishment, nor has it lost any structures due to erosion (60-year period).

Science Panel response: The dynamic shoreline changes on both sides of Shallotte Inlet are well-described in the IHA report and shown graphically in the Shallotte Inlet animation**.**
Over its aerial photographic history, 1938-present, Shallotte Inlet has been relatively fixed in location, in part by underlying geology. However, the adjacent ocean shorelines have experienced a single wide oscillation influencing several miles of oceanfront shoreline on both Holden Beach and Ocean Isle. The oscillations have been caused by changes in the offshore, ebb tidal channel and surrounding shoals. The channel alignments that caused the oscillation no longer exist.

The first aerial photography in 1938 shows the offshore ebb tidal channel hugging the Ocean Isle oceanfront shoreline for over a mile southwest of the inlet throat before discharging into deeper ocean waters. This channel alignment caused an accretionary bulge in the Ocean Isle shoreline extending several miles from the inlet. At that time the Holden Beach shoreline was a narrow sand spit. In later aerial photography the inlet channel alignment changed radically, most likely due to delayed changes resulting from the construction of the Intracoastal Waterway in the 1930s and from Hurricane Hazel in 1954.
By the 1960s the ebb channel shifted to directly offshore, collapsing the shoal offshore of Ocean Isle. By 1974 the offshore ebb channel shifted in the opposite direction, hugging the Holden Beach oceanfront shoreline extending for approximately a mile from the inlet, a shift in location of over two miles in less than 36 years. By that time, the bulge on Ocean Isle had been subdivided and developed with houses. Without the adjacent channel, the bulge on Ocean Isle rapidly eroded. After decades of shoreline adjustment, the oceanfront road near the inlet is now 3rd Street.

After the ebb channel shifted toward Holden Beach, the oceanfront shoreline commenced a period of relatively rapid accretion, forming a bulge in the shoreline similar to what had previously existed on the other side of the inlet, extending for more than two miles from the inlet. The present bulge along the Holden Beach oceanfront was created by the ebb channel alignment that hugged the Holden Beach shoreline, beginning around 1974. 2001 aerial photography shows that the ebb channel shifted again to directly offshore the inlet.

The present orientation of the ebb tide delta channel of Shallotte Inlet is a manifestation of repeated dredging of the ocean bar channel to provide beach fill material for the Ocean Isle Beach federal storm damage reduction project. Construction of the Ocean Isle Beach project, in early 2001, has used the bar channel for subsequent periodic nourishment of the federal project. The construction of the Ocean Isle Beach project and subsequent periodic nourishment operations has served to maintain the bar channel along an alignment more-or-less perpendicular to the adjacent shorelines. As long as this practice remains active, the reorientation of the bar channel back to an alignment toward Holden Beach will not occur. As a result, the bulbous configuration along the western 2 miles of Holden Beach will likely gradually erode until the shoreline attains a state of dynamic equilibrium. The time required for the west end of Holden Beach to reach this new dynamic equilibrium state is not known. What is known, the ebb channel conditions that created the accretion on Holden Beach no longer exist and future erosion of the bulge along more than 2 miles of shoreline should be anticipated, rather than the previous 27 years of accretion. The proposed inlet hazard area will be reviewed every 5 years and an adjustment can be made in the IHA, if supported by the actual response of shoreline along the west end of Holden Beach.

A primary recommendation of the IHA Report is that stable vegetation line setbacks are not recommended within the IHA. Inlet shoreline oscillations vary widely in frequency, erosion/accretion distances and distance from the inlet. Shallotte Inlet likely has the longest oscillation time and largest shoreline erosion/accretion changes addressed in the report. The proposed vegetation line setback of 60 feet is particularly inappropriate for the area that the Panel believes will erode in the coming decades. The Panel recommended a 30-Year Risk Line as an alternative setback. Near the inlet, the Risk Line is over 500 feet landward of the vegetation line setback but tapering to 10s of feet at the IHA/OEA boundary farther northeast. The Panel did not consider coastal building development in the IHA analysis. However, it should be noted that most of the area between the proposed vegetation line setback and the 30-Year Risk Line is now undeveloped, primarily due to Holden Beach town setback requirements. Along most of the oceanfront shoreline the 30-Year Risk Line is very close to the present local setback requirements. Allowing new development in the proposed IHA as far seaward as the vegetation line setback can be expected to the result in similar building loses to that experienced on Ocean Isle after the channel shifted in the 1960s.

In summary, concerning the IHA boundary and Holden Beach:

- The IHA defines the dynamic region influenced by the inlet (erosion and accretion). Without the inlet, the accretion bulge on Holden Beach would not exist.
- Shallotte, like Tubbs and Lockwood Folly, is an oscillating inlet—where accretion should be considered an ephemeral feature tied to the ebb shoal and channel alignment. Based on the vegetation line data, at Holden Beach, the accretionary wedge didn't exist in 1970 and didn't become significant until ~1992/93. That's only 30 years ago.
- The dynamic signal in the historic shoreline data is strong at Holden; the location of the IHA boundary is robustly defined by a sharp increase in the standard deviation of shoreline position and it appears that this location is somewhat independent of what dates are included in the computation.
- As proposed, the IHA boundaries should be reevaluated every 5 years. If the inlet and the Holden beach shoreline were stable in future updates, the IHA boundary would shift toward the inlet.
- Shallotte Inlet is similar to Lockwood Folly Inlet – shoreline oscillations are slow and not unexpected at Holden Beach.

1.1. **The Inlet Hazard Area Method (IHAM) developed by the Coastal Resources Commission's (CRC) Science Panel works for areas with erosion, but not accretion**. (*DCM note: argument being that relative to inlets with erosion problems, areas of accretion are not given relief in the calculations)*

Science Panel response: Where near-inlet oceanfront shorelines are oscillating, typically one side of the inlet erodes as the other is accreting but the local impacts reverse over a period of a few years to a few decades. Using the IHAM on the eroding shoreline produces an IHA boundary (90-Year Risk Line) and 30-Year Risk Line that are as close as possible to the 90-year Ocean Erodible Area (OEA) boundary and 30-year small building setbacks measured from the stable vegetation line. The IHAM is specifically intended to more accurately address the accreting shoreline where the recent stable vegetation line changes do not represent the expected higher erosion rates in the future.

1.2. **The method assumes worst-case scenario and seems to penalize areas that do not have erosion problems.** The boundary seems to be "overly conservative" or "overly protective." (*DCM note: the concern is when there is a "long" history of accretion or migration, and no history of structures threatened by erosion, is there really a hazardous risk of erosion*.)

Science Panel response: This statement is incorrect. The statistical analysis and HVL used shoreline data beginning in 1970. Worse conditions existed on Holden Beach between 1938 and 1970. The proposed IHA boundary is neither overly conservative nor overly protective, but realistic for the next ~30 to 90 years as is the Ocean Erodible Area outside the IHAs. In contrast the Ocean Isle statistical analysis started in 1933 during the period of accretion, not the worst case.

1.3. **The mapping method does not consider beach nourishment**. (*DCM note: argument assumes littoral drift moves sediment from the project area towards the inlet, where sediment is then trapped by the inlet and builds up on the Holden Beach side of the inlet - which suggests that the influence is not all inlet related*).

Science Panel response:

- The IHA defines the zone of inlet influence and hazard. While nourishment may reduce the risk, it does not change the region of influence.
- Nourishment is incorporated in the dataset, as it influences the shorelines used in the analysis. Any nourishment is included in the OEA and the IHA, so any difference is due to the inlet influence.
- Historically, nourishment near inlets has a poor success rate; inlets are a rapid sink for sediments. The requests for terminal groin permits at several inlets reflect the inability to manage near-inlet shorelines with beach nourishment.

1.4. **The fact that the ebb channel alignment of Shallotte Inlet has been favorable for Holden Beach for over a half century should have carried great weight.** While other oscillating inlets have oscillated back and forth over the last 50 years, something has been keeping Shallotte Inlet in a favorable alignment for Holden Beach. I think the existing IHA on the west end of Holden Beach does not need to be expanded at this time. Since dredging of the Shallotte Inlet began the inlet has remained stable. This is important when applied to the logic that the inlet has such a long effect on the shoreline. The Town's Coastal Engineer is of the opinion that if inlet maintenance is performed the west side will be stable. Ocean Isle Beach is a participant in a federally authorized 50-year storm damage protection project that uses the Shallotte Inlet as a borrow source. The sand located on the beach and the growth along the shoreline within that portion to be extended by the CRC from its current boundary has not and is not affected by the inlet, but instead that sand is deposited there from littoral drift east to west. (*DCM note: if the channel is maintained in it's current position, what is the real likelihood of the channel shifting on its own, and also there is an assumption that the accretion is in part due to beach nourishment and littoral drift of sediment.*)

Science Panel response:

- The dynamic nature of Shallotte Inlet is well-understood as described above and in the IHA report (page 29). It can also be visually seen in the draft Shallotte Inlet animation. Key points from the report:
    a. *Shallotte Inlet has oscillating inlet shorelines with oscillating oceanfront shorelines on both sides of the inlet.*
    b. *Seismic data from the nearshore area indicate the inlet is a permanent feature related to the paleo-channel of the ancestral Shallotte River. Since 1938 the throat position of the ebb (main) channel has shifted within a 900 feet wide corridor.*
    c. *Although the position of the ebb channel within the throat has not changed appreciably, its seaward outlet across the ebb-tidal delta has shifted widely, approximately 13,000 feet from Ocean Isle to Holden Beach carrying with it major changes in the offshore shoals.*
    d. *The bulbous shape of Holden Beach shoreline had begun forming by 1974. If the ebb channel becomes more westerly, then this accreted sand is expected to erode. Ocean Isle had the same bulbous shape between 1938 and 1958 before the ebb channel shifted, causing sever erosion along the north eastern end of Ocean Isle.*
- The bulbous shape of Holden Beach can only be reasonably stable if the ebb channel discharges at its extreme northeast limit, a condition that has not existed since 2001.
- The inlet dredging can be expected to encourage a short, linear ebb channel, directly offshore from the inlet throat, similar to the conditions that presently exist. Therefore, the dredging makes stabilizing the bulbous shoreline of Holden Beach less likely to remain in its present shape.

1.5. **The Science Panel did not include data collected locally (or the Town's data).** (*DCM note: Concern was expressed because periodic monitoring data collected by the Town was not included in this process*)

Science Panel response: Long-term annual shoreline surveys like that collected by the town are highly desirable. However, the surveys on Holden Beach cover only a short period of the inlet's 80+ year photographic history. Other inlets have no surveyed data. The IHAM was developed to address all inlets with similar analysis and to use the longer photographic records that better include historical oscillations and migration. At some point in the future it may be possible to make use of the survey data, but not likely for at least decades.

1.6. **The most recent FEMA data shows that the dunes on the west end have grown so much since 1987 from the east to west migration that expansion of such a magnitude re-designated many homes that were in a V zone as A zone properties.** This data scientifically indicates that the portion of the island is outside of any wave action as defined by the federal government, and clearly proves that the expanded Inlet Hazard Area is outside of any area affected by the Shallotte Inlet. (*DCM note: so, if this area was removed from the VE zone by FEMA, why does the Science Panel's analysis include it as a hazard.)*

Science Panel response: The Panel does not agree with this conclusion – the inlet influence and associated risk exists, independent of the FEMA mapping. FEMA's mapping guidelines require flood mapping to be based on existing conditions and prohibit the use of shoreline erosion data. The V-zone guidelines include a dune erosion model for a 100-year storm surge. However, the model is outdated and known to underestimate storm-induced erosion. Long-term erosion, inlet migration and inlet related shoreline oscillations are not included in any FEMA flood map.

2. **Mason Inlet at Figure Eight Island:** The report states that "the Panel agreed that the risk related to the inlet actually extended further north" than the IHAM identified. The IHAM identified transect-31, but the boundary was extended to transect-45. Other than an unexplained comment in a table that there is "increased potential for erosion at Mason Inlet-Figure Eight Island," we do not understand why the proposed IHA is extended beyond transect-31 (the IHAM identified boundary).

   Science Panel response: Actually, the report explains this specifically (page 67); bolding added for emphasis:

   > *Although the IHAM identified transect 31 as the inlet-ocean boundary (Figure 49), the Panel agreed that the risk related to the inlet actually extended further north.* ***It is expected that without regular management, the inlet related erosional risk would encompass the area up to transect 45, which is approximately the start of truncated dunes, indicating relative stability of the oceanfront shoreline's position over time with continued nourishment. This stability can also be seen in the shoreline change rate (LRR), which parallels the standard deviation starting at transect 45 (Figure 49).***

   In addition, the Management Agreement with the inlet property owner ends in 2031 and there is no guaranteed maintenance beyond that lifetime.

3. **New Topsail Inlet at Topsail Beach:** What is the basis for including the area around the canals? Except for maybe Hurricane Bertha (1996), there has never been an erosion problem, and the inlet has been migrating away from this area.
   3.1. This side of the inlet is accreting, and instead of using the "90-Year Risk Line" to map the landward boundary, the Science Panel extended the boundary away from the inlet to include the area adjacent to the canals
   3.2. This inlet displays consistent migration, but has the furthest inland sited HVL, 30YRL and 90 YRL in the entire IHA study at more than one half mile inland from the end of the

island. The placement of these lines make Topsail Beach appear to be the riskiest inlet in the state and that clearly isn't an accurate assessment. The HVL appears to overstate the risk.

Science Panel response: The inlet was evaluated differently for two separate reasons:

- New Topsail Inlet is the only clearly migrating inlet included in the report, migrating south at roughly 90 feet per year since 1938. To address the migration, the HVL on the inlet shoreline, and therefore the recommended 30 and 90-Year Risk Lines, were limited to an approximate 30-year record (1984-2016), a shorter period than used for any other inlet in the report. It is anticipated that with each 5-year IHA update, the Risk Lines would move south, historically about 450 feet, acknowledging the reduced inlet risk as the inlet continues to migrate farther south.
- In most cases the IHA landward boundary was based on the 90-Year Risk Line. At New Topsail Inlet the boundary was extended farther north to include the three canals that create a risk of an inlet breach in the future. The risk of an inlet breach at the canals is widely shared and the area was included in the present IHA for similar reasons.

Because the Risk Lines were not included in the proposed rules, the IHAM adjustments for future migration are not included in the proposed rules or future 5-year updates.

4. **Erosion Rate Setback Factors:**

4.1. The most serious problem with the proposed rules is the way that shoreline erosion rate transects are blocked to established shoreline segments with similar erosion rates. Those rates are then used to determine vegetation line building setback delineations. The proposed method severely underestimates the inlet erosion rates.

Science Panel response: The application of erosion-rate setbacks measured from vegetation lines is the primary concern of the Panel with the proposed IHA regulations. While it does not affect the proposed IHA boundaries, it does impact management decisions within the IHA.

- Both the method used to calculate erosion rates, and their application, measured from the vegetation line, will encourage building construction in extremely high-risk areas and grossly underestimate the inlet risk for existing property owners and their communities.
- The Panel spent considerable time attempting to develop a vegetation line referenced IHA approach. The IHAM and the Risk Lines were developed only after every method to use the vegetation line and erosion-rate setbacks proved ineffective in identifying inlet shoreline risks.
- Specifically: along the OEA, erosion rate transects are 50 m apart; end-point (last date minus first date) erosion rates are similar alongshore and a 17-point alongshore average (800 m) is used. Inlet shorelines are more dynamic and erosion can change to accretion over just a few transects. To account for this, radial transects were added for the IHA analysis, the transect interval was reduced to 25 m and the linear regression shoreline change rate was used instead of the end-point rate used for the

OEA. These steps should provide a more accurate inlet change rate. However, the same 17-transect alongshore blocking was used (400 m) for the proposed vegetation line erosion rate setbacks.

- The Panel's concern is that the 17-point blocking, even with 25-m transects, is too long and that a shorter one should be used. The consequence is that high erosion rates inside the inlet are being artificially lowered by the 17-point blocking.

4.2. A primary finding of this report is that the vegetation line is not a reliable reference feature for certain management purposes near inlets

Science Panel response: See the response relative to this comment in the introduction to this document. The Panel strongly recommends use of the Hybrid-Vegetation Line (HVL) for determining fixed building setback lines within the IHA. Fixed setback lines are already in place along most of the state's developed shorelines as Static Vegetation lines behind beachfill projects, the static exceptions and the Development Lines.

4.3. The 30-Year Risk Line was intended to be like the minimum OEA setback for 5,000 square foot buildings. The Science Panel's recommendations anticipated buildings larger than 5,000 square feet in at least parts of the recommended IHAs.

Science Panel response: As mentioned in the introduction to this document, the IHA report provides the CRC and DCM with a methodology, based on risk, which uses the Hybrid-Vegetation Line (HVL) to define a 30- and 90-year Risk Lines, similar to what is already used for vegetation line setbacks in the OEA. We strongly suggest that the CRC consider this methodology and at the very least, understand the consequences of not using it. The best way to observe the differences is to compare the two setback approaches on recent aerial photography.

An example figure is shown below for Shallotte at Holden Beach (note: base photography is 2016, large white numbers indicate the 2 and 7.5 ft/yr erosion rates). The red solid line would define the building setback based on the 2020 post-*Isaias* vegetation line (black line). Compare that to the dashed red line that defines the 30-year Risk Line, based on the Hybrid-Vegetation Line (HVL, black dashed line). It's important to note that, since the HVL here is based on 1970-2016 vegetation lines – at some point during that time period the vegetation line, which parallels the shoreline, fell along the dashed black line—and because of the inlet, there is a risk of it returning to that position. At this inlet, it is noteworthy that construction has followed the HVL. Similar figures for all 10 inlets are attached as Appendix A to this document. They well-illustrate the differences between present and past vegetation lines and the variation between inlets and inlet sides along our coast.

5. **Methodology:**

5.1. No outside peer review

Science Panel response:

- This comment is for the CRC to address.
- Because of the Panel's continuing IHA work, we have asked the six new panel members, all experienced technical writers and reviewers, to provide a peer review of the report. Their consolidated comments are in the attached Appendix B. Although an internal Panel review, the CRC can consider it as an independent review as none of the members were involved in the IHA work and their reviews were not influenced by the 3 panel members who worked on the IHA report. They were aware of the public comments but were not involved in drafting this response. In summary, their review:
  - It supports the general IHA methods and suggests implementation is appropriate to replace the existing IHAs.
  - It clearly notes that the floating vegetation line is not appropriate for referencing building setbacks within the proposed IHAs, and that the Hybrid-Vegetation Line (HVL) is more appropriate
- 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 Panel can serve as

co-author, but the technique depends on the remarkable GIS mapping capabilities of Ken Richardson and DCM.

5.2. Report seems to be based on the presumption that all inlets erode – as referenced in report, "…shorelines near inlets have long-term erosion rates approximately 5 times greater than other oceanfront shorelines." However, some are accreting, and the method doesn't consider it.

Science Panel response:

- As discussed in the Introduction to this document, the Panel disagrees with this comment, as the proposed IHA boundaries and the 30- and 90-year Risk Lines fully embrace both the eroding and accreting shorelines of inlets. Because accreting shorelines are incorporated into the dataset, they are reflected in the linear regression analysis performed for each inlet which was used to develop the 30- and 90-year Risk lines.
- The data do confirm that long-term erosion rates—on eroding inlet shorelines are, in fact dramatic, 5 times greater than other oceanfront erosion rates. Which is why the IHA designation is required.

5.3. Standard deviation graphs appear to be used to identify locations where "*inlet influence begins*," but does not identify location of "*dominant influence*" as suggested in Task 2 of the CRC's charge to the Science Panel.

Science Panel response: The report identifies the point that separates the inlet influence area from the oceanfront area. Because each inlet is different and because the historic shorelines are indicative, but don't fully represent the dynamic nature of these inlets, it was not possible to apply the same objective criteria to each inlet, or to quantify the influence at say the 0% or 80% level. What could be identified with confidence is the point separating inlet from oceanfront influence. Moreover, the transects within the IHA possessing higher standard deviation values reflect higher shoreline variability and thus do depict zones within each IHA that are more influenced than others.

5.4. Of the 18 locations where IHAs are recommended, only about 6 use the IHAM with no modifications to locate the alongshore IHA boundary.

Science Panel response:

- As discussed in the Introduction to this document, the Panel would have preferred an IHAM that worked just on statistical numbers, but at many inlets it provided only a starting point. Panel expertise, with their experience dredging, mapping, coring, and studying these inlets was required to refine the boundaries at many inlets.
- The report considered 10 inlets with 18 sides. Four of these sides are on undeveloped islands where the IHA was established island-wide. Of the remaining 14 sides, the ocean-inlet boundary picked objectively by the IHAM was used at 9. The panel revised the IHAM-suggested boundary at 5 sides. Of these, 2 were moved toward the inlet and 3 were moved away. The fact that the IHAM worked objectively at 9 sides (64%) is significant, indicating that the method has considerable skill.

Appendix A: Inlet figures showing the differences between:

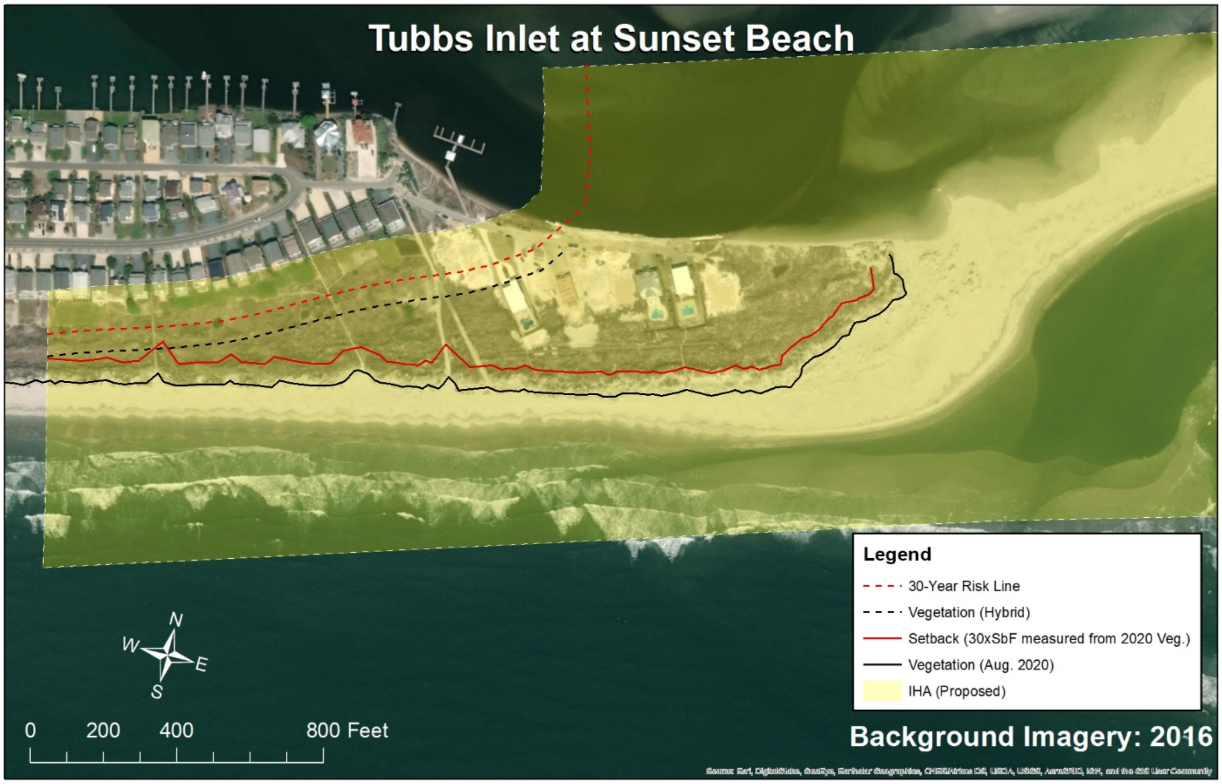
a) the existing 2020 vegetation line (solid black line) vs the Hybrid-Vegetation Line (dashed black line), and
b) the proposed 30-year setback using the vegetation line (solid red line) vs the Panel's recommended 30-Year Risk Line (dashed red line).

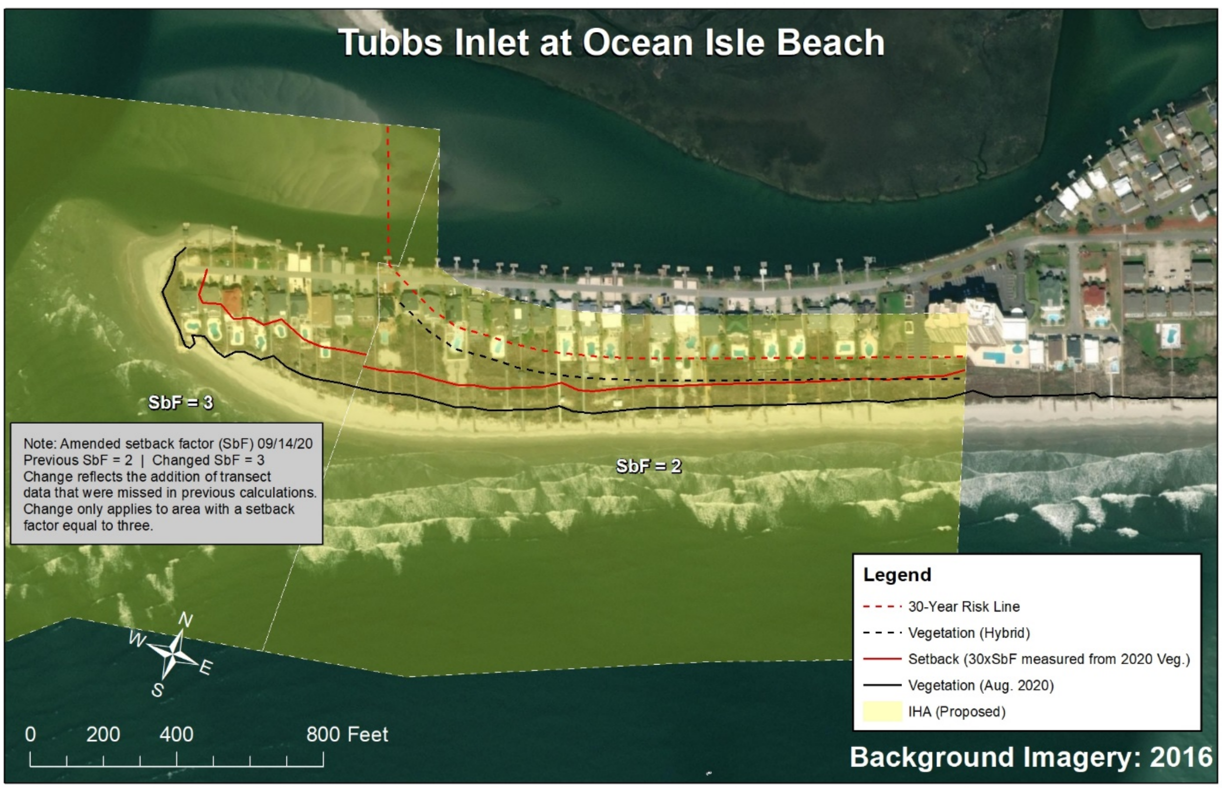
The figures include 14 inlet sides. Not included here are figures for non-developed inlet sides, which are discussed in the report but where the entire island is included in the IHA (Carolina Beach Inlet and Masonboro Inlet at Masonboro Island, Rich Inlet and New Topsail Inlet at Lea-Hutaff Island).

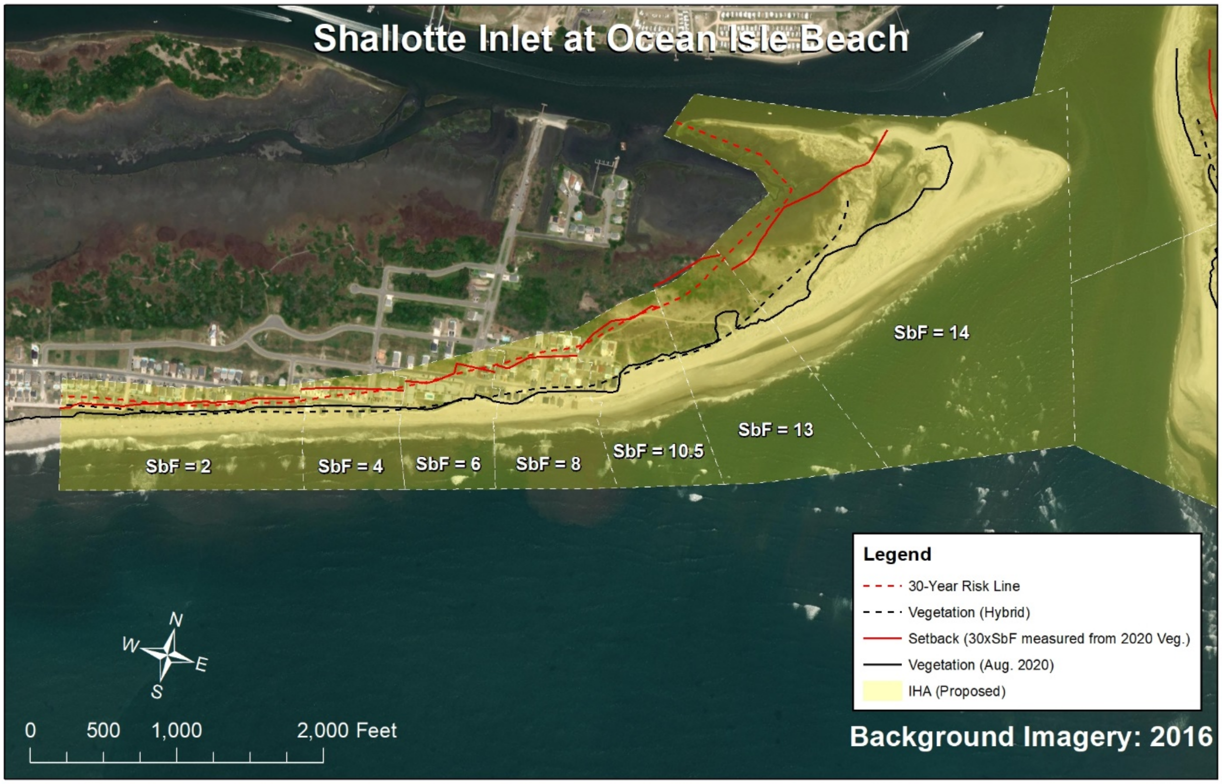
Following the IHA report outline, figures are ordered from south to north.
Other figure details:

- Large white numbers are the Setback Factors (SbF) in ft/yr which indicate the proposed blocked erosion rates used to locate the 30-year setback distance, landward of the existing vegetation line.
- Retreat of the vegetation line is evident wherever the 2020, post-*Isaias* vegetation line falls landward of the vegetation shown in the underlying 2016 photograph (e.g., Tubbs Inlet at Ocean Isle, Lockwood Folly Inlet at Oak Island).

In reviewing these figures, recall that the HVL indicates a relatively recent, historic vegetation line (post-1970 for most inlets, post-1938 for Rich). Consequently, the area in front of the HVL is relatively recently deposited. At five of these 14 inlet sides, development has already occurred seaward of the HVL (e.g., both sides of Tubbs Inlet, Shallotte Inlet at Ocean Isle Beach).
At most of the inlets, the 2020 vegetation line is significantly seaward of the HVL


Tubbs Inlet at Sunset Beach
Legend
30-Year Risk Line
Vegetation (Hybrid)
Setback (30xSbF measured from 2020 Veg.)
Vegetation (Aug. 2020)
IHA (Proposed)
N
W
E
S
0
200
400
800 Feet
Background Imagery: 2016


Tubbs Inlet at Ocean Isle Beach
SbF = 3
SbF = 2
Note: Amended setback factor (SbF) 09/14/20
Previous SbF = 2 | Changed SbF = 3
Change reflects the addition of transect
data that were missed in previous calculations.
Change only applies to area with a setback
factor equal to three.
Legend
30-Year Risk Line
Vegetation (Hybrid)
Setback (30xSbF measured from 2020 Veg.)
Vegetation (Aug. 2020)
IHA (Proposed)
N
W
E
S
0
200
400
800 Feet
Background Imagery: 2016

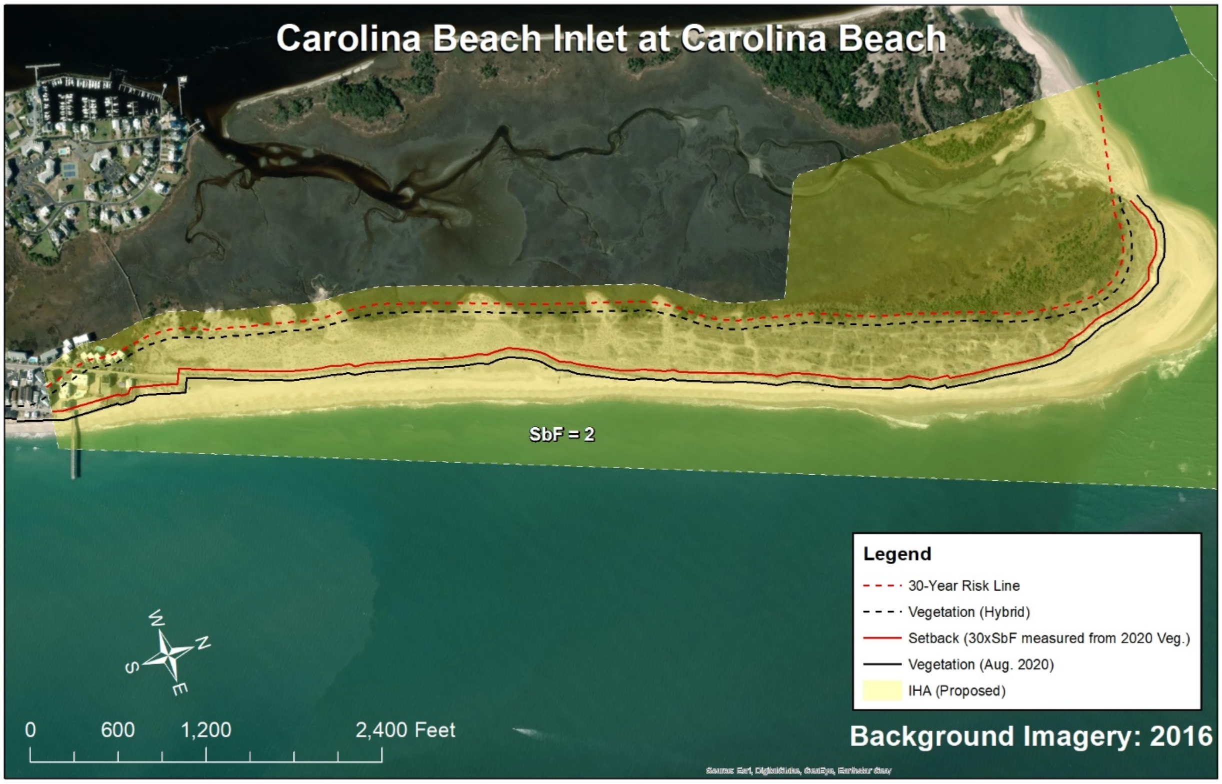


Shallotte Inlet at Ocean Isle Beach
SbF = 14
SbF = 13
SbF = 10.5
SbF = 8
SbF = 6
SbF = 4
SbF = 2
Legend
30-Year Risk Line
Vegetation (Hybrid)
Setback (30xSbF measured from 2020 Veg.)
Vegetation (Aug. 2020)
IHA (Proposed)
N
W
E
S
0
500
1,000
2,000 Feet
Background Imagery: 2016

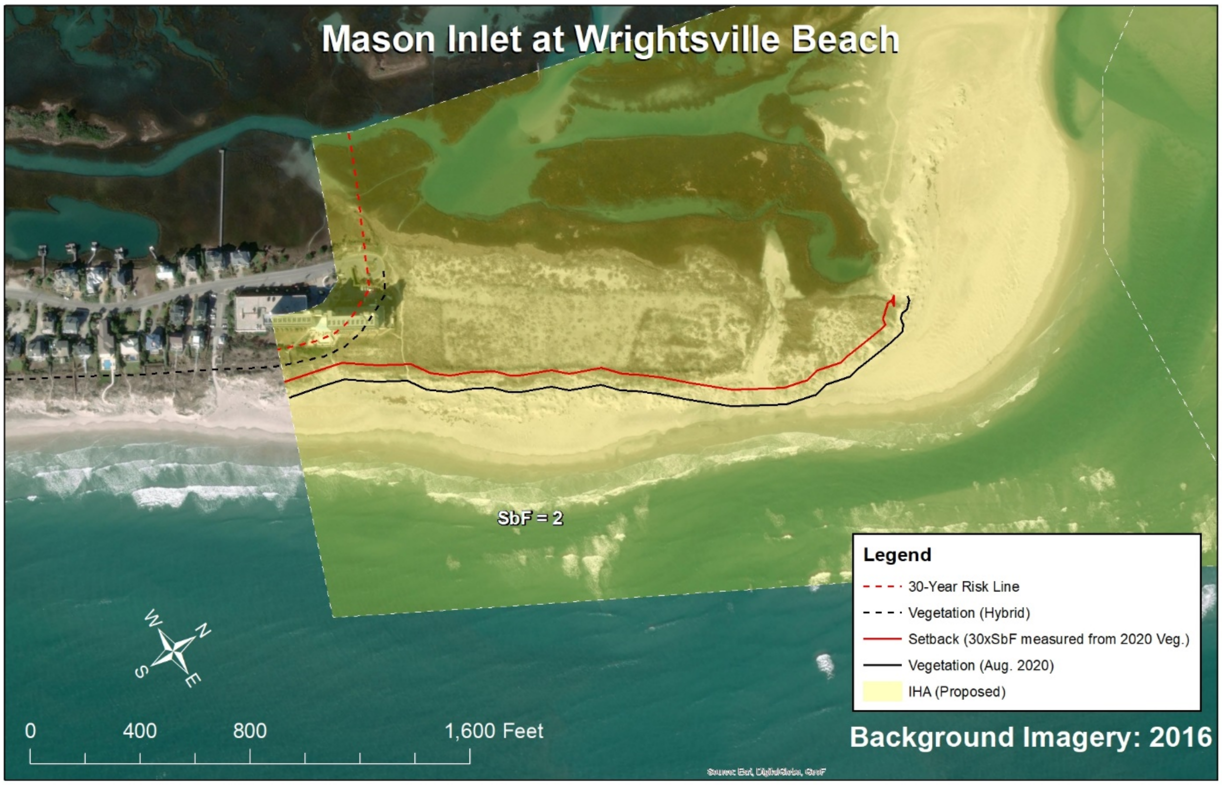
Shallotte Inlet at Holden Beach
SbF = 7.5
SbF = 2
Legend
30-Year Risk Line
Vegetation (Hybrid)
Setback (30xSbF measured from 2020 Veg.)
Vegetation (Aug. 2020)
IHA (Proposed)
N
W
E
S
0
800
1,600
3,200 Feet
Background Imagery: 2016


Lockwood Folley Inlet at Holden Beach
SbF = 4.5
SbF = 2
SbF = 3
SbF = 4
SbF = 3
SbF = 2
Legend
30-Year Risk Line
Vegetation (Hybrid)
Setback (30xSbF measured from 2020 Veg.)
Vegetation (Aug. 2020)
IHA (Proposed)
N
W
E
S
0 500 1,000 2,000 Feet
Background Imagery: 2016

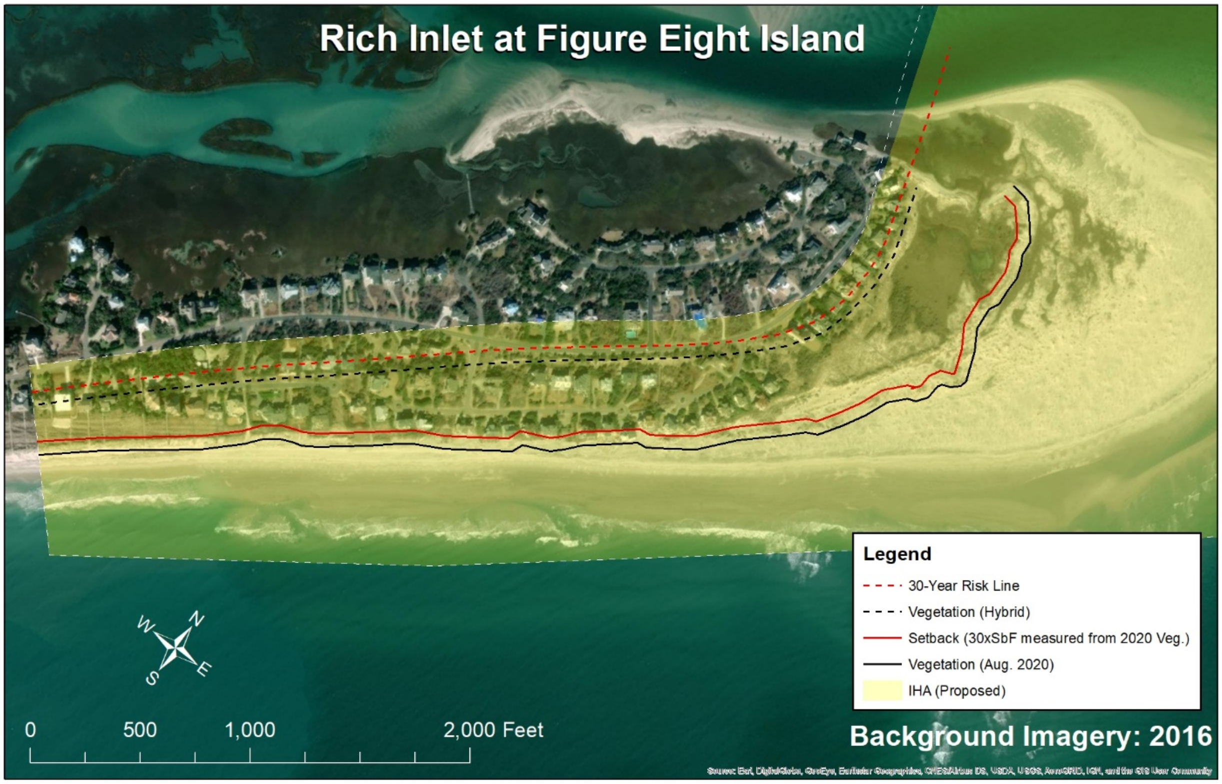

Lockwood Folley Inlet at Oak Island
F = 4.5
SbF = 2
Legend
30-Year Risk Line
Vegetation (Hybrid)
Setback (30xSbF measured from 2020 Veg.)
Vegetation (Aug. 2020)
IHA (Proposed)
N
W
E
S
0 500 1,000 2,000 Feet
Background Imagery: 2016


Carolina Beach Inlet at Carolina Beach
SbF = 2
Legend
30-Year Risk Line
Vegetation (Hybrid)
Setback (30xSbF measured from 2020 Veg.)
Vegetation (Aug. 2020)
IHA (Proposed)
W
N
S
E
0
600
1,200
2,400 Feet
Background Imagery: 2016

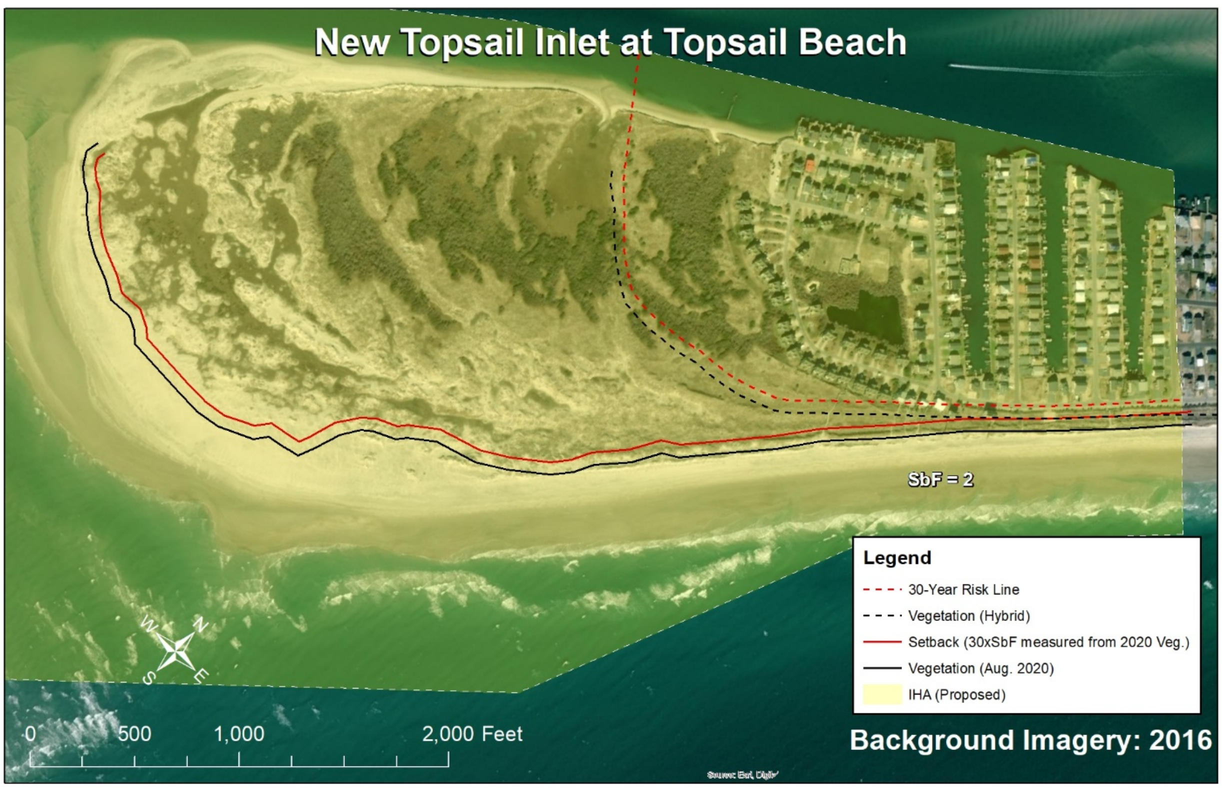

Masonboro Inlet at Wrightsville Beach
SbF = 2
Legend
30-Year Risk Line
Vegetation (Hybrid)
Setback (30xSbF measured from 2020 Veg.)
Vegetation (Aug. 2020)
IHA (Proposed)
W
N
S
E
0
250
500
1,000 Feet
Background Imagery: 2016


Mason Inlet at Wrightsville Beach
SbF = 2
Legend
30-Year Risk Line
Vegetation (Hybrid)
Setback (30xSbF measured from 2020 Veg.)
Vegetation (Aug. 2020)
IHA (Proposed)
W
N
S
E
0
400
800
1,600 Feet
Background Imagery: 2016

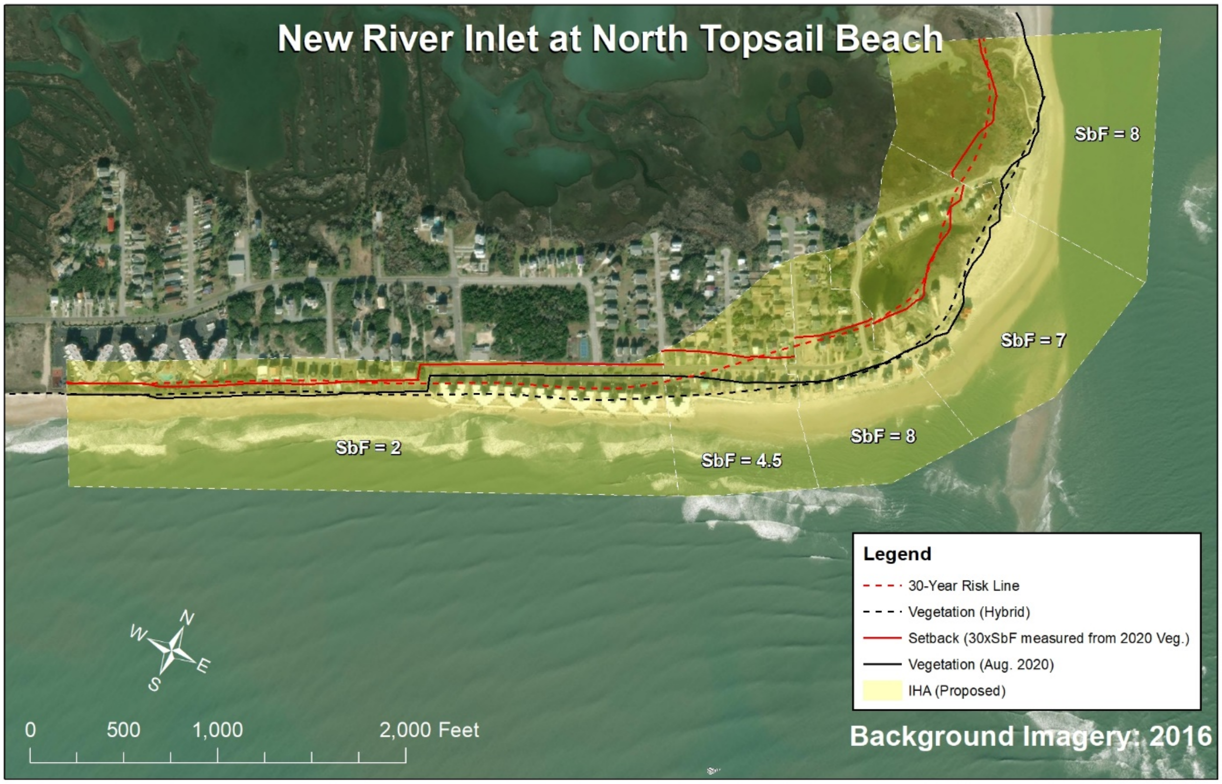

Mason Inlet at Figure Eight Island
SbF = 2
Legend
30-Year Risk Line
Vegetation (Hybrid)
Setback (30xSbF measured from 2020 Veg.)
Vegetation (Aug. 2020)
IHA (Proposed)
W
N
S
E
0
500
1,000
2,000 Feet
Background Imagery: 2016

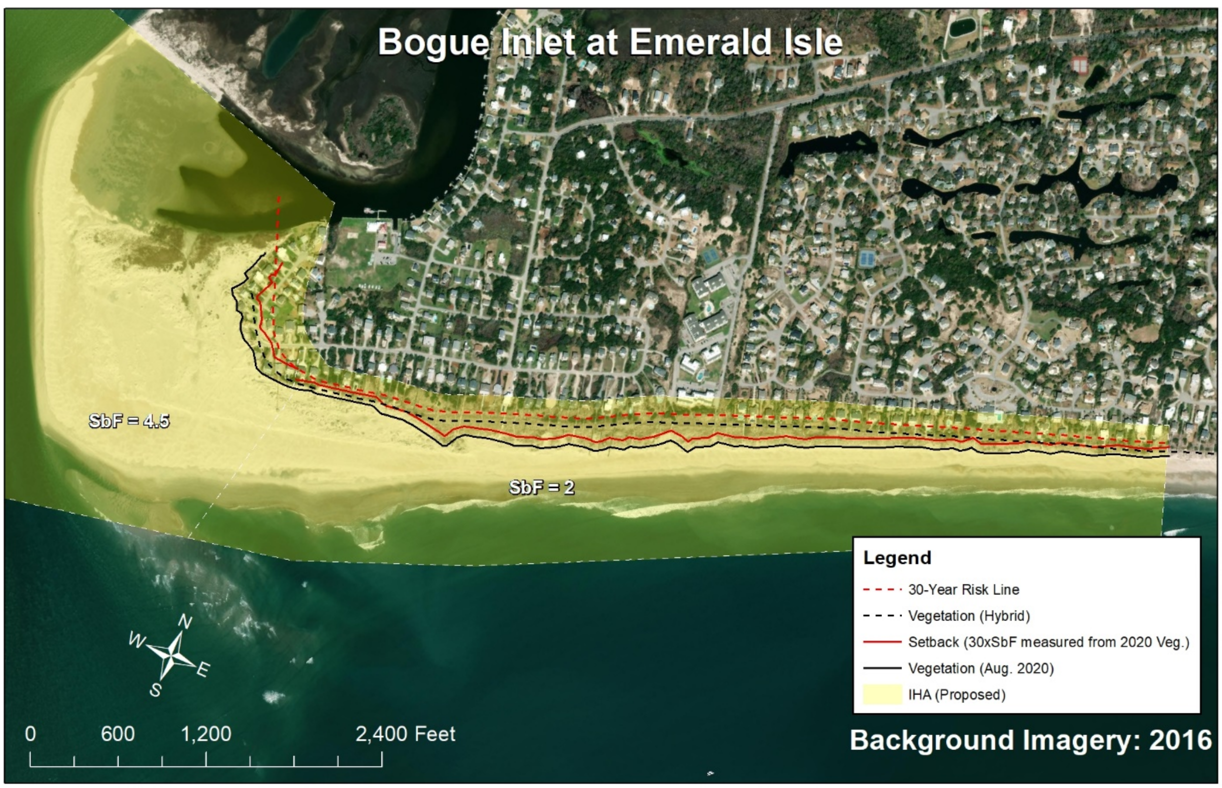


Rich Inlet at Figure Eight Island
Legend
30-Year Risk Line
Vegetation (Hybrid)
Setback (30xSbF measured from 2020 Veg.)
Vegetation (Aug. 2020)
IHA (Proposed)
W
N
S
E
0
500
1,000
2,000 Feet
Background Imagery: 2016



New Topsail Inlet at Topsail Beach
SbF = 2
Legend
30-Year Risk Line
Vegetation (Hybrid)
Setback (30xSbF measured from 2020 Veg.)
Vegetation (Aug. 2020)
IHA (Proposed)
W
N
S
E
0
500
1,000
2,000 Feet
Background Imagery: 2016


New River Inlet at North Topsail Beach
SbF = 8
SbF = 7
SbF = 8
SbF = 4.5
SbF = 2
Legend
30-Year Risk Line
Vegetation (Hybrid)
Setback (30xSbF measured from 2020 Veg.)
Vegetation (Aug. 2020)
IHA (Proposed)
N
W
E
S
0
500
1,000
2,000 Feet
Background Imagery: 2016


Bogue Inlet at Emerald Isle
SbF = 4.5
SbF = 2
Legend
30-Year Risk Line
Vegetation (Hybrid)
Setback (30xSbF measured from 2020 Veg.)
Vegetation (Aug. 2020)
IHA (Proposed)
N
W
E
S
0
600
1,200
2,400 Feet
Background Imagery: 2016

Appendix B: Internal Peer Review of the IHA Report by new members of the Science Panel
Review of 2019 Inlet Hazard Area Boundary Report

Sub-panel Summary

The 2019 Inlet Hazard Area Boundary Report was reviewed by four of the six new members of the NC Science Panel that were not authors of the original report, referred to here as the Sub-panel, for the primary purpose of identifying potential defects in the proposed methodology delineating inlet hazard area boundaries (IHAM). Other, more general or editorial, recommendations are provided in detail under comment sections for each reviewer below. All reviewers agree that the establishment of a hybrid vegetation line – a reference line that is consistently visible in aerial photographs and represents the most landward historic position (defined by the span of photographs) is important to capture the more long-term cycles of adjacent shoreline position exhibited around North Carolina tidal inlets. We recommend that the name be changed, however, from 'hybrid vegetation line' to 'historic landward vegetation limits' to more fully encompass the nature of this important reference line. There was also consensus in the use of shoreline variability, defined by standard deviation of shoreline position, as the appropriate metric for establishing the boundary of the inlet hazard areas. All reviewers recognized, nevertheless, that it is extremely difficult to define a specific quantified value of standard deviation or the slope of shoreline variability in the alongshore direction that works at every tidal inlet across North Carolina. This is problematic at tidal inlets having multiple changes in shoreline variability values as one progresses alongshore from the inlet, e.g. Bogue, Rich, Topsail inlets, because it relies on the expertise of the Science Panel to select an exact edge of the IHA and not simply a pre-established metric that works everywhere. 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.

McNinch comments

Overall, the 2019 Inlet Hazard Area Boundary Report is well written – concise, logically-organized, and the methodology (IHAM) is sound. The figures and the examples, in particular, are excellent and make the document easy to understand and apply. The following specific comments are aimed at strengthening the scientific argument for exploiting aerial photographs to extract vegetation and shorelines which are the fundamental data used in the inlet hazard area methodology:

1) Inlet morphodynamics are briefly described in the Executive Summary and the Introduction, namely, explaining the oscillatory and persistent migrating behavior types of inlets in North Carolina. A little more explanation, however, regarding the spatiotemporal dynamics of tidal inlets would strengthen the reasoning of selecting aerial photographs as the primary data set utilized in this effort. We should stress that inlet morphodynamics occur over small to meso spatial and temporal scales (meters-kilometers and from hours to decades); meaning the data used to characterize shoreline change around inlets need to span from hours of storm events through multiple decades.
2) A tremendous amount of work and published literature has vetted the use of rectified aerial photographs for mapping coastal shorelines and vegetation lines. A few more references and text highlighting the well-documented strengths and weaknesses of this methodology would be helpful particularly in light of the main point – crafting a methodology that works across many of NC's tidal inlets require a consistent data type that exists at all of them and

spans the required spatiotemporal scales needed to capture shoreline behavior around inlets. Simply put, aerial photographs are the best that we have. Other methodologies may be employed in future years as aerial lidar and UAS photogrammetry (providing accurate topography) become more widespread in space and time but, for now, metrics extracted from georectified aerial photographs are the best for this application.

3) The hybrid-vegetation line is explained but a few more sentences and references describing the significance of coastal vegetation with respect to how it reflects a period of time without recent inundation or erosion (and for how long). Since aerial photographs are not collected daily or always before and after storms, a reference metric is required that spans the interval between flights. Coastal dune vegetation does just that (based on typical recovery times in NC). Using the most landward vegetation line to calculate the hybrid-vegetation line therefore provides a conservative measure of the most landward inundation during the time period captured by the aerial photographs.
4) Alongshore spatial smoothing is justifiable and correctly applied, especially when constructing a fixed line that is compiled from multiple time periods (most landward vegetation line).
5) The use of aerial imagery from 1970-2000 seems a bit arbitrary as stated. Why that time period? Coincidentally, that 30-year period is one of the lowest multi-decade periods for tropical cyclones in the North Atlantic. Why not include a wider range say from 1960's to 2010?
6) Use of linear regression versus end-point for shoreline behavior is a no-brainer. Some could argue that a higher-order polynomial fit could be used but that approach rarely works uniformly across so many coastal features (i.e. 10 tidal inlets spanning very different physical conditions).
7) The use of shoreline change standard deviation as a metric for defining the IHA is a reasonable approach. Using the standard deviation of data that are sampled intermittently in time and at a frequency far lower than the behavior of what is being described (i.e. hourly-storm event shoreline change sampled seasonally or annually) can be misleading, nevertheless. That is why, in part, maximizing the time period for analysis is important (more than 1970-2000 if doable).
    a. An additional simple approach that may be added to a boundary defined by the break in slope of shoreline change standard deviation is a set alongshore distance as a function of the size of the ebb tidal delta (say, the seaward distance to the 7-m isobaths). The size of the ebb delta and the regional wave climate are primary drivers to shoreline fluctuations in the inlet hazard areas, a function of wave refraction and dissipation around the ebb tidal delta.
8) The exceptions noted in the Modifications to the computed inlet hazard area are important. These exceptions, though messy, are important factors to address when looking to locate-specific boundaries. My only suggestion is to more clearly document the underlying geological factors used in these considerations. If underlying substrates are more erosion-resistant, for example, let's cite the report containing the core logs. Similarly, if seismic data are considered to show ancient channel locations those profiles should be shown in a figure or cited at the minimum.

Murray comments

Overall, the IHAM reflects well the state of the science concerning shoreline dynamics and coastal processes; the focus on the greatly enhanced variability of shoreline position, associated with the tendency for cyclic alternations between erosion and accretion, encompasses the main source of enhanced vulnerability of inlet-adjacent shorelines, relative to non-inlet-adjacent shorelines. Inlet-adjacent shoreline are subject to both long-term averaged erosion rates (which are tied to and generally equal to those of nearby non-inlet-adjacent shorelines), and to cyclic variations in shoreline position.

Given this tendency to cyclic variations in shoreline position, a method that distinguishes a different cross-shore reference frame (for determining landward setback restrictions on land use) for inlet adjacent shorelines is necessary. The cross-shore reference frame tied to the most landward vegetation line (in observational timeframe), the Hybrid Vegetation Line, is a very appropriate choice. Using a vegetation line that can be identified in aerial photos parallels the present vegetation line that forms the reference frame in non-inlet-adjacent areas, but takes into account the tendency for cyclic variability on inlet-adjacent shorelines.

The present vegetation line clearly isn't appropriate in inlet-adjacent areas because vegetation and dunes can be re-established on timescales that are shorter than those of the cyclic variations between shoreline erosion and accretion in inlet-adjacent areas. Consider the case in which an inlet-adjacent shoreline has been accreting over recent years, with a present vegetation line that is seaward of the landward-most vegetation line (over the observational period). Using present vegetation line as a cross-shore reference for land-use restrictions in inlet affected areas, in the same way as restrictions are imposed outside of inlet hazard areas, would be misleading—implying that the land a given distance behind the present vegetation line near an inlet has the same expected lifetime as land at that distance landward of the present vegetation line in areas removed from an inlet. Such an approach that uses the present vegetation line would neglect the most pertinent aspect of inlet-adjacent shorelines: the cyclic variability. Using the landward-most vegetation line could still underestimate the enhanced risks in inlet-adjacent areas if the period of observations isn't long enough to capture the landward most limit of the cyclic variations in shoreline position. But, given the desirability to use a vegetation line (which is identifiable and parallels the methodology away from inlets), the landward most vegetation line in the observational period is clearly the best choice.

Regarding the criteria for defining the alongshore boundaries of IHAs: Using variability in shoreline position as the key metric is very appropriate. Defining a universal criterion based on a particular threshold for variability or using a break in slope in the variability vs. alongshore distance plots, while necessary, will inevitably be challenging. Clear breaks in slope delineate the inlet-affected and non-inlet-affected portion of the shoreline for most of the inlet shorelines. However, in some cases, ambiguity arises in exactly where to draw the line between inlet-affected and non-inlet-affected portions of the shoreline (e.g. for Lockwood-Folly and Mason Inlets). In such cases, the choice of threshold inlet-variability (or LRR), and choices about how to smooth the data alongshore (to reduce the effects of processes that are effectively noise for these purposes) affects the exact alongshore limits of the IHA. Such choices can, therefore, affect just which properties lie within the IHAs. Given that in such ambiguous cases a 'correct' answer doesn't exist, disputes in some cases seem unavoidable.

The Linear Regression Rates (LRR) is used in the IHAM as a secondary criterion for delineating IHAs. Using the for LRR for the purpose of determining alongshore limits to the IHAs seems less natural than using the variability in shoreline position; If observations over a sufficiently long period were available, the LRRs for inlet-affected shorelines should approach those of non-inlet-affected shoreline, while the variance in shoreline position for inlet-affected shorelines would remain higher than that for non-inlet-adjacent shorelines even as the observational period becomes arbitrarily long.

Finally, determining erosion rates by linear regression rather than end-point differences is clearly the best choice, especially given the high variability in shoreline position adjacent to inlets.

Hawkes comments (condensed by McNinch)

Hawkes provided many editorial comments directly in the posted report. Only points relevant to the methodology are repeated here. Hawkes agreed with the establishment and methodology of determining a hybrid vegetation line but suggested that the term be changed to *historic landward vegetation limits*. Establishing the exact location of the IHA boundary, as exemplified in Figures 6 and 9, was unclear as to whether this was done by locating an established quantified metric or simply by “eye” when the slope of shoreline variability changed. Lastly, Hawkes recommended further explanation of the complexities controlling hydraulic efficiency in tidal inlets (p. 22).