VILLAGE OF BALD HEAD ISLAND
SHORELINE PROTECTION PROJECT

FINAL ENVIRONMENTAL IMPACT STATEMENT

Prepared By:

U.S. Army Corps of Engineers
Wilmington District

and

Land Management Group, Inc.
(Third-Party Contractor)

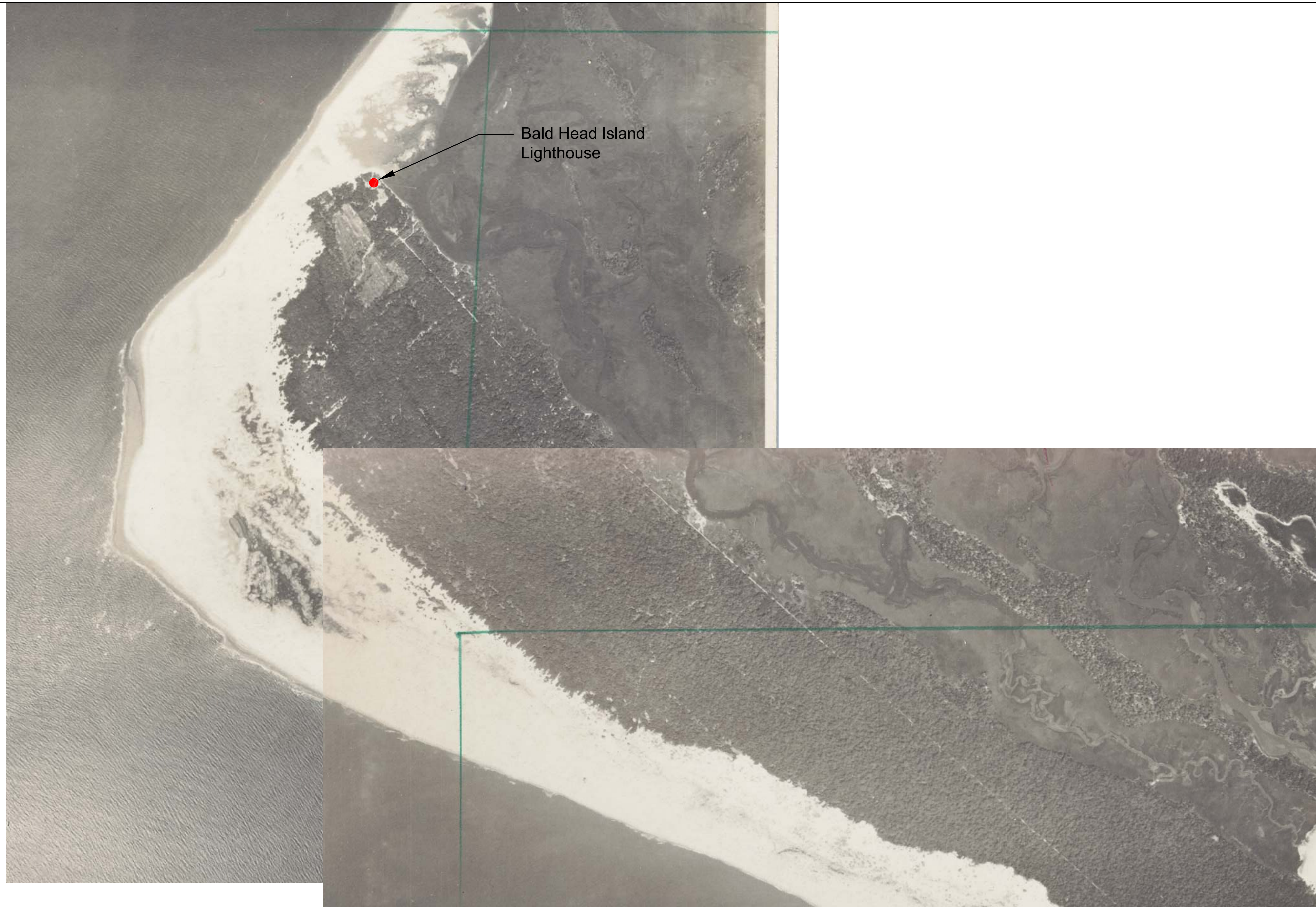
VOLUME III

(APPENDIX L THROUGH APPENDIX W)

August 2014

APPENDIX L

BALD HEAD ISLAND HISTORIC AERIAL IMAGERY

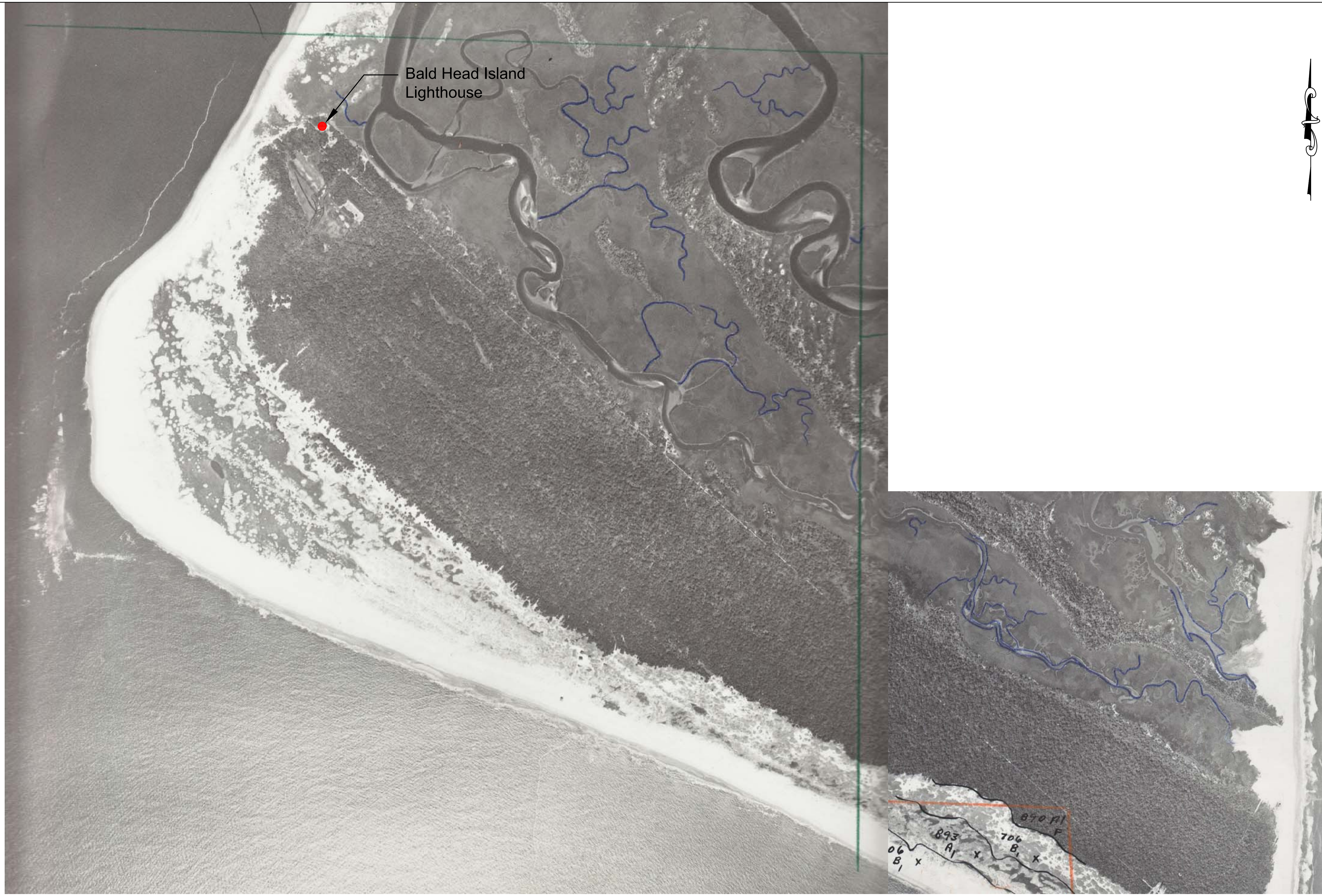


Aerial photography from NRCS.

0 600 1200 2400

LMG
LAND MANAGEMENT GROUP INC.
Environmental Consultants
Post Office Box 2522
Wilmington, North Carolina 28402
Telephone: 910-452-0001

Project:	**Village of Bald Head Island Shoreline Protection Project** **Draft Environmental Impact Statement**
Title:	***1938 NRCS Aerial***
Date:	4/2013
Revision Date:	NA
Scale:	**1"=1200'**
Job Number:	40-11-238
Drawn By:	
Figure:	



Aerial photography from NRCS.

0 600 1200 2400

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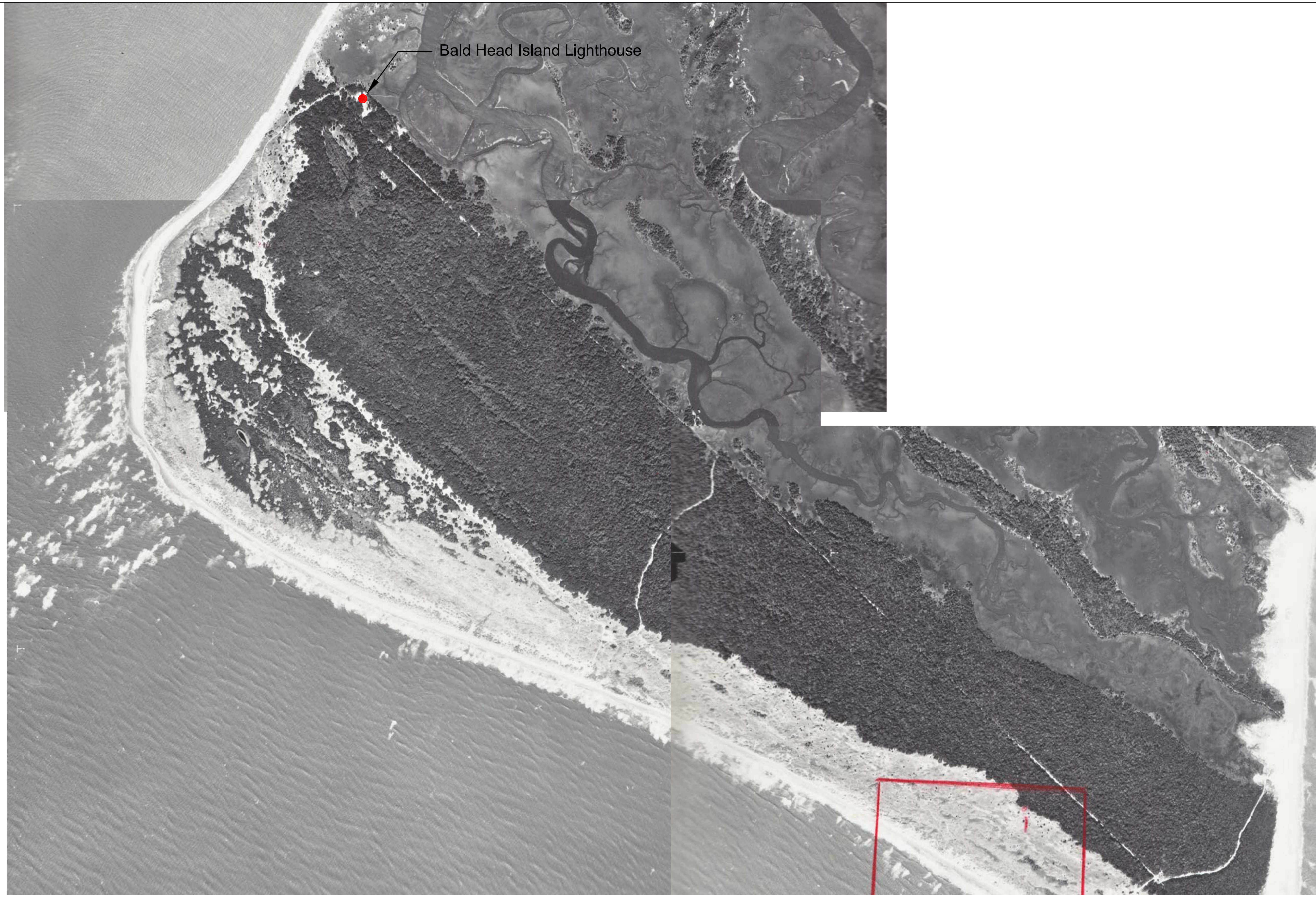
Project:	**Village of Bald Head Island Shoreline Protection Project** Draft Environmental Impact Statement
Title:	***1956 NRCS Aerial***
Date:	4/2013
Revision Date:	NA
Scale:	1"=1200'
Job Number:	40-11-238
Drawn By:	
Figure:	



Aerial photography from NRCS.

0 600 1200 2400

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Project: **Village of Bald Head Island Shoreline Protection Project** **Draft Environmental Impact Statement**	Date: 4/2013	Revision Date: NA
	Scale: **1"=1200'**	Job Number: 40-11-238
Title: ***1972 NRCS Aerial***	Drawn By:	Figure:

0 600 1200 2400

Aerial photography from NRCS.

LMG
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Project: **Village of Bald Head Island Shoreline Protection Project** **Draft Environmental Impact Statement**	Date: 4/2013	Revision Date: NA
Title: ***1981 NRCS Aerial***	Scale: **1"=1200'**	Job Number: 40-11-238
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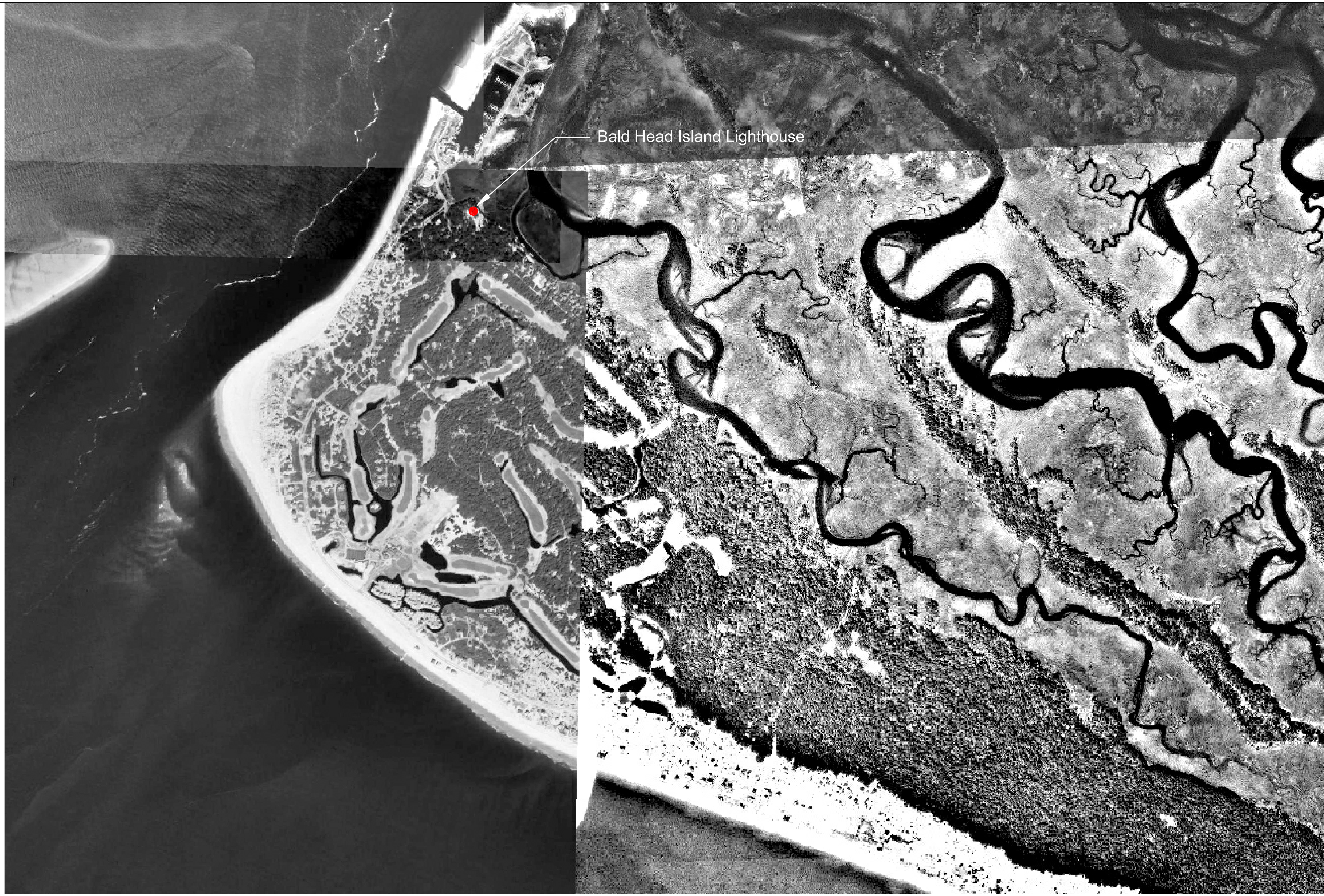
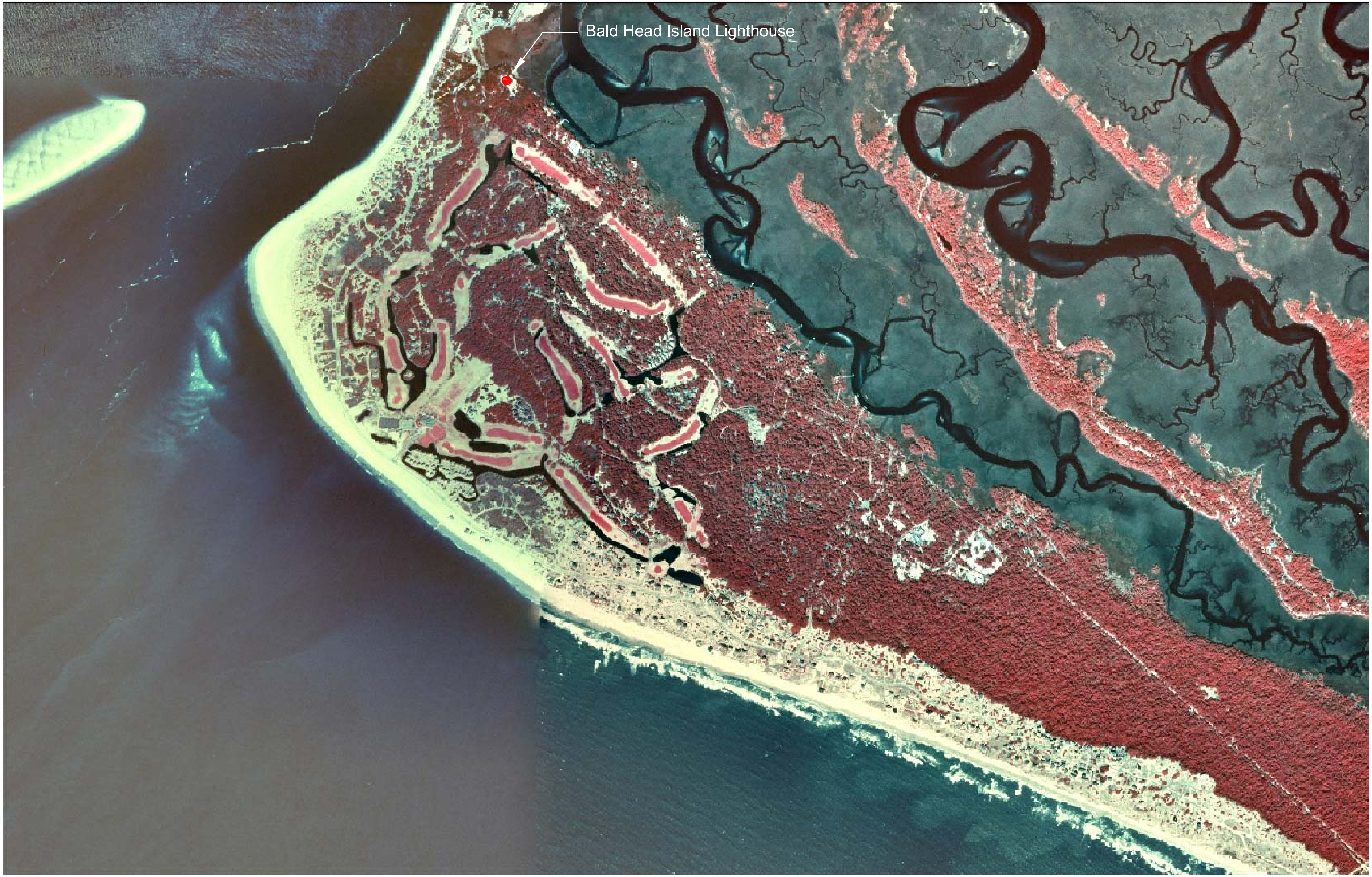


Aerial photography from USDA-NRCS.

0 600 1200 2400

LMG Land Management Group Inc. Environmental Consultants Post Office Box 2522 Wilmington, North Carolina 28402 Telephone: 910-452-0001	Project: **Village of Bald Head Island Shoreline Protection Project** **Draft Environmental Impact Statement**	Date: 4/2013	Revision Date: NA
		Scale: **1"=1200'**	Job Number: 40-11-238
	Title: ***1993 NAPP Aerial***	Drawn By:	Figure:



Aerial photography from USDA-NRCS.

0 600 1200 2400

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Project: **Village of Bald Head Island Shoreline Protection Project** Draft Environmental Impact Statement	Date: 4/2013	Revision Date: NA
Title: ***1998 NAPP Aerial***	Scale: **1"=1200'**	Job Number: 40-11-238
	Drawn By:	Figure:

Aerial photography from USDA-NRCS.

0 600 1200 2400

LMG LAND MANAGEMENT GROUP INC. Environmental Consultants Post Office Box 2522 Wilmington, North Carolina 28402 Telephone: 910-452-0001	Project: **Village of Bald Head Island Shoreline Protection Project** **Draft Environmental Impact Statement**	Date: 4/2013	Revision Date: NA
		Scale: **1"=1200'**	Job Number: 40-11-238
	Title: ***2004 Aerial Photograph***	Drawn By:	Figure:

Aerial photography from USDA-NRCS.

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Project: **Village of Bald Head Island Shoreline Protection Project** **Draft Environmental Impact Statement**	Date: 4/2013	Revision Date: NA
	Scale: **1"=1200'**	Job Number: 40-11-238
Title: ***2008 Aerial Photograph***	Drawn By:	Figure:

Aerial photography from USDA-NRCS.

0 600 1200 2400

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Project: **Village of Bald Head Island Shoreline Protection Project** Draft Environmental Impact Statement	Date: 4/2013
	Revision Date: NA
Title: ***2010 Aerial Photograph***	Scale: 1"=1200'
	Job Number: 40-11-238
	Drawn By:
	Figure:

APPENDIX M

BIRD NESTING DATA (1984-2011)

Appendix M. Bald Head Island shorebird monitoring data between 1984 and 2011 provided by NC Wildlife Resources Commission.

Date	Species	Number of Birds	Number of Breeding Pairs	Habitat	Landside	Comments	Latdeg	Latmin	Longdeg	Longmin	Lat-Long Accuracy
1984	Piping Plover	10		sand spit-inlet beach	inlet	New Inlet --from old data compiled by John Fussell -- American Birds and Bill Brokaw	33	54	77	52.20000076	estimate from map
1985	Piping Plover	2			inlet	New Inlet -data from American Birds, Bill Brokaw, John Fussell	33	54	77	52.20000076	estimate from map
1986	Piping Plover	1			inlet	New Inlet -data from American Birds, Bill Brokaw, John Fussell	33	54	77	52.20000076	estimate from map
1987	Piping Plover	1			inlet	New Inlet- data from American Birds, Bill Brokaw, John Fussell	33	54	77	52.20000076	estimate from map
1988	Piping Plover	0			inlet	New Inlet- data from American Birds, Bill Brokaw, John Fussell	33	54	77	52.20000076	estimate from map
1989	Piping Plover	0			inlet	New Inlet- data from American Birds, Bill Brokaw, John Fussell	33	54	77	52.20000076	estimate from map
1987	Piping Plover	1				from data compiled by David Allen	33	54	77	52.20000076	estimate from map
1989	Piping Plover	4				from data compiled by David Allen	33	54	77	52.20000076	estimate from map
5/26/1989	Wilson's Plover	17	8	sand beach/dunes/sand spit-inlet beach	ocean, inlet	8 pairs and 1 territorial female, 1 nest found with 3 eggs, 3 young chicks seen also.	33	54	77	52.20000076	estimate from map
5/26/1989	Piping Plover	0				Areas surveyed: From Mouth of Bald Head Creek to beyond the river point, from site of old coast guard station (Capt. Charlie's) to the cape point and N to New Inlet	33	54	77	52.20000076	estimate from map
12/31/1990	Piping Plover	0			ocean, inlet	South side of New inlet (shoaled in since then)	33	54.7999992	77	57	estimate from map
1/19/1991	Piping Plover	0					33	51	77	58	estimate from map:center of larger area covered
6/8/1991	Piping Plover	0					33	51	77	58	estimate from map
7/1/1994	Piping Plover	0					33	51	77	58	estimate from map:center of larger area covered
1/18/1996	Piping Plover	0					33	54	77	52.20000076	estimate from map

Appendix M. Bald Head Island shorebird monitoring data between 1984 and 2011 provided by NC Wildlife Resources Commission.

6/1/1996	Piping Plover	0					33	54	77	52.20000076	estimate from map
7/1/1997	Piping Plover	0					33	51.4000015	78	0	estimate from map
7/1/1998	Piping Plover	0					33	54	77	52.20000076	estimate from map
6/1/1999	Piping Plover	0					33	54	77	52.20000076	estimate from map
7/1/1999	Piping Plover	0					33	54	77	52.20000076	estimate from map
6/1/2000	Piping Plover	0					33	54	77	52.20000076	estimate from map
7/1/2000	Piping Plover	1				north end	33	54	77	52.20000076	estimate from map
9/28/2000	Piping Plover	1					33	54.9000015	77	55.79999924	estimate from map
11/17/2000	Piping Plover	1			ocean		33	51.5	78	0.5	estimate from map
2/1/2001	Piping Plover	0					33	50.7799988	77	57.93999863	hand held GPS
3/3/2001	Piping Plover	1		sand beach/intertidal surf	ocean	50 yards west of Captain Charlie's crossover (.75 mi west of Cape Fear)	33	51.3300018	78	0	estimate from map
3/22/2001	Piping Plover	2		dunes	ocean	chasing Wilson's, these 2 pipers were in the area of beach disposal	33	52	78	0.600000024	estimate from map
3/22/2001	Piping Plover	1		sand beach/intertidal surf	ocean	100 yards east if Captain Charlie's crossover (.25 mi west of Cape Fear)	33	51.5	78	0.330000013	estimate from map
3/27/2001	Piping Plover	0					33	52	78	0.600000024	estimate from map
3/27/2001	Piping Plover	1		sand beach	ocean	east of Cpt. Charlie's crossover (.25 mi west of Cape Fear)	33	51.5	78	0.330000013	estimate from map
3/27/2001	Piping Plover	3		sand beach/intertidal surf	ocean	east of Cpt. Charlie's crossover (.5 mi west of Cape Fear)	33	51.4000015	78	0.25	estimate from map
5/26/2001	Piping Plover	0		sand beach/dunes/mud flat-sandflat	ocean	west beach	33	52.1100006	78	0.629999995	hand held GPS
5/26/2001	Piping Plover	0		sand beach/dunes/mud flat-sandflat	ocean	Cape Fear	33	50.5600014	77	57.68000031	hand held GPS
5/26/2001	Piping Plover	0		sand beach/dunes/mud flat-sandflat	ocean	south beach	33	51.1100006	77	59.20000076	hand held GPS

5/30/2001	Piping Plover	0				sand disposal on beach front in center part of survey area- this area not surveyed	33	51.5499992	78	0.600000024	estimate from map
5/30/2001	Wilson's Plover	18	9	overwash/dunes	ocean	9 breeding pairs	33	54	77	52.20000076	estimate from map
5/30/2001	American Oystercatcher	2	1	overwash/dunes	ocean	1 breeding pair	33	54	77	52.20000076	estimate from map
5/30/2001	Willet	22	11	overwash/dunes	ocean	11 breeding pairs	33	54	77	52.20000076	estimate from map
6/2/2001	Piping Plover	0		sand beach/dunes/mud flat-sandflat	ocean	Cape Fear	33	50.5600014	77	57.68000031	hand held GPS
6/2/2001	Piping Plover	0		sand beach/dunes/mud flat-sandflat	ocean	west beach	33	52.1100006	78	0.629999995	hand held GPS
6/2/2001	Piping Plover	0		sand beach/dunes/mud flat-sandflat	ocean	south beach	33	51.1100006	77	59.20000076	hand held GPS
7/1/2001	Piping Plover	0					33	51.5	78	0	estimate from map
7/8/2001	Piping Plover	5		intertidal surf	ocean	.25 mi. west of Cape Fear	33	50.5	77	58.15000153	estimate from map
8/16/2001	Piping Plover	1		intertidal surf	ocean	near mouth of Cape Fear river	33	51.5999985	78	0.600000024	estimate from map
7/1/2002	Piping Plover	0		sand beach/sand spit-inlet beach	inlet, sound, ocean		33	51	77	58	survey not site specific
8/23/2002	Piping Plover	1		sand beach/intertidal surf	ocean	midway btwn Cape Fear and the mouth of the Cape Fear River, no bands	33	50.5600014	77	57.68000031	estimate from map
9/13/2002	Piping Plover	1		intertidal surf	ocean	.5 miles W of Cape Fear, no bands	33	51.4000015	78	0.25	estimate from map
11/25/2002	American Oystercatcher	30				aerial survey	33	51	77	58	survey not site specific
6/23/2003	Piping Plover	0					33	51	77	58	survey not site specific
6/4/2004	American Oystercatcher	2	1		ocean	~2 miles past sign; 1 breeding pair	33	52.9000015	77	57.5	survey not site specific
6/4/2004	Wilson's Plover	2	1		ocean	1 breeding pair; nest with 3 eggs observed at the The Point	33	50.5	77	57.79999924	estimate from map

Appendix M. Bald Head Island shorebird monitoring data between 1984 and 2011 provided by NC Wildlife Resources Commission.

6/4/2004	Wilson's Plover	2	1		ocean	1 breeding pair; 1 chick observed in a washover behind the first row of dunes. Another male flew into pairs territory causing pair to defend chick and territory; ~2 miles past sign	33	52.9000015	77	57.5	estimate from map
7/1/2005	Piping Plover	0					33	51	77	58	survey not site specific
2/1/2006	Piping Plover	0					33	51	77	58	survey not site specific
5/2/2006	Piping Plover	4			ocean	South Point	33	51	77	58	survey not site specific
6/7/2006	Red Knot	30				east beach	33	51	77	58	survey not site specific
6/7/2006	Piping Plover	0				mid and rising tide	33	51	77	58	estimate from map:center of larger area covered
7/1/2006	Piping Plover	0	0				33	51	77	58	survey not site specific
6/6/2007	Wilson's Plover	1				North End of Island; non committal - possibly just a single male	33	54.428299	77	56.90650177	estimate from map:center of larger area covered
6/6/2007	American Oystercatcher	4	2			N end of Bald Head Island - 2 pair on beach - appear to be finished nesting	33	54.428299	77	56.90650177	estimate from map:center of larger area covered
6/6/2007	Wilson's Plover	4	2			South Point; one territory had nest with 3 eggs; other had agitated adults	33	50.5974998	77	57.74449921	estimate from map
6/6/2007	Wilson's Plover	16	8			North End of Bald Head Island - defensive behavior	33	54.428299	77	56.90650177	estimate from map:center of larger area covered
2010	American Oystercatcher	2	1			Observed by Emily Rice (waterbird biotech)					
2011	Wilson's Plover	6	3			Observed by BHIC.					

APPENDIX N

TELEMETRY DATA SUMMARY (CAPE FEAR RIVER)

(Prepared by NC Division of Marine Fisheries)

NC DMF Telemetry Data Summary – Cape Fear River (prepared by NC DMF)

Since 2011, the North Carolina Division of Marine Fisheries has maintained an acoustic monitoring array of on average 30 Vemco VR2W receivers stationed throughout the lower Cape Fear basin (Figure 1.) to track the movements and migrations of acoustically tagged anadromous fish. The two lower most stations located at Bald Head Island and Caswell Beach (LOCF01, LOCF02 respectively), have overlapping detection ranges (up to 2.5 mi)and serve as a "gate" at the river mouth to record any tagged fish in that region of river (Figure 2). Between April 2011 and January2014, 80 Atlantic sturgeon (*Acipenser oxyrhynchus*) and 2 shortnose sturgeon (*Acipenser* brevirostrum) were captured and implanted with Vemco V16 acoustic transmitters in the Cape Fear River system.Using pooled detection data across project years, tagged sturgeon (*Acipenser spp.*) were detected by stations LOCF01 or LOCF02, nine out of twelve calendar months (Table 1). This pattern of presence / absence in the lower reaches of the Cape Fear is driven by the reproductive migrations and differences in seasonal habitat use of mature and sub-adult sturgeon. Two main peaks in sturgeon movement, spring immigration and fall emigration, are the primary periods in which fish are located at the river mouth (Figure 3.) Mature Atlantic sturgeon have been detected to enter the Cape Fear starting late Feb, and exiting out of the river by the end of May. Sub-adult Atlantic sturgeon have been detected to enter the river starting in March, with the last fish entering the system in May. Sub-adult Atlantic sturgeon then typically spend the summer months (June-Aug) in deep water stretches above the saltwater interface (north of Wilmington, NC), before starting to emigrate to the ocean in September. Sturgeon tagged within the Cape Fear River typically are only detected briefly (< 20mins) at stations LOCF01 or LOCF02, before moving out of the receiver range and being detected later up-river (migrating in) or deemed to have left the system (migrated out). However, several adult Atlantic sturgeon tagged by various research institutions along the east coast have also been detected over the course of several days between Sep-May at the river mouth, indicating that this area can host large fish from other systems during their extended coastal migrations.

Table 1. Presence of Sturgeon (*Acipenser spp.*) in the lower Cape Fear River based on pooled acoustic tag detections from April 2011, to January 2014. “X” indicates at least one tag detection at that station for that month.

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
LOCF01			X	X	X				X	X	X	X
LOCF02	X	X	X	X						X	X	X

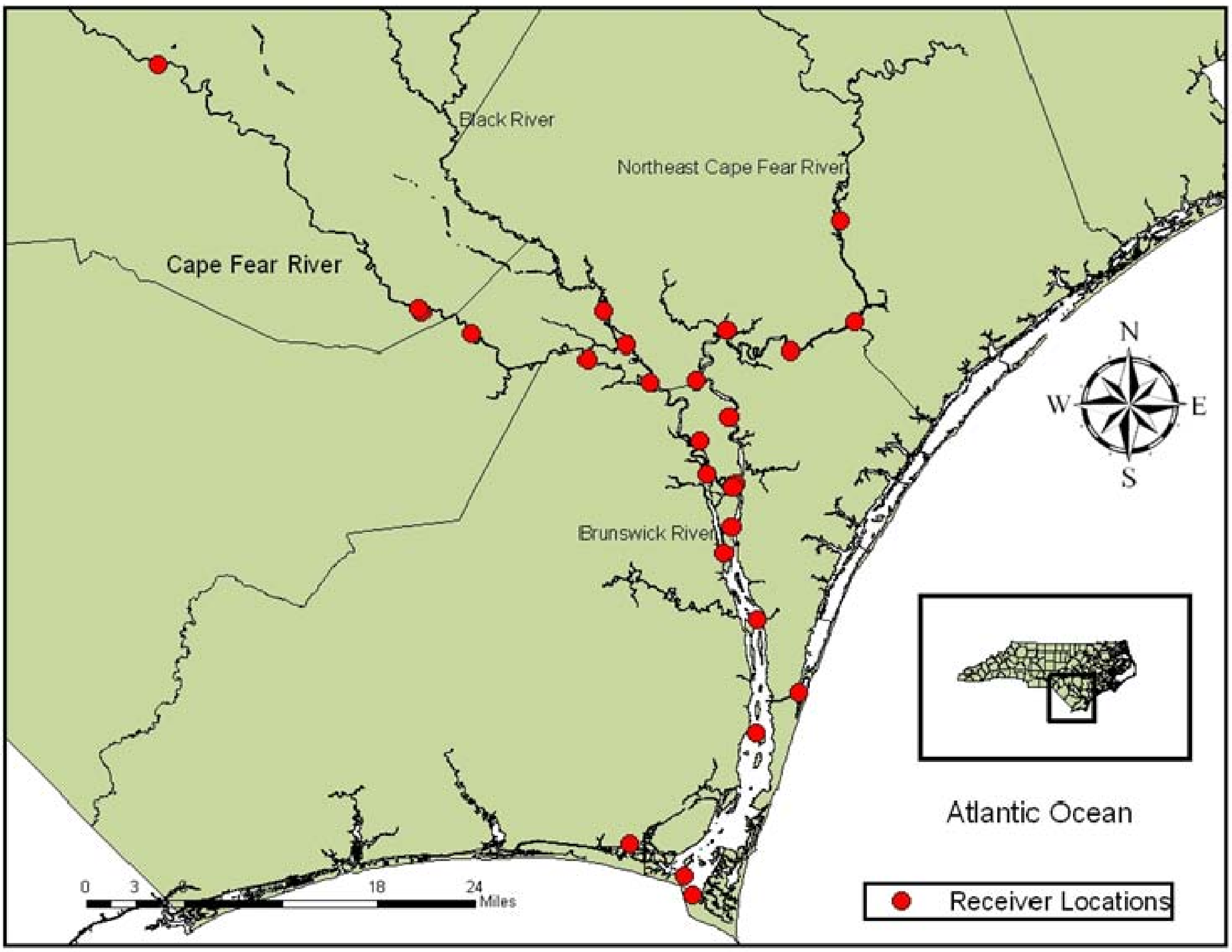


Figure 1.Acoustic monitoring stations within the Cape Fear system.

Figure 2.Satellite image showing the locations of acoustic receiver stations LOCF01 and LOCF02, which form the “gate” at the mouth of the Cape Fear River.

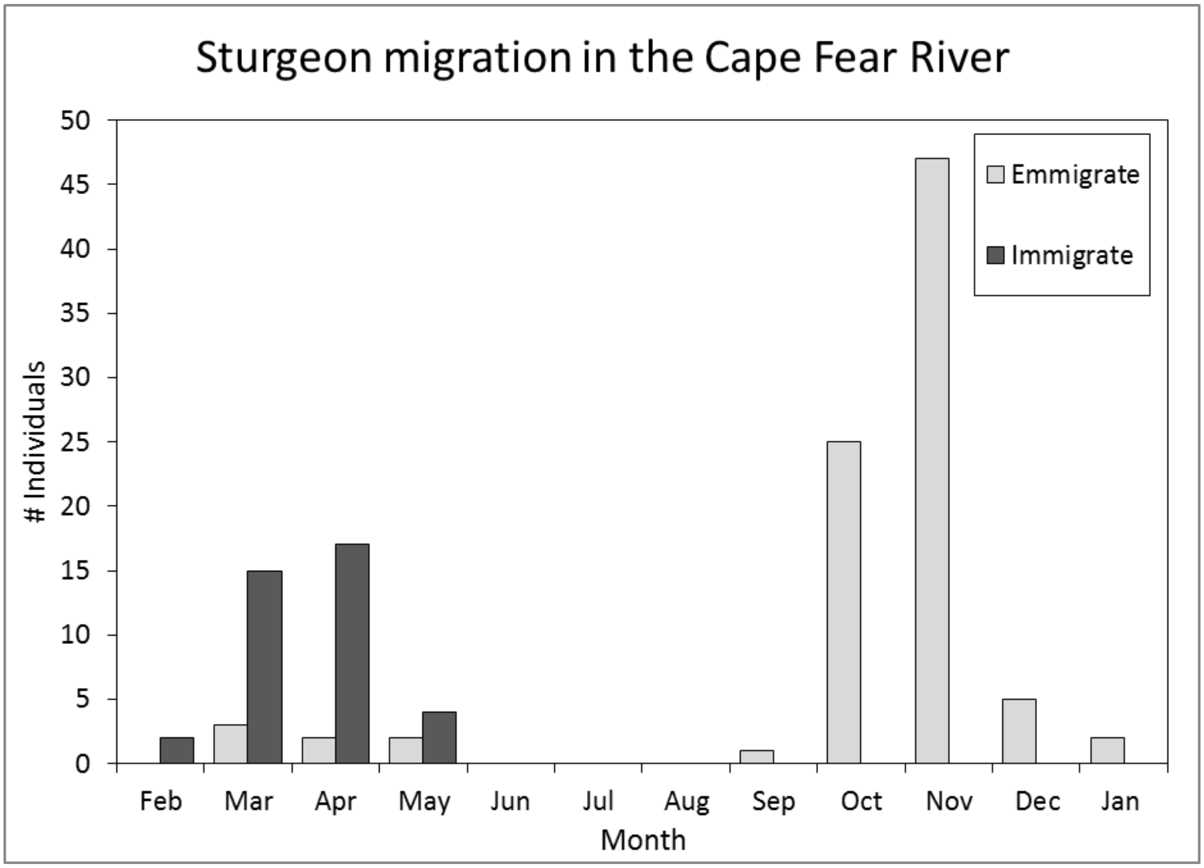


Figure 3.The number of individual sturgeon entering or leaving the Cape Fear River system pooled by month from April 2011 to Jan 2014.

APPENDIX O

ANNOTATED BIBLIOGRAPHY:
NEARSHORE AND ESTUARINE FISHERIES DATA
(NORTH CAROLINA AND SOUTH CAROLINA INLETS)

(Assembled by Land Management Group, Inc. August 2013)

ANNOTATED BIBLIOGRAPHY:

Nearshore and Estuarine Fisheries Data
North Carolina and South Carolina Inlets
(With Emphasis on Inlets of the Cape Fear Region)

Prepared for

Village of Bald Head Island Shoreline Protection Project

1. **Birkhead, W.A. et al. 1979.** Ecological monitoring in the lower Cape Fear estuary, 1971-1976. Report 79-1. Carolina Power and Light Company, Raleigh, North Carolina. 292 pp.

   Carolina Power and Light Company. 1979. Brunswick Steam Electric Plant, Ocean Larval Fish, November 1976-August 1978. Environmental Technology Section. 119 pp.

   Carolina Power and Light Company. 1985. Brunswick Steam Electric Plant, Cape Fear Studies, Interpretive Report. Environmental Technology Section. 93 pp.

   Carolina Power and Light Company. 1992. Brunswick Steam Electric Plant, 1992 Biological Monitoring Report. Environmental Technology Section. 60pp.

   Location of Studies: Lower Cape Fear River Estuary, NC.

   Synopsis of Studies: As part of Carolina Power and Light's NPDES Permit NC0007064, CP &L, now Progress Energy, embarked on a multi–decade, comprehensive biological monitoring program to describe the offshore concentrations and changes in density over time of commercially important taxa in the nearshore and estuarine environments of the Cape Fear River Estuary. Beginning in 1971 and continuing through 1992, fish and invertebrate taxa were sampled, identified and monitored for changes in abundance, seasonality, or recruitment to the estuary via impingement resulting from the normal operations and modification of the Brunswick Electric Steam Plant's (BESP) water intakes. More than 40 taxa (CP&L, 1979) of fish and invertebrates were identified with 9 (CP&L,1992) commercially significant species (Atlantic menhaden, bay anchovy, spot, croaker, southern flounder, brown shrimp, pink shrimp, white shrimp, and blue crab) studied in 5 different locations throughout the Cape Fear River Estuary. Conclusions (as of the 1992 biological monitoring report) were that the normal operations of the BESP have not adversely affected the typical species composition, seasonal occurrence, and spatial distribution of dominant fish and shellfish in the Cape Fear Estuary.

2. **Hackney, C.T., M. Posey, S. Ross, and A. Norris. 1996.** A Review and Synthesis of Data on Surf Zone Fishes and Invertebrates in the South Atlantic Bight and the Potential Impacts from Beach Renourishment. For Wilmington District, US Army Corps of Engineers, Wilmington, North Carolina.

   Location of Study: South Atlantic Bight (SAB) (Cape Hatteras, NC to Cape Canaveral, FL) with special emphasis on North Carolina.

   Synopsis of Study: The paper provides a thorough review of fishes and benthic invertebrates most common in the surf zone along the South Atlantic Bight. The study identified 130 different taxa found in the surf zone of the SAB with 40 of those occurring in North Carolina. Discussion of life histories of 9 fish species and 5 invertebrate groups that are important to humans for food and recreation as well as other important species found in the surf zone of the SAB and to provide recommendations on future management and biological monitoring needs as they relate to repeated beach renourishment of the barrier islands of the Southeastern United States.

3. **Markovsky, W.C. 2004.** The role of the Cape Fear River discharge plume in fisheries production: aggregation and trophic enhancement. A Thesis submitted to the University of North Carolina at Wilmington. Department of Biological Sciences. 86 pp.

   Location of Study: The Cape Fear River and nearshore waters, NC.

   Synopsis of Study: The thesis study examined the effects of small river plumes such as the Cape Fear River on the overall abundance of larval fish abundance compared to the less turbid waters of the adjacent waters and to compare this with other known plume effects of larger rivers like the Mississippi River. Conclusions of this study suggest that smaller river plumes also have higher concentrations of ichthyoplancton possibly suggesting greater larval aggregation compared to the adjacent waters but more research is needed to fully understand these processes. Note that sampling included a station west of Bald Head Island in the mouth of the Cape Fear River.

4. **Moser, M. L., and S. W. Ross. 1993.** Distribution and movements of shortnose sturgeon (Acipenser brevirostrum) and other anadromous fishes of the lower Cape Fear River, North Carolina. Final Report to the U.S. Army Corps of Engineers, Wilmington, North Carolina.

Moser, M.L. and S.W. Ross. 1995. Habitat use and movements of shortnose and Atlantic sturgeons in the Low Cape Fear River, North Carolina. Transactions of the American Fisheries Society. 124 (2): 225-235.

Location of Studies: Cape Fear River, NC.

Synopsis of Studies: To provide life history, distribution of and habitat requirements of shortnose and Atlantic sturgeons as well as other anadromous fish species known to occur in the Cape Fear River such as striped bass and American shad.

5. **Versar, Inc. 2003.** Effects of dredged material beach disposal on surf zone and nearshore fish and benthic resources on Bald Head Island, Caswell Beach, Oak Island and Holden Beach, NC; Interim study findings, Volume I Text. Report prepared for Frank Yelverton, USACE Wilmington District. 61pp.

Versar, Inc. 2003b. Effects of dredged material beach disposal on surf zone and nearshore fish and benthic resources on Bald Head Island, Caswell Beach, Oak Island and Holden Beach, NC; Interim study findings, Volume II Figure and Tables. Report prepared for Frank Yelverton, USACE Wilmington District. 321pp.

Versar, Inc. 2004. Year 2 recovery from impacts of beach nourishment on surf zone and nearshore fish and benthic resources on Bald Head Island, Caswell Beach, Oak Island, and Holden Beach, NC. (Final study findings). Report prepared for Frank Yelverton, USACE Wilmington District. 54pp.

Location of Studies: Bald Head Island, Caswell Beach, Oak Island, and Holden Beach, NC.

Synopsis of Studies: A two-year study evaluating the water quality and biological effects of large scale beach disposal that was conducted as part of the Cape Fear River navigational channel deepening project. Fish sampling results reported between 39 and 92 nekton species identified between the surf zone and nearshore waters depending on the sampling gear type used (haul seine, otter trawl and gillnet). Results of this sampling documented similar surf zone species as those found in the South Atlantic Bight study by Hackney et al. 1996. The final report of the two year study indicated no immediate impacts in fish abundances and diversities among disturbed, undisturbed, and reference stations at any beach.

6. **Ross, S. W. and John Bichy. 2002.** Checklist of the Fishes Documented from the Zeke's Island and Masonboro Island Components of the North Carolina National Estuarine Research Reserve. The National Estuarine Research Reserve Technical Report Series 2002:2 31pp.
   Location of Study: Masonboro Island and Zeke's Island, NC.

   Synopsis of Study: This report establishes baseline data to document the two Reserves (Masonboro Island and Zeke's Island) ichthyofauna and is to serve as a benchmark to measure future changes. This effort documents 155 and 103 fish species, representing 58 families, so far recorded from Masonboro Island and Zeke's Island NCNERR components, respectively.

7. **Ross, S. W. and Johnny E. Lancaster. 1996.** Movements of juvenile fishes using surf zone nursery habitats and the relationship of movements to beach nourishment along a North Carolina beach: Pilot project. Final Report to NOAA Office of Coastal Resource Management and the U. S. Army Corps of Engineers (Wilmington District) for NOAA Award No. NA570z0318. 31p.

   Location of Study: Masonboro Island and Carolina Beach, NC.

   Synopsis of Study: This study showed that two dominant fishes, Florida pompano and Gulf kingfish, using the surf zone as a nursery area exhibited a strong fidelity to small areas of the beach. Since these fishes are quite mobile, this suggests that resources at most beach locations where they initially settle are not limiting or that predation pressures are not high enough to cause large scale movements during the nursery period. Through the use of small coded wire tags it was determined through consistent recaptures of individuals in the same vicinity that large sections of the surf zone are functionally independent habitats.

8. **Hettler Jr., W. F. and C. J. Chester. 1990.** Temporal distribution of ichthyoplankton near Beaufort Inlet, North Carolina. Marine Ecology Progress Series 68:157-168.

   Location of Study: Beaufort Inlet, NC

   Synopsis of Study: This study provides a database on the species, numbers, and sizes of larval/early juvenile fishes in a North Carolina inlet throughout the entire year. Species were classified into 3 main temporal assemblages: winter and early spring, late spring, and summer. All species collected during winter were advanced post flexion larvae or juveniles, while many of the spring/summer species were pre-flexion and flexion larvae. At total of 74 species or genera representing 34 families were collected during the study. Anchovy dominated the non-winter catches.

Variability in observed total fish densities between hauls within collections was high. About one-third of the species found in the collections later utilized nearby marshes as a nursery habitat.

9. **Hettler Jr., W. F. and D. L. Barker. 1993.** Distribution and abundance of larval fishes at two NC Inlets. Estuarine, Coasts and Shelf Science. 37, 161-179.

Location of Study: Oregon Inlet, NC and Ocracoke Inlet, NC.

Synopsis of Study: Oregon Inlet and Ocracoke Inlet were quantitatively sampled for larvae at new moon monthly intervals during 1988-89. Stations inside of both inlets were sampled both during day and night at single stations. Oregon inlet, located in a more temperate marine province, was expected to have a different taxonomic community than Ocracoke Inlet, but, of 77 taxa collected from both inlets, 54 occurred at both inlets. Documented differences in lowest and highest abundances were reported for each inlet with Oregon Inlet lowest occurring in Feb. and highest in late August. Ocracoke Inlet had it's lowest in November highest in June. The highest percentage of larval abundance differed at each site with the majority of larvae capture near the bottom at Oregon Inlet and near the surface at Ocracoke Inlet. Most larvae were caught at night at both sites. Twenty-one species were significantly different in mean length between the two inlets.

10. **Hettler Jr., W. F. and Jonathan A. Hare. 1998.** Abundance and size of larval fishes outside the entrance to Beaufort Inlet, North Carolina. Estuaries, Vol 21, No. 3, 476-499pp.

Location of Study: Beaufort Inlet, NC.

Synopsis of Study: Sampling of seven (7) ocean-spawned, estuarine-dependent fishes (Atlantic menhaden, spot, Atlantic croaker, pinfish, Gulf flounder, summer flounder, and southern flounder) was conducted on two transects, one on either side of Beaufort Inlet, North Carolina during the winter immigration season. Larval densities and lengths varied greatly between species and locations either inside or outside the inlet. Larval densities also varied greatly both inside and outside the inlet depending upon the direction of the wind component. Distance, direction to the inlet from offshore shelf spawning areas and water temperature all play a role in overall densities outside the inlet. Patterns in larval density outside of Beaufort Inlet were complex and apparently influence by both physical processes that supply larvae to the nearshore region and nearshore physical dynamics.

11. **Weinstein, M.P., Sidney L. Weiss, Ronald G. Hodson, and Lawrence R. Gerry. 1980.** Retention of three taxa of postlarval fishes in an intensively flushed tidal estuary, Cape Fear River, North Carolina. Fisheries Bulletin. Vol. 78, No. 2.

   Location of Study: Cape Fear River, NC.
   Synopses of Study: Fixed nets were used to sample postlarvae of spot, Atlantic croaker, and flounders over several 24-hour periods in the Cape Fear River, near Wilmington, North Carolina. Results of this study indicate that that postlarva of these species exhibit behavioral patterns with respect to photoperiod and tide which are instrumental in enabling these organisms to maintain selected positions in the estuary and avoid being flushed seaward. By migrating to the surface at night, both spot and flounders make apparent use of tides to augment lateral migration into the marsh. However, Atlantic croaker tended to remain more toward the bottom and accumulated in larger numbers in deep water at the head of the estuary.

12. **Hare, J. O., J.A. Quinlan, F.E. Werner, B.O. Blanton, J.J. Govini, R.B. Forward, L.R. Settle, and D.E. Hoss. 1999.** Larval transport during winter in the SABRE study area: results of a coupled vertical larval behavior-three-dimensional circulation model. Fisheries Oceanography. 8(2): 57 7

   Location of Study: Beaufort Inlet, NC.

   Synopsis of Study: Two surveys of larval abundance and water flow were performed within the estuarine region near Beaufort Inlet, North Carolina. Each survey extended over 2 full semidiurnal tidal cycles and included measurements of larvae concentration and velocity distribution at several locations. A net ingress of larvae from the open ocean into the estuary was observed during both surveys. Most larvae entered the estuary over the eastern and central portions of the inlet, where the subtidal flow was up-estuary. However, the mean circulation played a minor role in the net movements of larvae into the estuary. Net up-estuary transport of larvae was principally due to variation of larval abundance with tidal flow; with abundance during flood tide usually far exceeding ebb tide abundance. This mode of transport was likely driven by a behavioral response to tidal flow in which larvae tended to descend to the bottom on falling tides and reside throughout the water column on rising tides.

13. **Hare, Jonathan A., John A. Quinlan, Francisco E. Werner, Brian O. Blanton, John J. Govoni, Richard B. Forward, Lawrence R. Settle, and Donald E. Hoss. 1999.** Larval transport during winter in the SABRE study area: results of a coupled vertical larval behavior-three dimensional circulation model. Fisheries Oceanography. 8(Supplemental 2), 57-76.

Location of Study: Circulation Model using fictitious locations between Cape Romain, SC and Cape Hatteras, NC (South Atlantic Bight Recruitment Experiment [SABRE])

Synopsis of Study: Three dimensional circulation model was used in conjunction with larval fish vertical behavior models to study the interaction between larval vertical distribution, advection and the outcome of larval transport along the central portion of the east coast of the United States. Vertical behavior models were developed for Atlantic menhaden and spot. The purpose of the model was to investigate the transport pathways of Atlantic menhaden and spot larvae from offshore spawning grounds to estuarine nursery habitats. Both physical (e.g. wind) and biological (e.g. changes in larval behavior) events were responsible for many of the observed patterns in larval transport. Overall, larval transport was determined by circulation but was modified by larval vertical distributions.

14. **Blanton, J. O., Francisco E. Werner, Andras Kapolnai, Brian O. Blanton, David Knott, and Elizabeth L. Wenner. 1999.** Wind-generated transport of fictitious passive larvae into shallow tidal estuaries. Fisheries Oceanography. 8(Supplemental 2), 210-223.

Location of Study: Model depicting the North Edisto Inlet, SC.

Synopsis of Study: Both field and model results indicate that wind stress with an onshore component efficiently transports particles and larvae toward inlets where they can be transported by flood tide into estuarine environments. Peak abundance of larval white shrimp and blue crab megalopae are associated with certain wind directions. Passive particles were initially distributed uniformly in a zone of the continental shelf which extended 20 km offshore and 20 km alongshore in either direction. Each simulation was conducted for five tidal cycles (2.5 days) under constant wind stress. These simulations indicated that larvae are withdrawn from the continental shelf into the inlet from a narrow zone parallel to the shoreline but extending less than 5 km offshore. The withdrawal zone changed to one directly offshore of the inlet only for a wind direction that pointed directly toward the inlet mouth. Under downwelling-favorable winds, particles originating in the surface accumulate along the downwind boundary and drift shoreward with time causing a pooling of larvae along the coast. This scenario is repeated with less efficiency for upwelling-favorable winds with particles originating near the bottom.

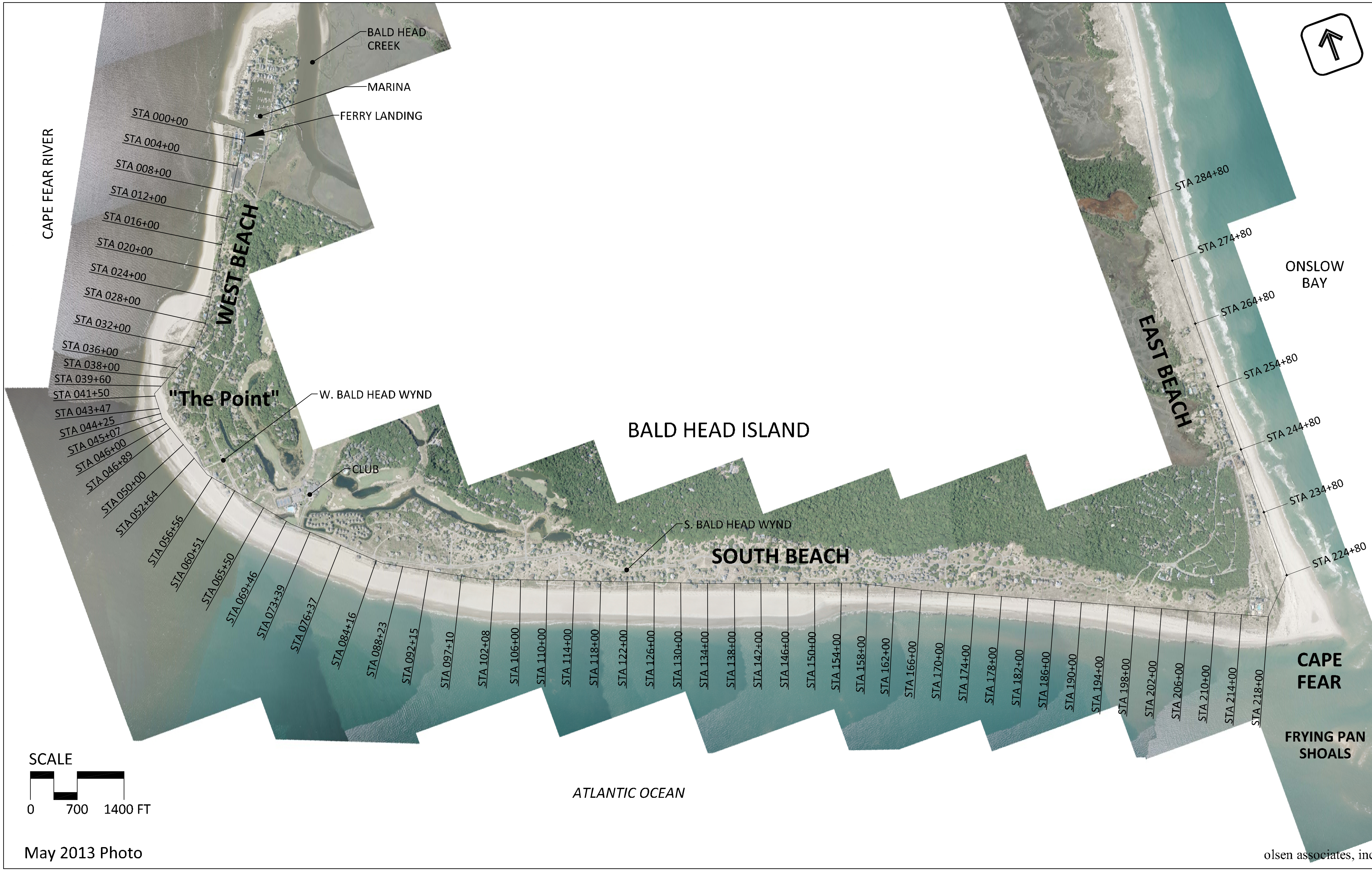
15. Allen, Dennis M. and D. Lynn Barker. 1990. Interannual variations in larval fish recruitment to estuarine epibenthic habitats. Marine Ecology Progress Series. Vol. 63: 113-125.

Location of Study: North Inlet Estuary, SC.

Synopsis of Study: More than 45 species of fish were collected during epibenthic sled trawls from the North Inlet estuary in South Carolina between 1981 and 1985. Two distinct periods of larval fish recruitment were identified: summer in which gobies and anchovies were most abundant and winter, in which spot and croaker dominated. Arrival dates were consistent during all years of collections. It was also reported that during extended periods of low salinity in the winters of 1983 and 1984, winter taxa were significantly more abundant than in other years. Low salinity conditions represented extreme changes for an otherwise high salinity estuary, yet no notable differences in the taxonomic composition, ranks, or timing of arrivals were observed between the 4 winters sampled. Further, size distributions of larval fishes were very similar at all locations. These observations suggest that factors controlling larval fish recruitment and fluctuations in abundance were operating on a large spatial scale. Major ecosystem level disturbances such as extreme reductions in salinities during some winters did not appear to alter temporal patterns of larval fish recruitment as much as the magnitude of utilization of epibenthic habitats.

APPENDIX P

STATION LOCATION MAP



Island-wide beach monitoring baseline.

APPENDIX Q

ENVIRONMENTAL CONSEQUENCES SUMMARY TABLE (BY ALTERNATIVE)

Appendix Q. Summary of Direct, Indirect, and Cumulative Environmental Consequences by Alternative

Resource	Description of Stressor	Direct (D, Indirect (I)	Alt 1		Alt 2		Alt 3		Alt 4		Alt 5		Alt 6	
Threatened and Endangered Species			Level of Effect	Potential for Cumulative Effect (Y or N)	Level of Effect	Potential for Cumulative Effect (Y or N)	Level of Effect	Potential for Cumulative Effect (Y or N)	Level of Effect	Potential for Cumulative Effect (Y or N)	Level of Effect	Potential for Cumulative Effect (Y or N)	Level of Effect	Potential for Cumulative Effect (Y or N)
Marine Mammals	Collision Threat	D	Absent to Low	N	Absent to Low	N	Absent to Low	N	Absent to Low	N	Absent to Low	N	Absent to Low	N
	Effects to Foraging Habitat	I	Absent to Low	N	Absent	N	Absent to Low	N	Absent to Low	N	Absent to Low	N	Absent to Low	N
Sea Turtles	Collision Threat	D	Absent to Low	N	Absent to Low	N	Absent to Low	N	Absent to Low	N	Absent to Low	N	Absent to Low	N
	Physical Loss of Nesting Habitat	I	Moderate to High	N	High	N	Low	N	High	N	Low	N	Low to Moderate	N
	Beach Compaction/Compatability	I	Absent to Low	N	Absent to Low	N	Absent to Low	N	Absent to Low	N	Absent to Low	N	Absent to Low	N
	Beach Impediments (e.g. Escarpments) to Adult Females	I	Low to Moderate	N	Moderate	N	Low to Moderate	N	Moderate	N	Low to Moderate	N	Low to Moderate	N
	Structural Impediments/Interference with Adult Females or Hatchlings	I	Low to Moderate (Groinfield)	N	Absent	N	Low to Moderate (Groinfield)	N	Absent	N	Moderate to High	N	Low to Moderate	N
	Predator Concentration	I	Low to Moderate (Groinfield)	N	Absent	N	Low to Moderate (Groinfield)	N	Absent	N	Moderate to High	N	Low to Moderate	N
Birds	Physical Loss of Nesting Habitat	I	Absent to Low	N	Moderate to High	N	Low to Moderate	N	Moderate to High	N	Low	N	Low	N
	Degradation of Nesting Habitat	I	Absent to Low	N	Moderate to High	N	Low to Moderate	N	Moderate to High	N	Low	N	Low	N
	Physical Loss of Foraging Habitat	I	Moderate to High	N	Moderate to High	N	Low to Moderate	N	Moderate to High	N	Low	N	Low	N
	Degradation of Foraging Habitat (e.g. reduced prey abundance)	I	Moderate	N	Low	N	Moderate	N	Moderate	N	Low to Moderate	N	Moderate	N
	Nest Interference	I	Low to Moderate	N	Absent to Low	N	Low to Moderate	N	Low to Moderate	N	Low	N	Low to Moderate	N
Fish	Entrainment	D	Absent to Low	N	Absent to Low	N	Absent to Low	N	Absent to Low	N	Absent to Low	N	Absent to Low	N
	Effects to Water Column	I	Low	N	Low	N	Low	N	Low	N	Low	N	Low	N
	Effects to Larval Transport	I	Absent	N	Absent	N	Absent	N	Absent	N	Absent to Low	N	Absent to Low	N
	Effects to Foraging Habitat	I	Low	N	Low	N	Low	N	Low to Moderate	N	Low	N	Low	N
	Effects to Ingress/Egress to Estuary	I	Absent	N	Absent	N	Absent	N	Absent	N	Absent to Low	N	Absent to Low	N
Plants	Physical Loss of Habitat	D, I	Moderate to High	N	High	N	Moderate	N	High	N	Low	N	Low	N
	Degradation of Habitat/Effects to Germination and Growth	D, I	Moderate	N	Moderate	N	Moderate to High	N	Moderate to High	N	Moderate	N	Moderate	N
Permit Area Habitat Type														
Subtidal Bottom	Physical Loss	D, I	Absent	N	Absent	N	Absent	N	Absent	N	Low	N	Low	N
	Habitat Degradation	I	Low	N	Absent	N	Moderate	N	Moderate	N	Low to Moderate	N	Low to Moderate	N
Wet Beach	Physical Loss	D, I	Low	N	Low	N	Low	N	Low	N	Low	N	Low	N
	Habitat Degradation	I	Moderate	N	Low to Moderate	N	Moderate	N	Moderate to High	N	Low	N	Low	N
Dry Beach	Physical Loss	D, I	High	N	High	Y	Moderate	N	Moderate to High	Y	Low	N	Low	N
	Habitat Degradation	I	Moderate	N	Moderate to High	N	Moderate	N	Moderate to High	N	Low to Moderate	N	Moderate	N
Dunes	Physical Loss	D, I	Moderate to High	N	High	Y	Low to Moderate	N	High	Y	Low	N	Low	N
	Habitat Degradation	I	Low to Moderate	N	Moderate to High	N	Low to Moderate	N	Moderate	N	Low to Moderate	N	Moderate	N
Interdunal Wetlands	Physical Loss	D, I	Absent to Low	N	High	N	Absent to Low	N	High	N	Absent	N	Absent	N
	Habitat Degradation	I	Absent to Low	N	Low to Moderate	N	Absent to Low	N	Low to Moderate	N	Absent	N	Absent	N
Maritime Thicket/Forest	Physical Loss	D, I	Absent	N	High	N	Absent	N	High	N	Absent	N	Absent	N
	Habitat Degradation	I	Absent	N	Moderate to High	N	Absent	N	Moderate to High	N	Absent	N	Absent	N
Estuarine Salt Marsh	Physical Loss	D, I	Absent	N	Absent	N	Absent	N	Absent	N	Absent	N	Absent	N
	Habitat Degradation	I	Absent	N	Absent	N	Absent	N	Absent	N	Absent	N	Absent	N

Note: This table is intended to provide a general summary of the potential adverse effects to federally-listed species and the habitats identified in the permit area. For a complete description of the potential beneficial and adverse effects for all resources refer to Section 5 of the Final EIS.

APPENDIX R

FISH LARVAE RESPONSE MODEL

Project-related impacts to Tidal Hydraulics and Potential Transport of Fish Larvae Following Terminal Groin Construction Bald Head, North Carolina

June 14, 2012
Revised September 26, 2012

Abstract. The Delft3D numerical model was employed to compute potential differences in hydraulics following construction of a semi-permeable terminal groin at the western terminus of Bald Head Island, North Carolina. The previously calibrated depth-averaged, tide-only model was reconfigured and run to describe tides during a 30-day spring-neap lunar cycle under both beach fill only and terminal groin with beach fill conditions. Several drogues were placed in the nearshore waters off Bald Head in order to track the potential hydraulic pathways of nondescript particles (hypothetical fish larvae) from the nearshore into the inlet on route to the interior estuary system. Tidal currents, drogue routes, and travel duration were directly compared under with and without project conditions. Additionally, the Delft3D particle tracking model was applied to the hydrodynamic model result in order to simulate instantaneous, localized deployment of multiple particles in the nearshore of Bald Head Island and map said particle movements and concentrations throughout the domain under with- and without- terminal groin conditions. The results of these analyses suggest that a terminal groin at Bald Head will have no far-reaching effects on the tidal hydraulics of the inlet. Differences in tidal flows are minor and localized about the general vicinity of the structure. These predicted alterations to tidal flows are not expected to meaningfully hamper the ability of suspended biota or fish larvae to reach the inlet from the nearshore waters proximate to Bald Head.

The Delft3D model was utilized to simulate the effects of the proposed terminal groin on tidal flows. Calibration of the depth-averaged model is discussed in detail under separate cover[1]. Two model domains were developed for this investigation, the first includes a 1.2 Mcy beach fill which extends along the south-facing shoreline of Bald Head between Station 166+00 and the Point. This simulation reflects erosion control measures which have been historically employed along Bald Head Island. The second model scenario includes the proposed, semi-permeable terminal groin with placement of 1.2 Mcy of beach nourishment, the distribution of which differs from the beach fill only condition in order to pre-fill the fillet east of the terminal groin requiring a beach fill which effectively terminates at about Station 130+00.

[1] Olsen, 2012. "Calibration of a Delft3D model for Bald Head Island and the Cape Fear River Entrance. Phase I." Prepared for the Village of Bald Head Island. Prepared by Olsen Associates, Inc. 2618 Herschel Street Jacksonville, FL 32204. April 2012.

The sixteen existing tube groins were conservatively represented in both models as thin dams, an impermeable and infinitely tall impediment to flow in the model. The proposed permeable terminal groin was modeled as a porous plate, the permeability of which is controlled by a friction term which was set to 4.5 for these simulations, roughly representing a level of permeability between about 10 and 30 percent by best estimation.

The tide-only model was driven by water level fluctuations derived via astronomical constituents developed by the Topex/Posiden constituent model database. Tidal phase and amplitude for the following twelve constituents were specified for 49 contiguous boundary segments along the flow domain: M2, S2, N2, K2, K1, O1, P1, Q1, MF, and MM. The model was run for a period of 30 days in order to simulate a complete spring-neap lunar cycle. Water elevation computed by the model at Southport is shown in **Figure 1**. The annual tide range shown in **Figure 2** illustrates an overall lack of significant seasonal variability in the tides near the study area, which suggests the period selected for analysis herein is a reasonable proxy for typical conditions.

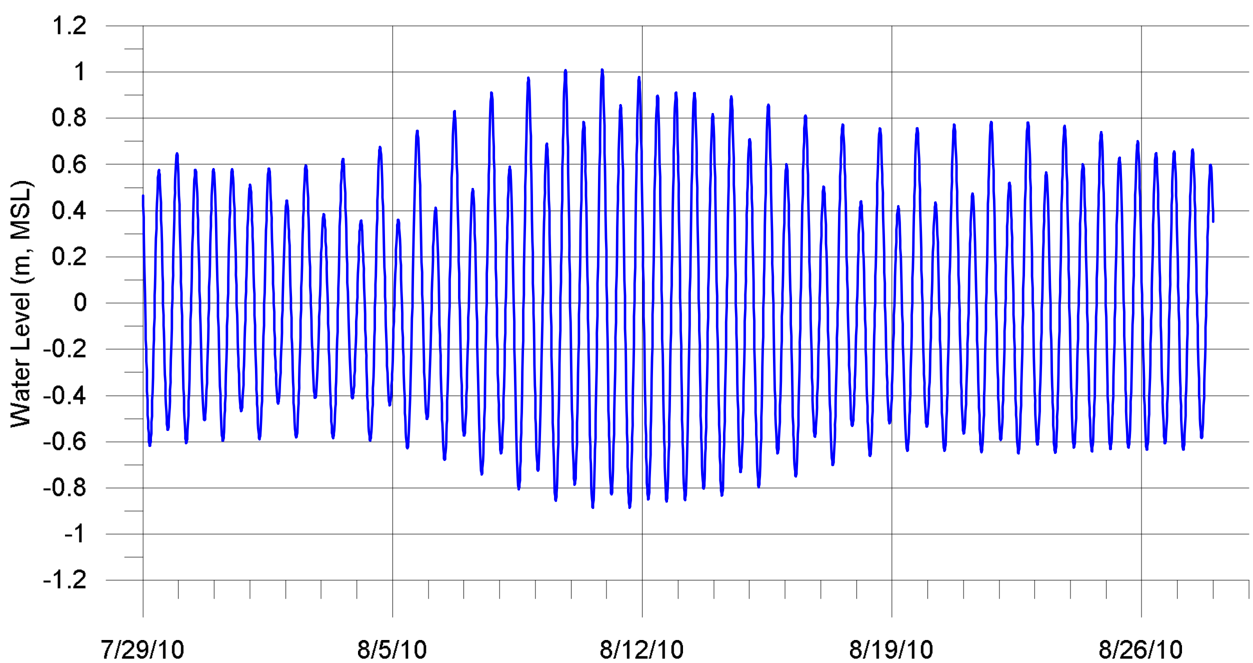


Figure 1: Computed tides at Southport for the simulation period analyzed herein.

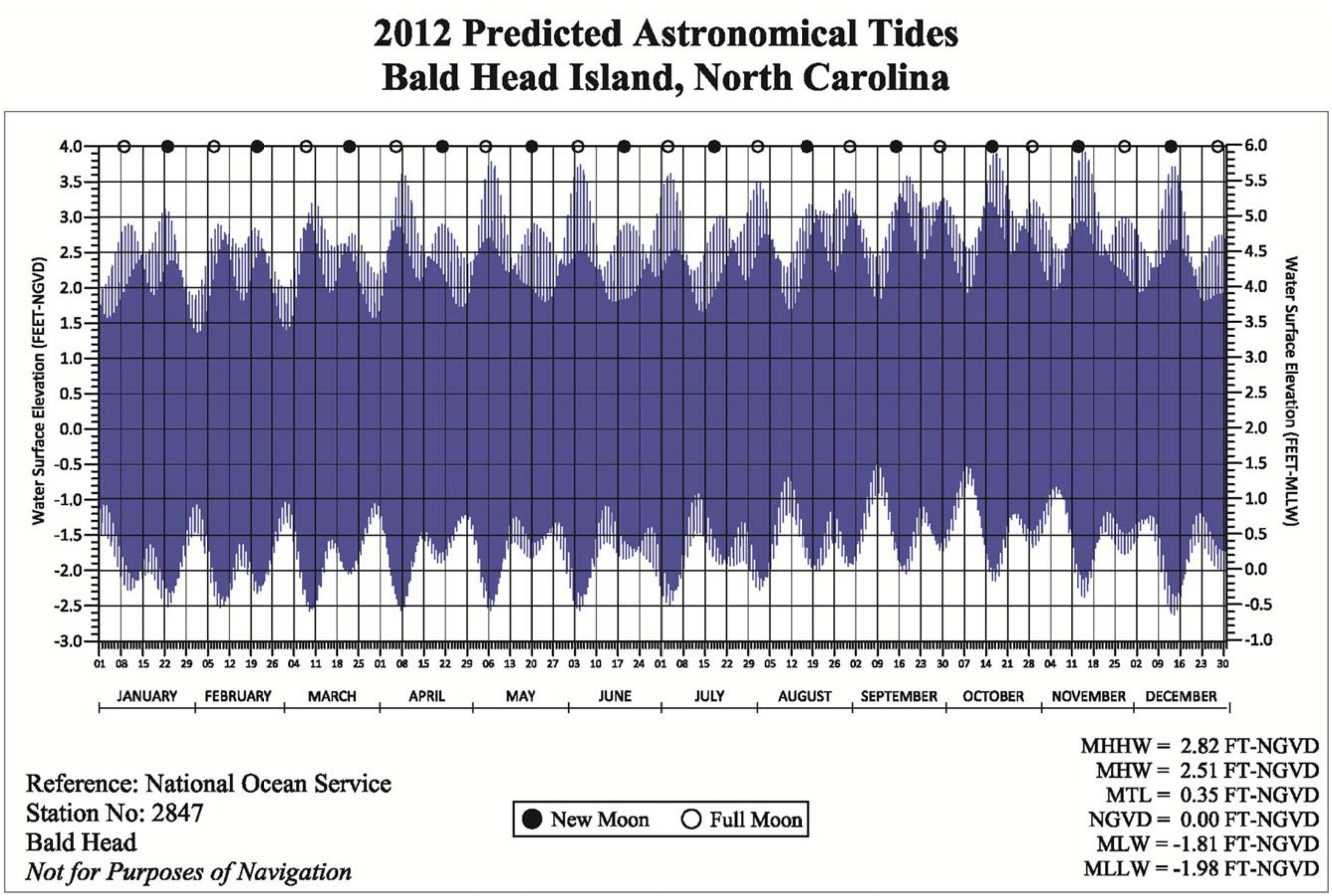


Figure 2: Predicted tides for 2012.

Figure 3 plots the residual tidal currents following the one-month simulation for the beach fill without terminal structure simulation. Residual flow is defined as the "net" flow that remains after subtracting all of the flood flow vectors from the ebb flow vectors for one lunar month. **Figure 4** comparatively plots residual flows computed under the with terminal groin condition. The model results indicate that large-scale patterns of residual flow are unchanged between alternatives. Locally, however, the terminal groin appears to accelerate ebb-directed residual flows immediately west of the structure. This is attributable to a reduction in flood tide velocity in the immediate lee/shadow of the terminal groin.

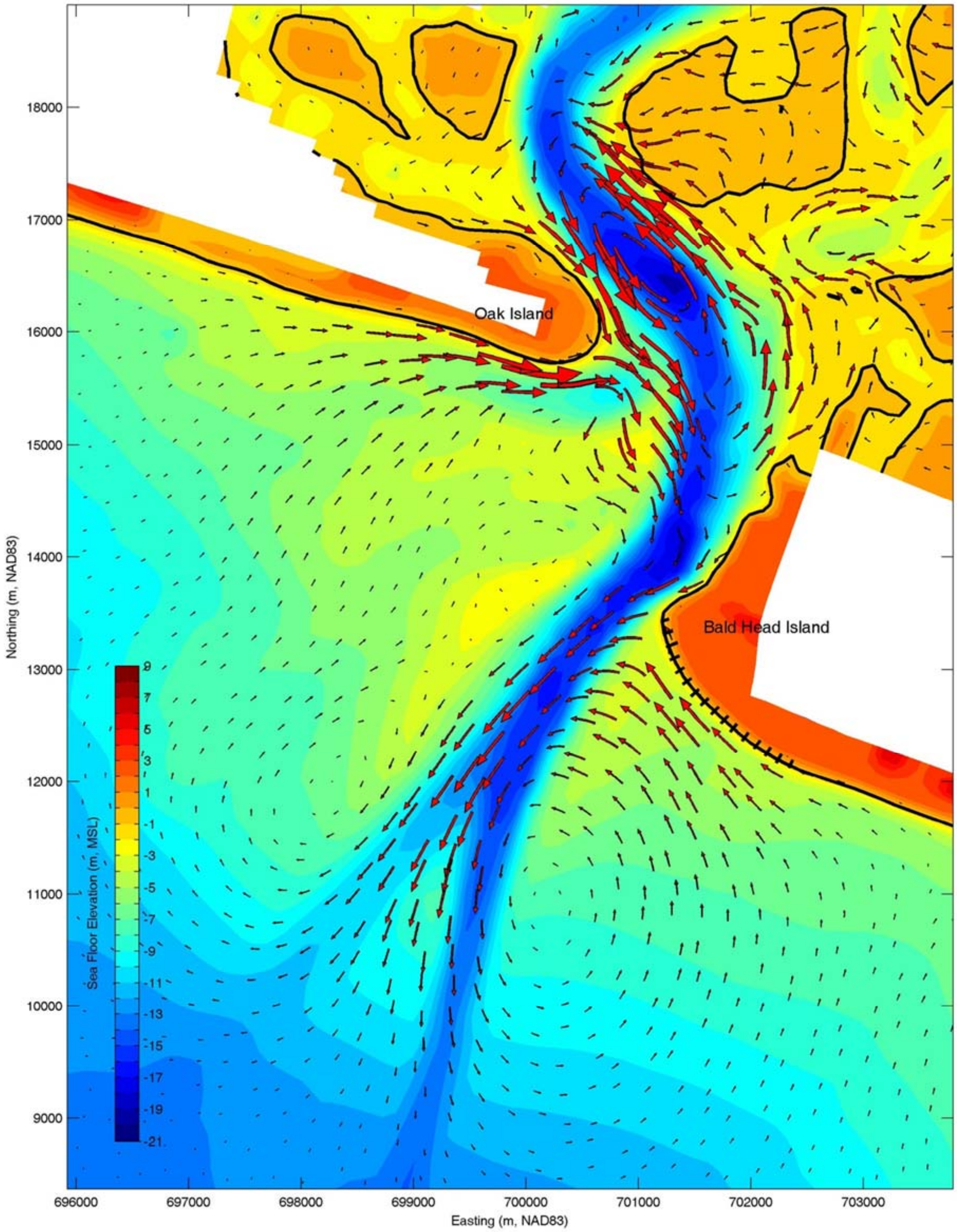


Figure 3: Residual tidal flow computed following 1-month tide only simulation under 1.2Mcy beach fill and tube groins conditions.

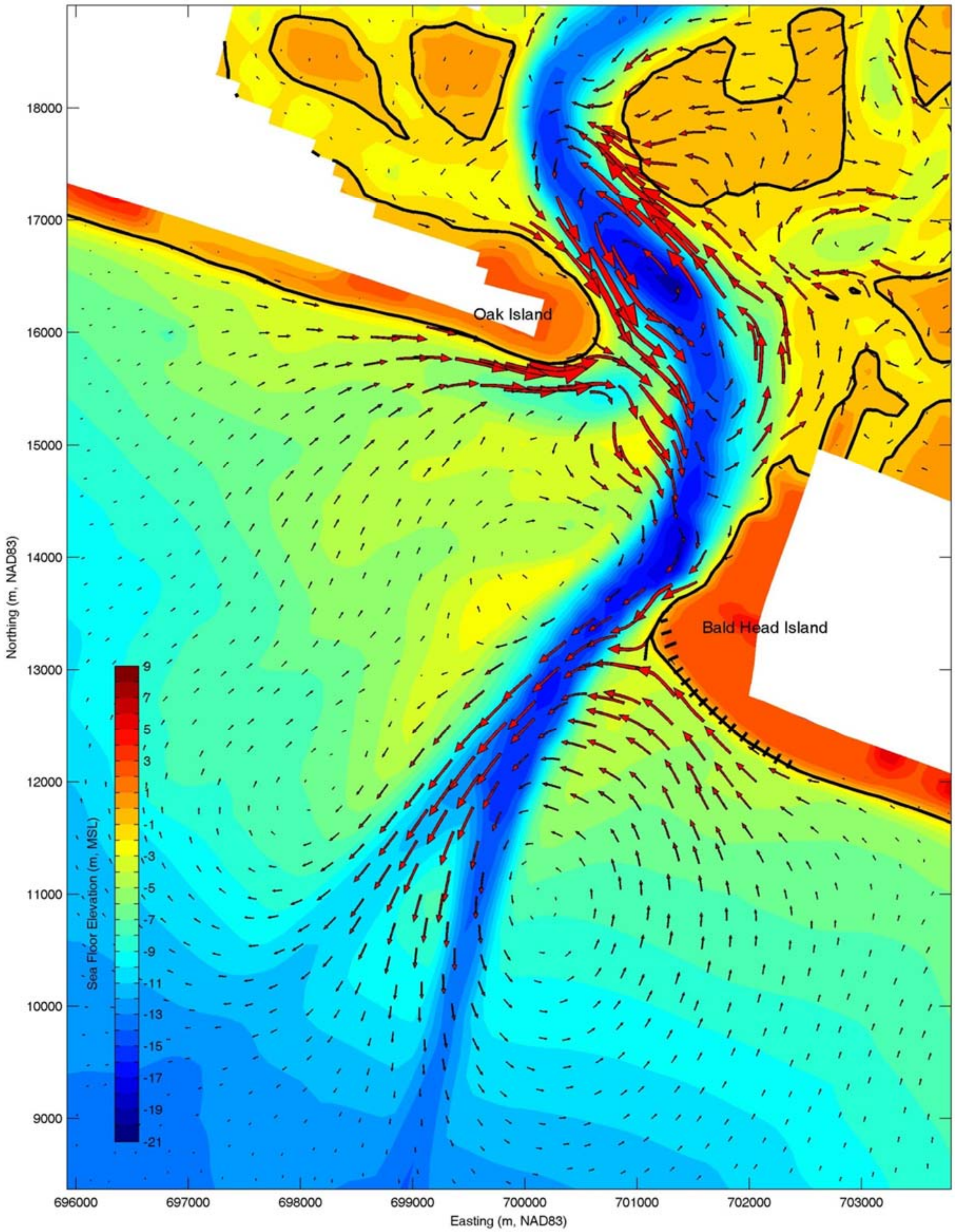


Figure 4: Residual tidal flow computed following 1-month tide only simulation under terminal groin with 1.2Mcy beach fill and tube groins conditions.

Figures 5 and **6** plot peak ebb tidal vectors and magnitudes under without- and with-terminal groin conditions, respectively. Comparison of the figures suggest the terminal groin most notably results in a modest decrease in ebb tidal velocities immediately offshore of the structure's seaward end near Bald Head Shoal. The magnitude of this decrease is on the order of 0.1 to 0.15 m/s and is limited to areas near the terminal groin. This decrease in flow velocity is partially offset by a small increase in the nearshore profile south of the groin field typically measuring less than 0.1 m/s. In terms of overall inlet hydraulics, the patterns of ebb tidal flow are not significantly altered following placement of the terminal groin.

Figures 7 and **8** plot peak flood tidal velocities and magnitudes under without- and with-terminal groin conditions, respectively. Comparison of the figures suggests that installation of the proposed terminal groin alters flood tides more significantly than the aforementioned ebb effects. This is predominantly due to (a) the reclamation of shoreline updrift and eastward of the terminal groin where with-project tides are non-existent, and (b) the redirection of flood tidal flow by the groin's seaward tip. The latter effect results in a small shadow zone in the lee of the terminal structure on a flood tide, which extends more-or-less to the limits of the navigation channel where the reduction in speed is negligible (<0.1 m/s). Peak reductions in flood tidal velocities on the order of about 0.5 m/s are identified very near the structure. The model results suggest that flood tidal velocities within, and slightly west of, the Bald Head Shoals I channel range will increase by about 0.1 m/s in response to the flow decrease computed adjacent to the proposed groin. Like the ebb tidal patterns within the inlet, the terminal structure is not predicted to have far-reaching effects on the tidal hydraulics of the inlet.

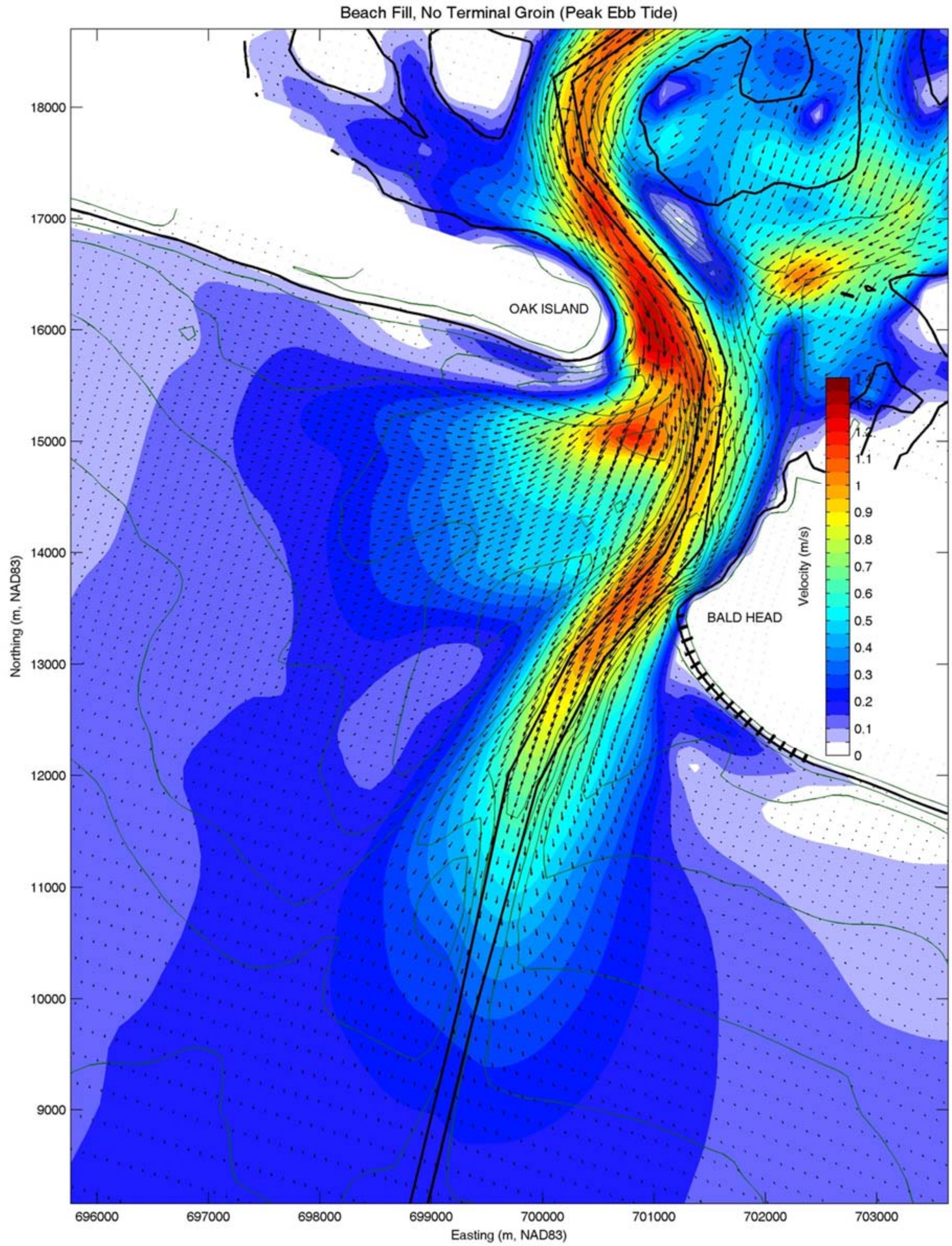


Figure 5: Peak ebb tidal flow computed following 1-month tide only simulation under 1.2Mcy beach fill and tube groins conditions.

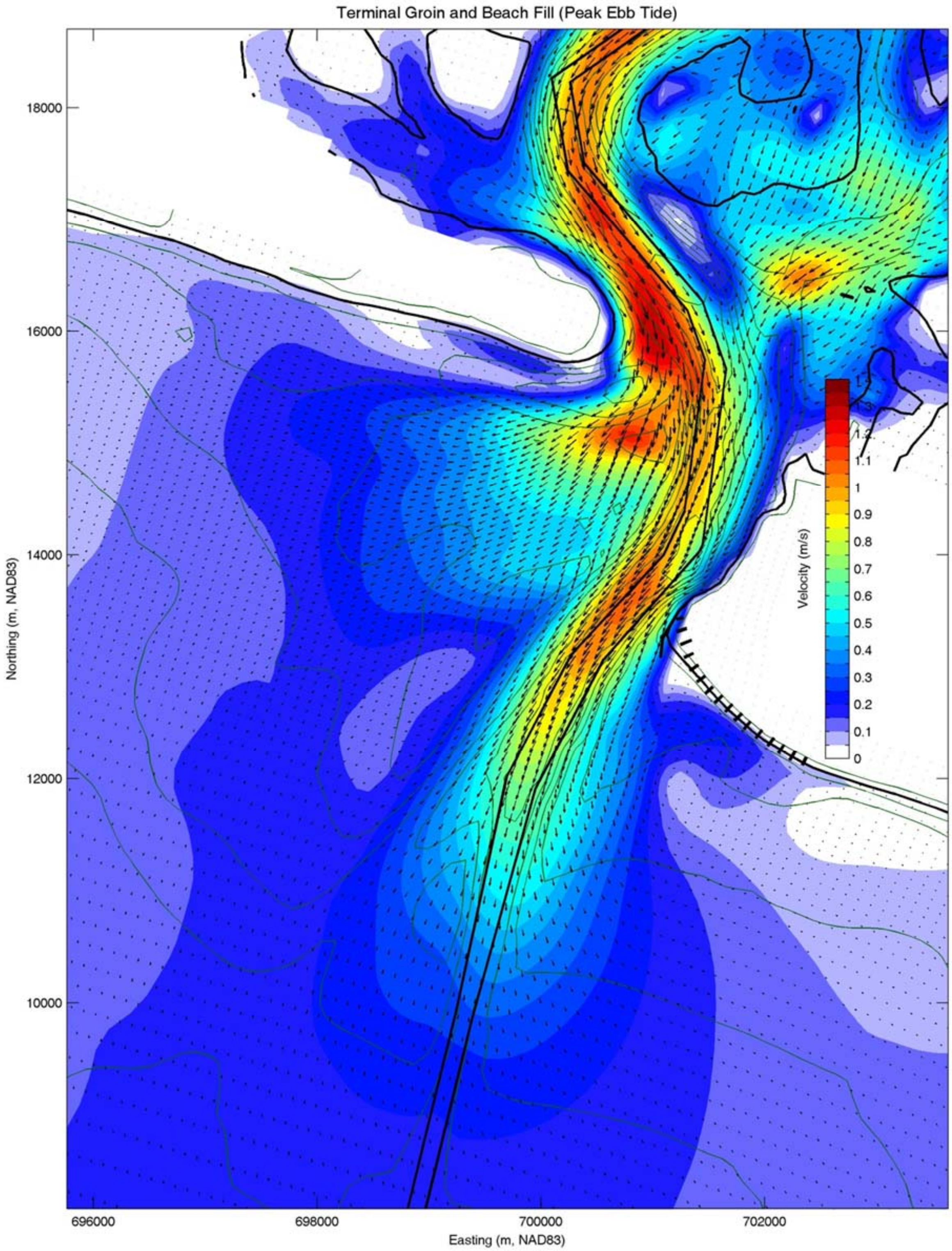


Figure 6: Peak ebb tidal flow computed following 1-month tide only simulation under terminal groin with 1.2Mcy beach fill and tube groins conditions.

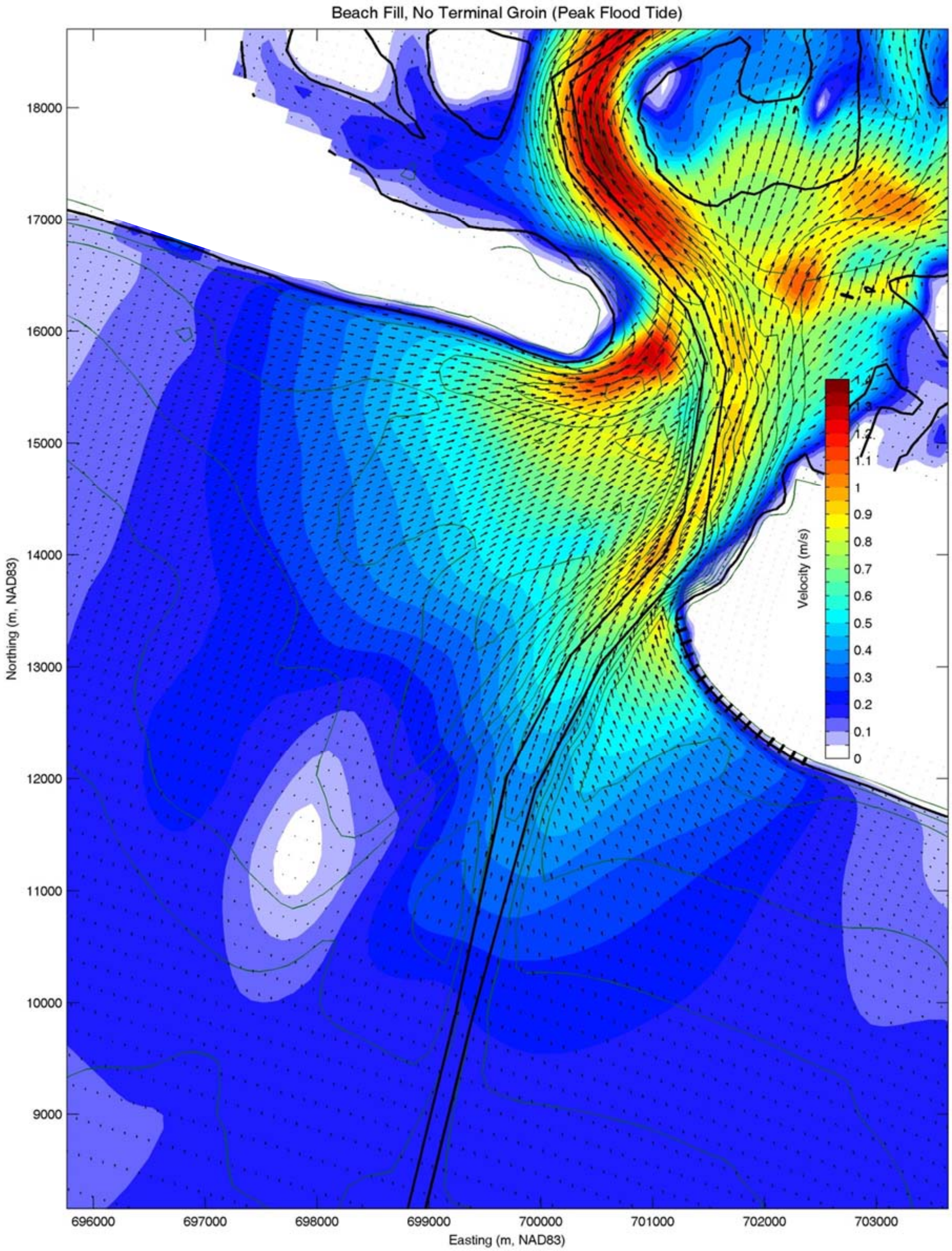


Figure 7: Peak flood tidal flow computed following 1-month tide only simulation under 1.2Mcy beach fill and tube groins conditions.

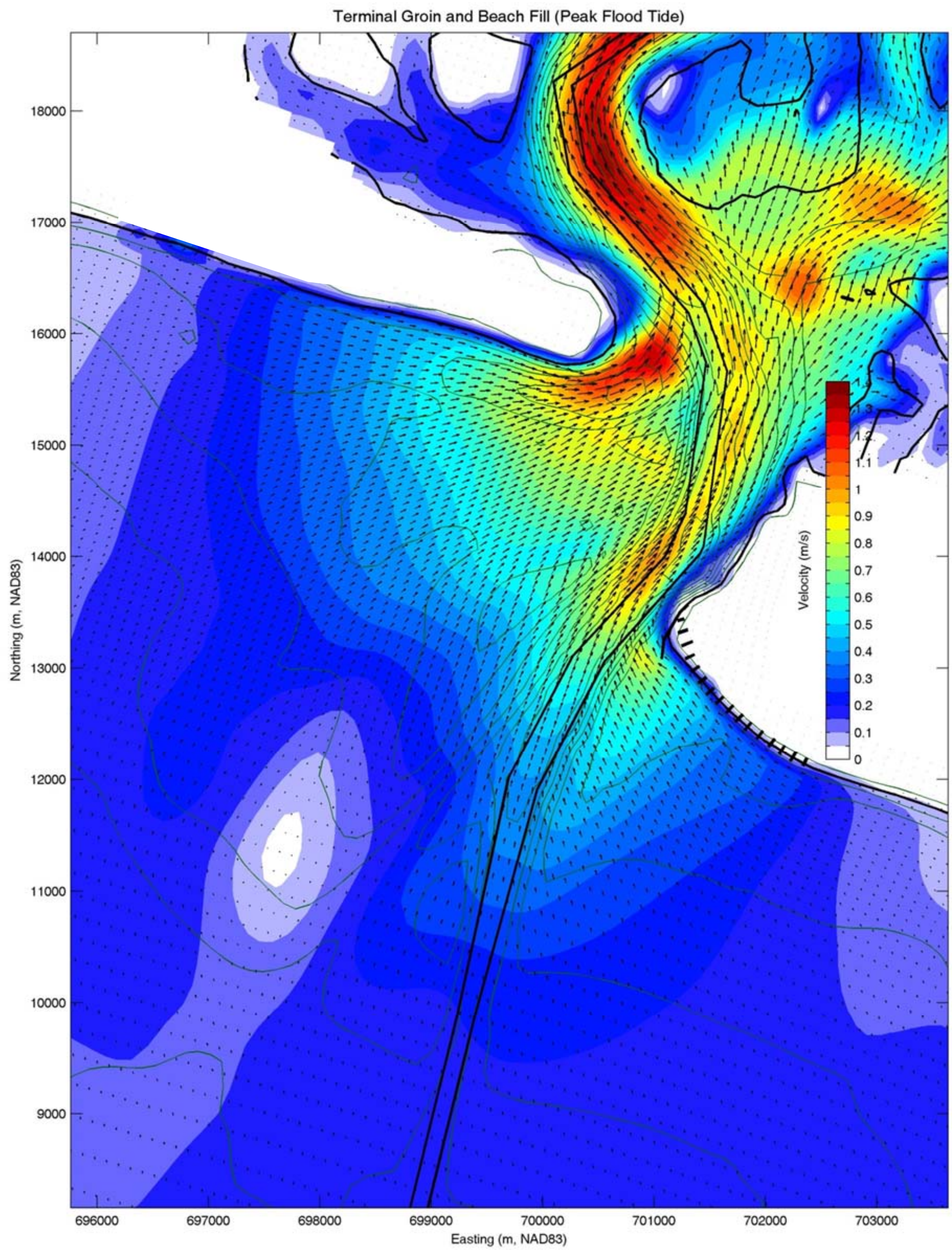


Figure 8: Peak flood tidal flow computed following 1-month tide only simulation under terminal groin with 1.2Mcy beach fill and tube groins conditions.

The hydrodynamic models were also utilized to evaluate potential changes in flow patterns which might affect the tidal transport of fish larvae from the Bald Head Island nearshore area to the inlet. Hypothetical larvae were simulated by deploying drogues at various nearshore and offshore locations within the model domain. Drogues were initially deployed at seven locations varying in distance from the inlet, see **Figure 9**. Drogue C was deployed the farthest from the inlet (about 2.1 miles east of the inlet) and is located in the nearshore in an area where flood tidal currents are respectively weak. Based on the model results shown in **Figure 7**, drogue C is located along the edge of influence the flood tidal influence where peak velocities are predicted to be less than 0.2 m/s. Drogues D through G were initially placed along a shore perpendicular azimuth beginning east of the groin field and extending slightly more than 1,500 meters offshore.

At each location, the drogues were deployed twice during the 30-day simulation. The first deployment occurred at time step one in the model which corresponds to a neap tide condition – this time step equates to 29 July 2010 00:00 in **Figure 1**. Following deployment, these drogues were tracked throughout the entire model simulation. Additional drogues were deployed at each location and tracked beginning at a time step equivalent to 17:50 hours on 10 August 2010. This time step reflects conditions present during the simulated spring tide range. The locations of drogue deployments were identical between neap and spring simulations, and deployments were timed to roughly correspond with a mid-tide. In addition to the water level data presented in **Figure 1**, water levels during the deployment are indicated on each result illustration presented below.

The path and duration of travel for each drogue was calculated and compared both with and without the terminal groin. It is assumed that once a particle passes west of the western tip of Bald Head Island and enters the inlet, it enters a hydraulic regime which is dominated by river flows, tidal currents, and pressure fields which operate well outside of the influence of the terminal groin as noted in the above discussion. **Figure 10** demonstrates the extreme variability in drogue tracks once a particle leaves the nearshore zone and enters the influence of the inlet. The figure plots the movements of all drogues for the entire simulation. For reference, **Figure**

11 plots the path of drogue A for the entire monitoring period. The particle pathway suggests that once the drogue enters the inlet it travels throughout the dominant tidal range of the inlet traversing a path through the estuary, about 7-8 miles upriver, and into the open ocean along the ebb tidal platform.

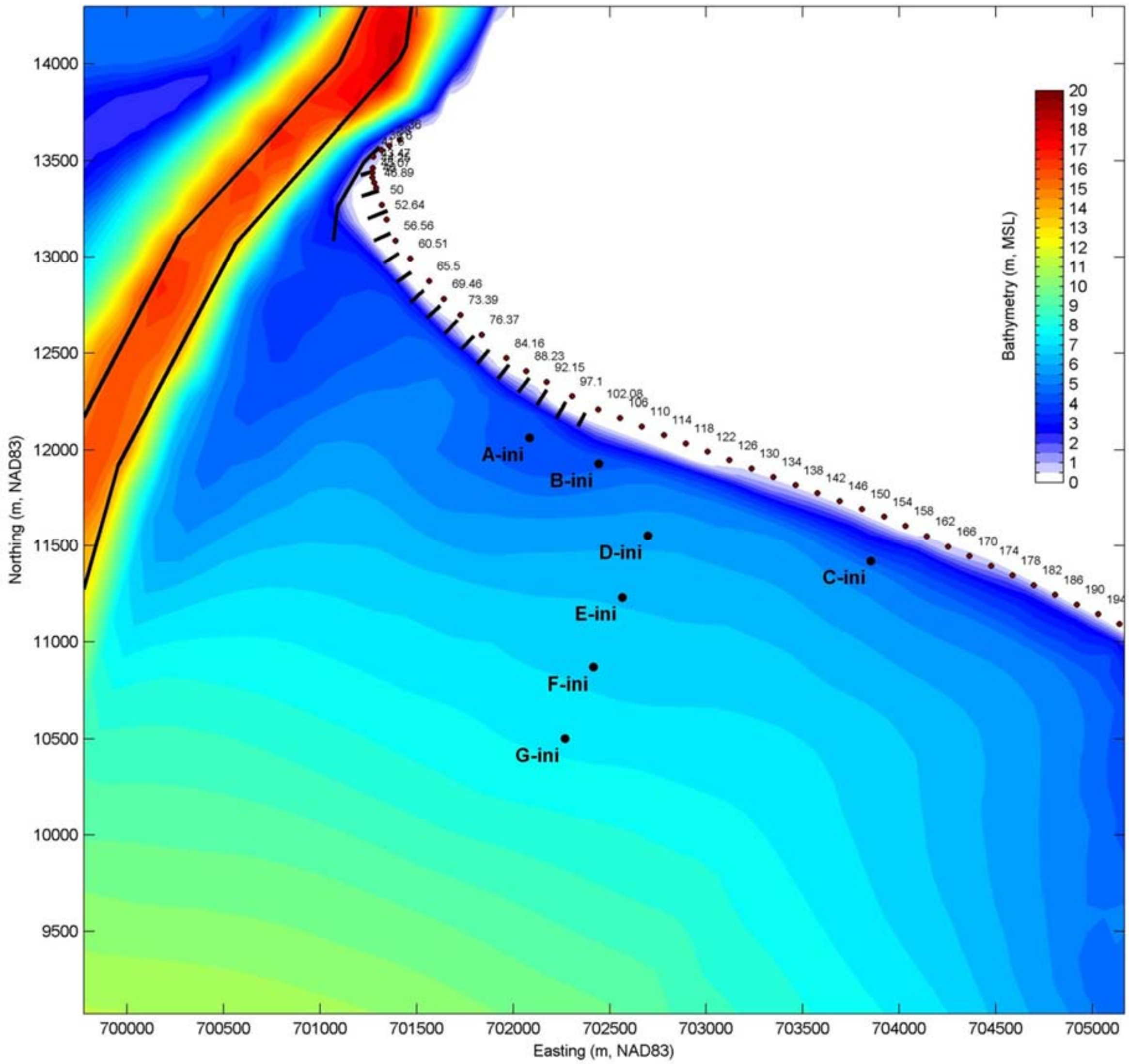


Figure 9: Initial deployment of each drogue tacked for this analysis.

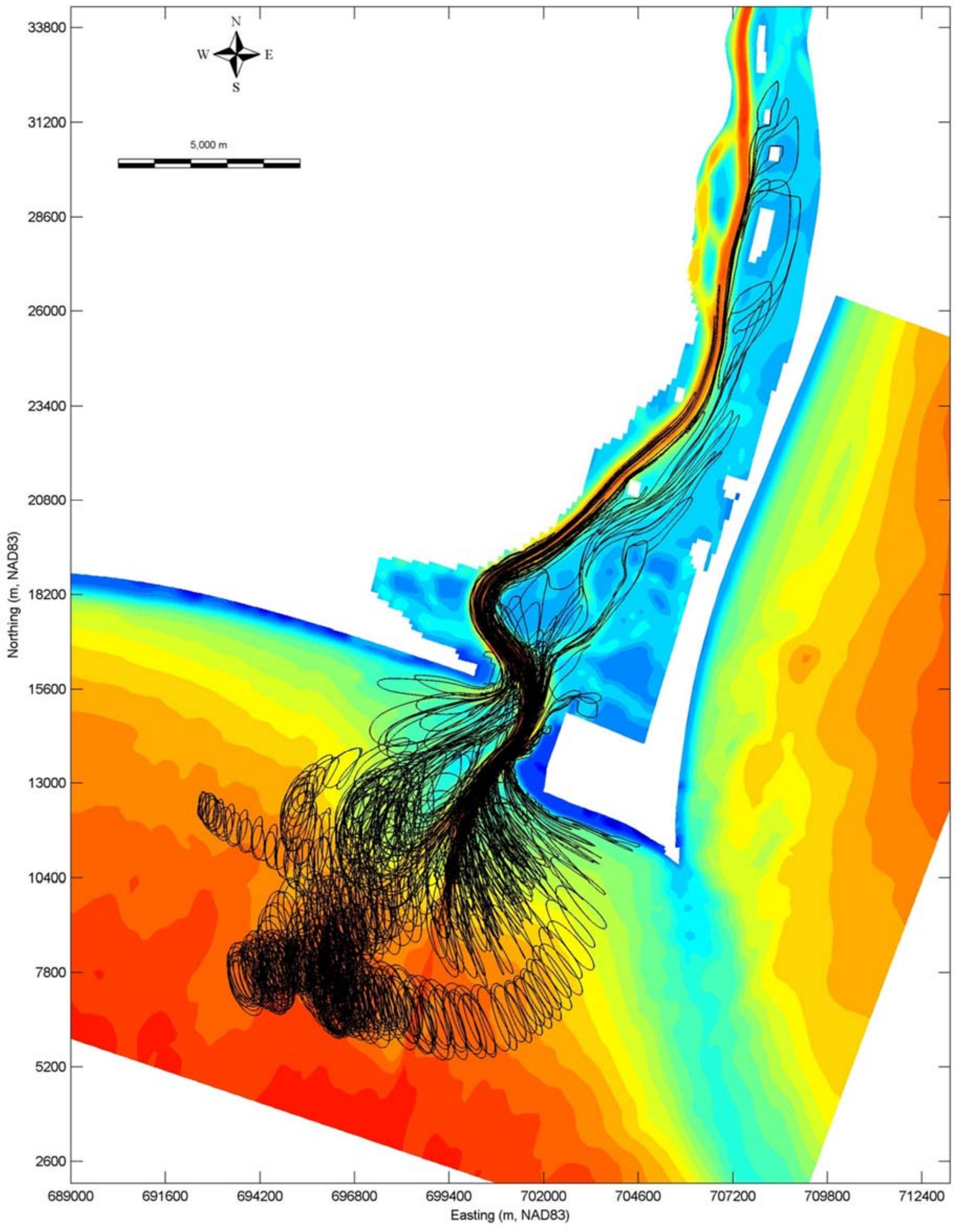


Figure 10: All drogue tracks for the entire monitoring period.

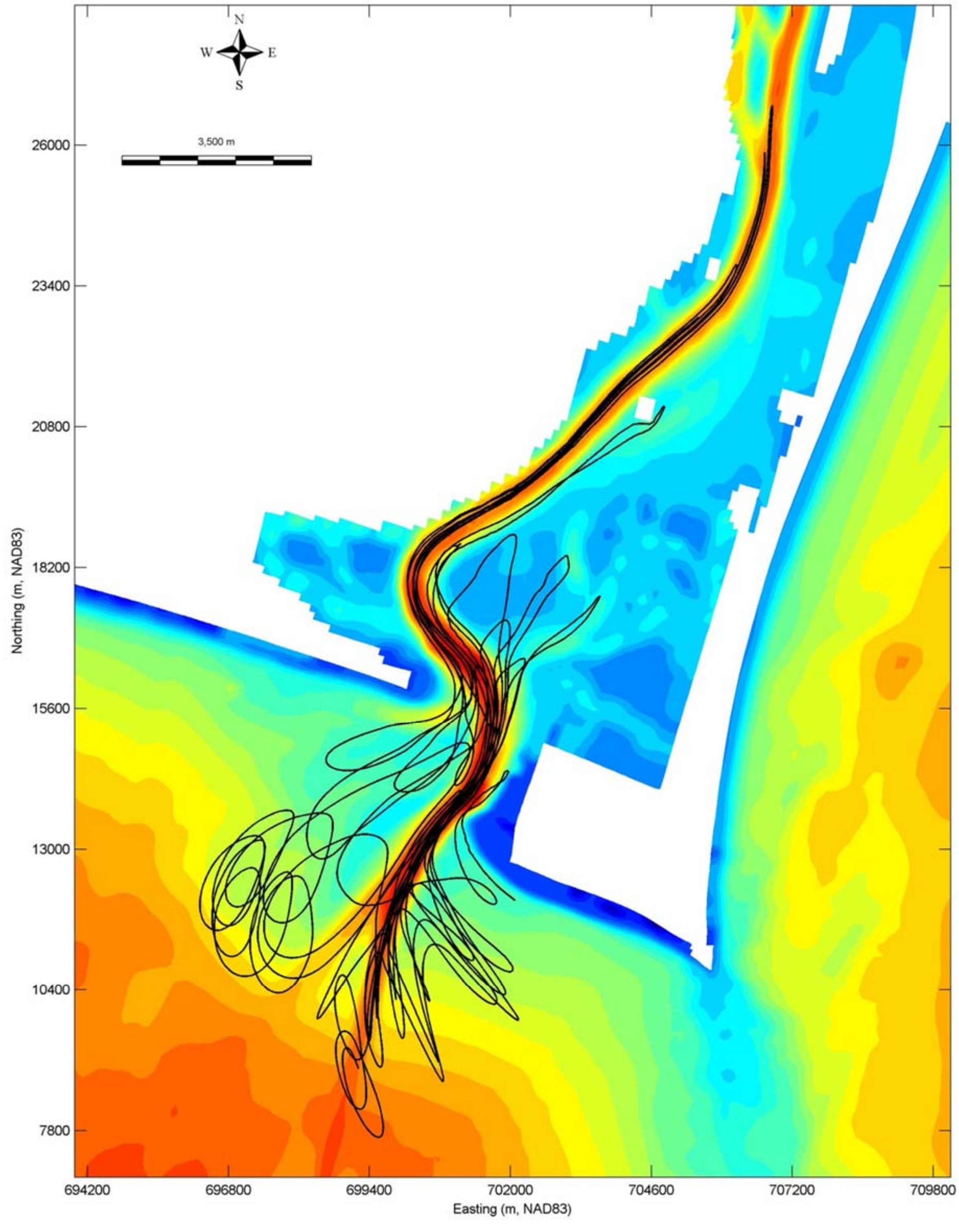


Figure 11: Path of drogue 'A' for the entire monitoring period.

Summary results for each drogue are tabulated in **Tables 1** and **2** for neap and spring tide drogue releases, respectively. The tabular results indicate the total number of model time steps required for the drogue to reach the inlet along with the total travel time, in hours. Each time step represents 0.2 minutes, or 12 seconds in the numerical model. The difference between the beach fill only and with terminal groin travel times is additionally noted. Negative times suggest longer travel times under the with terminal groin condition.

Table 1: Drogue travel times when released during a neap tide.

Drogue ID	Fill Only		Terminal Groin w/ Fill		Difference
	No. Time Steps	Time (hrs)	Time Steps	Time (hrs)	(hrs)
A	1,840	6.1	1,855	6.2	-0.05
B	1,975	6.6	1,990	6.6	-0.05
C	9,075	30.3	9,360	31.2	-0.9
D	2,385	8.0	2,425	8.1	-0.1
E	2,620	8.7	2,625	8.8	-0.02
F	2,920	9.7	2,920	9.7	0.0
G	5,820	19.4	5,800	19.3	0.1

Table 2: Drogue travel times when released during a spring tide.

Drogue ID	Fill Only		Terminal Groin w/ Fill		Difference
	No. Time Steps	Time (hrs)	Time Steps	Time (hrs)	(hrs)
A	290	1.0	330	1.1	-0.1
B	455	1.5	580	1.9	-0.4
C	10,300	34.3	17,710	59.0	-24.7
D	730	2.4	950	3.2	-0.7
E	3,070	10.2	3,320	11.1	-0.8
F	3,520	11.7	3,600	12.0	-0.3
G	3,780	12.6	3,820	12.7	-0.1

The tracking results suggest that the travel time from the nearshore off Bald Head Island to the inlet is, generally speaking, very modestly slowed following the construction of a beach fill with a terminal groin. There were two exceptions to this finding whereby drogue releases F and G on a neap tide experienced either no change or a slight decrease in travel time following groin construction. Typically drogues released during a spring tide were slowed slightly more than those released during a neap tide. In either case, with the exception of one outlier (drogue C), these differences were very modest. The data suggest that, on average, drogue travel was slowed by about 0.16 hours (9.6 minutes) for the neap tide releases. For the spring tide releases, travel time was slowed by an average of about 3.9 hours under with groin conditions. The larger spring tide difference is wholly attributable to drogue C initially located at the eastern boundary of tidal influence. This drogue tended to slow primarily near the intertidal beach under with terminal groin conditions resulting in an abnormally large delay of about 24.7 hours for drogue C. Possible reasons for the performance of drogue C on a spring tide are discussed below.

Neap Tide Releases. **Figures 12** through **18** compare individual drogue tracks computed under with and without terminal groin conditions for drogues released during a neap tide condition. The time required to reach the inlet is noted on each figure along with the tidal phase at Southport during the period of measurement. Travel times to the inlet varied between 6.1 and 31.2 hours typically corresponding with initial distance from the inlet. Differences in travel time with and without the terminal groin varied between 3 and 57 minutes and also typically correlate with the distance from the inlet. As previously stated, the average time difference potentially attributable to the terminal groin was less than 10 minutes indicating the structure is not expected to significantly hinder the timely ability of a nearshore particle to reach the inlet. Travel directions between with and without groin simulations typically deviated only near the inlet itself as flows are diverted both around (and weakly through) the pre-filled, porous terminal groin rather than being carried directly around the sandy shoreline of the Point of Bald Head Island.

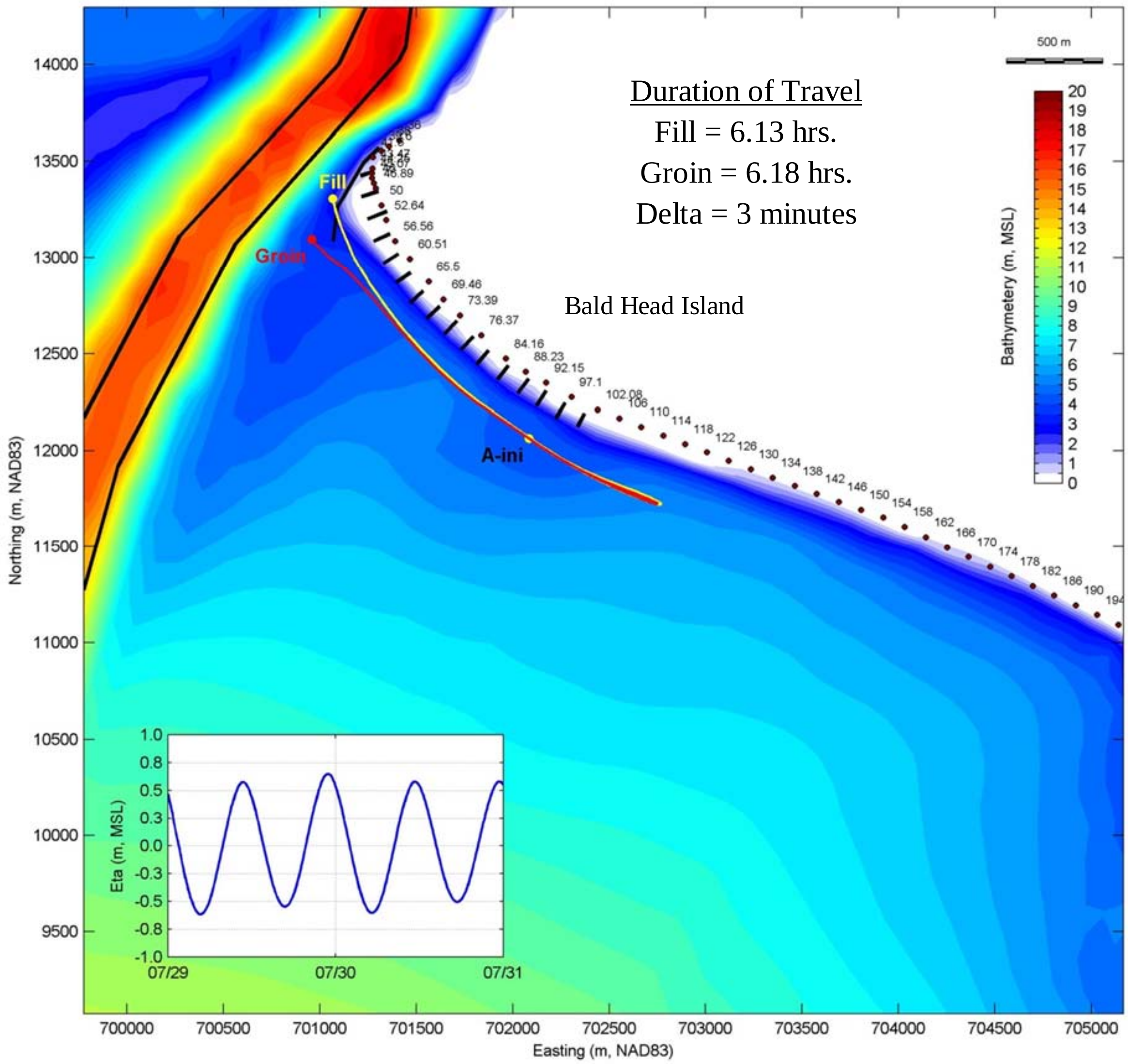


Figure 12: Drogue track A from deployment to inlet, with and without the terminal groin.

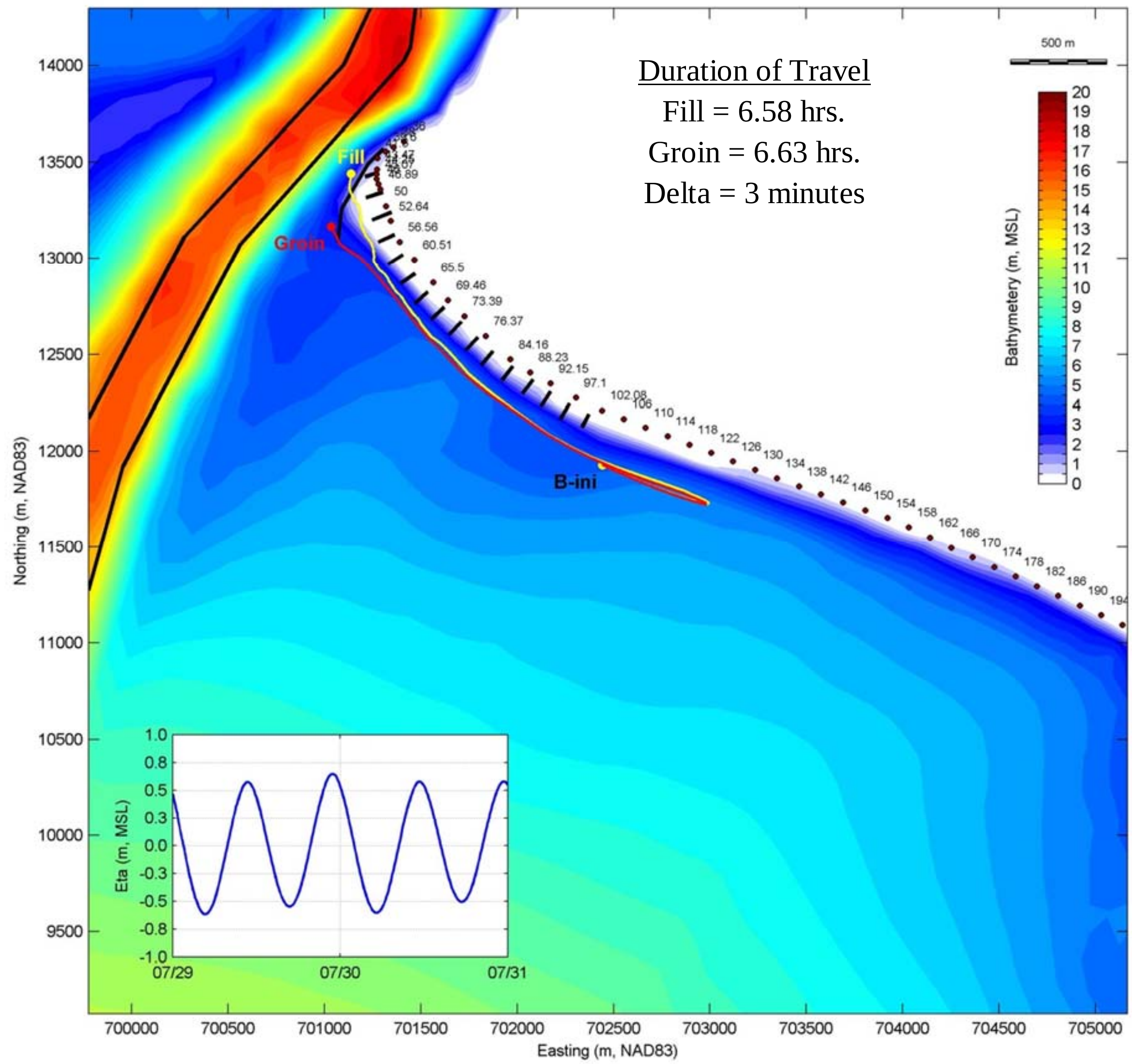


Figure 13: Drogue track B from neap tide deployment to inlet, with and without the terminal groin.

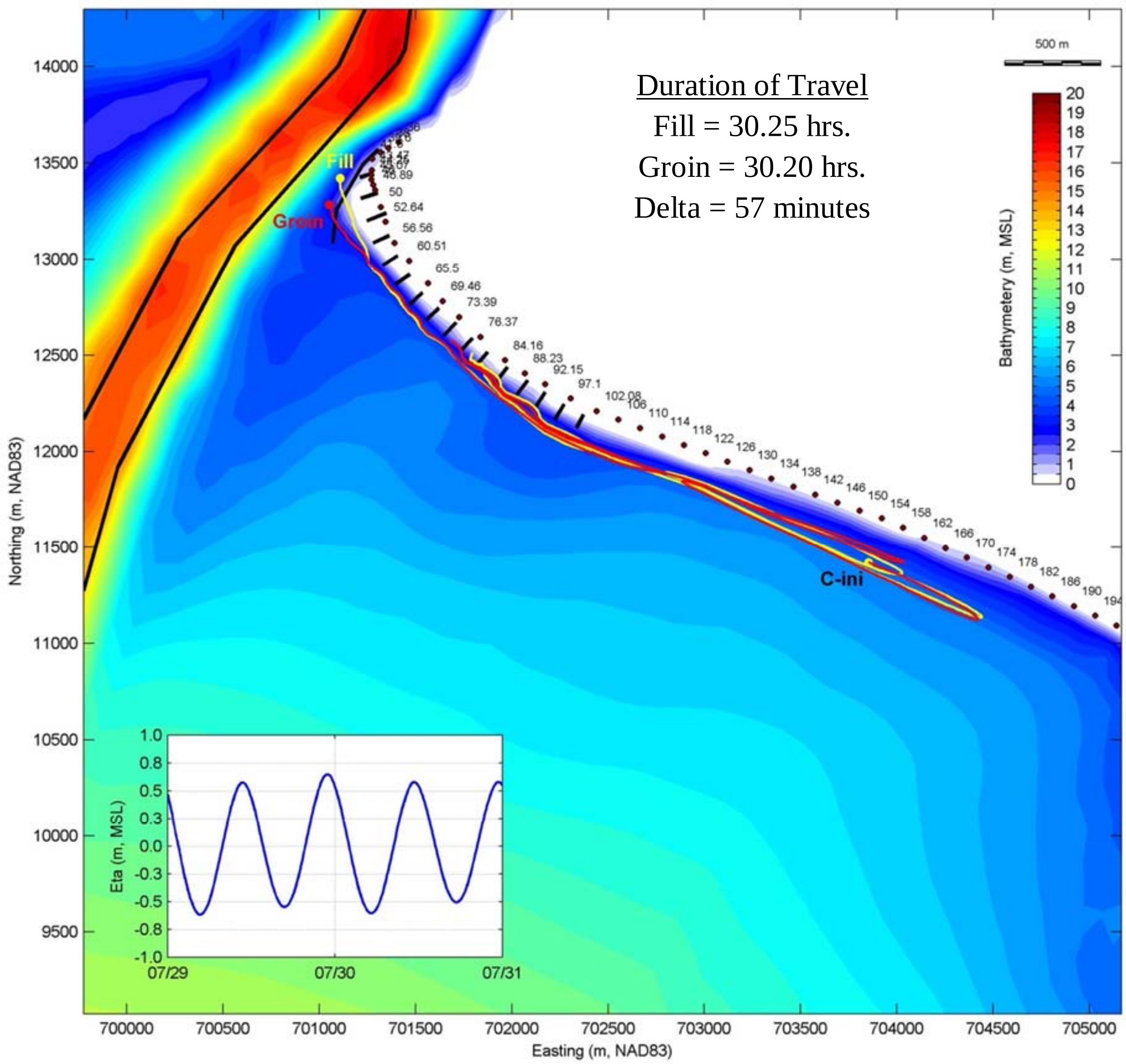


Figure 14: Drogue track C from neap tide deployment to inlet, with and without the terminal groin.

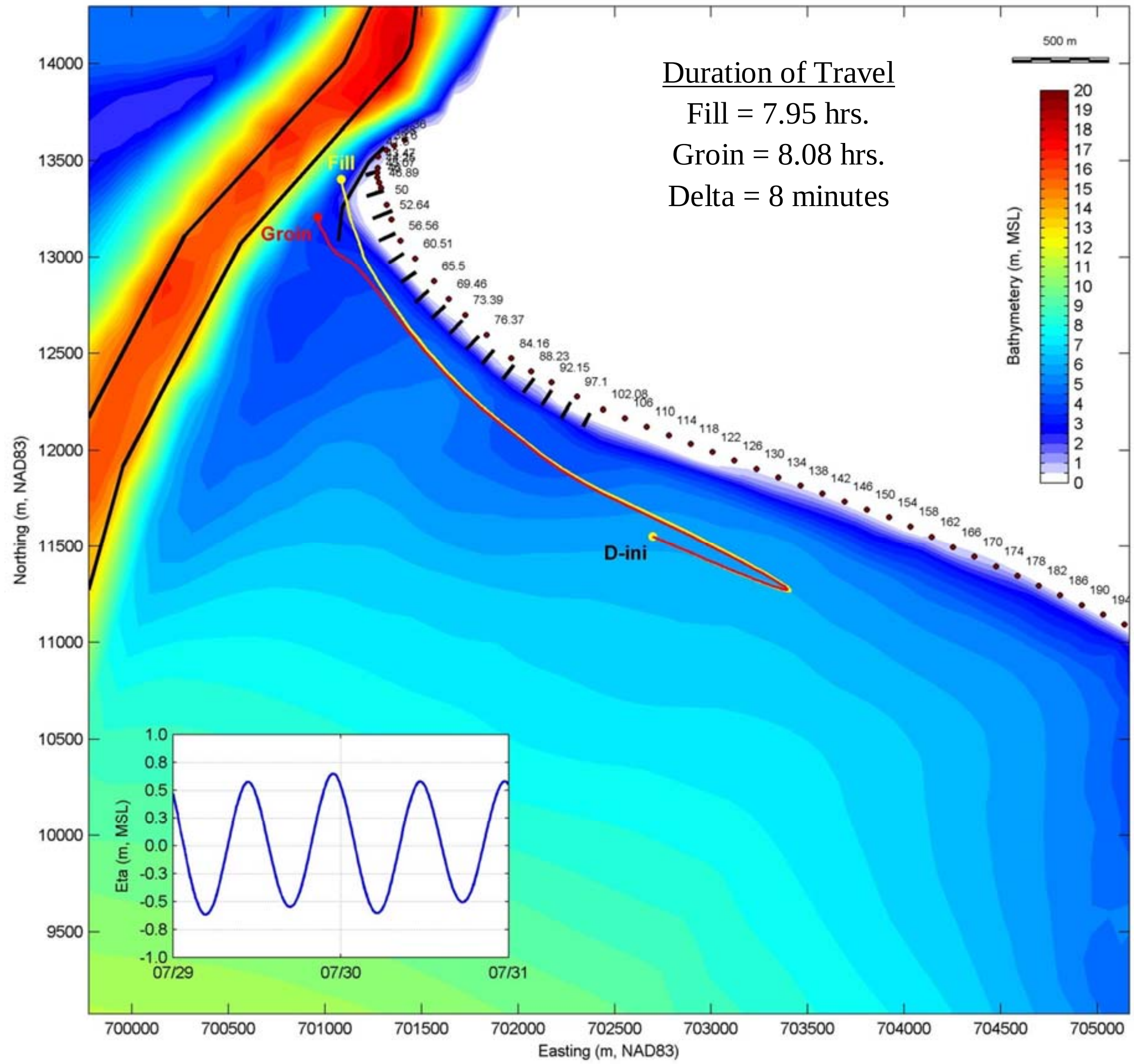


Figure 15: Drogue track D from neap tide deployment to inlet, with and without the terminal groin.

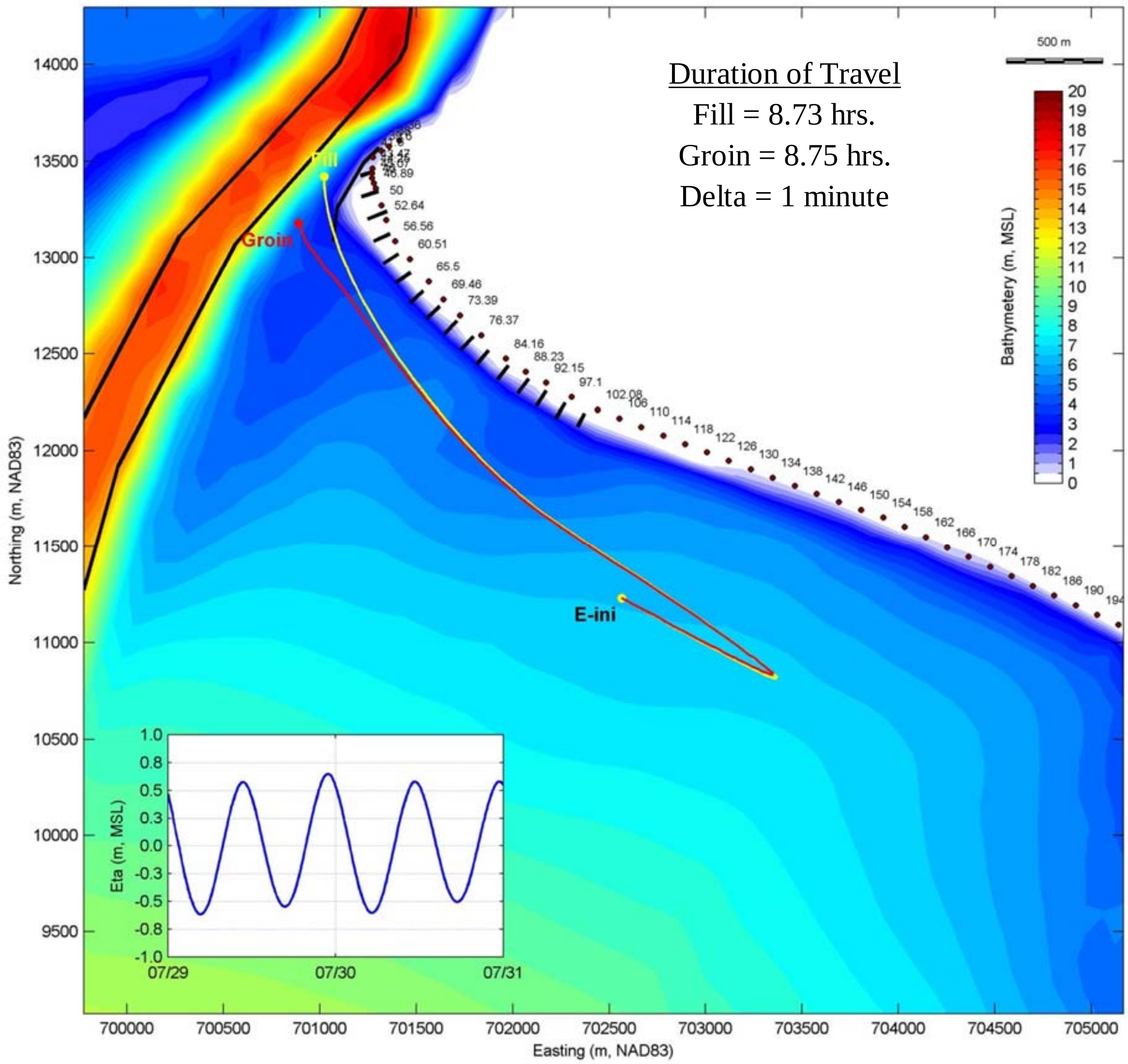


Figure 16: Drogue track E from neap tide deployment to inlet, with and without the terminal groin.

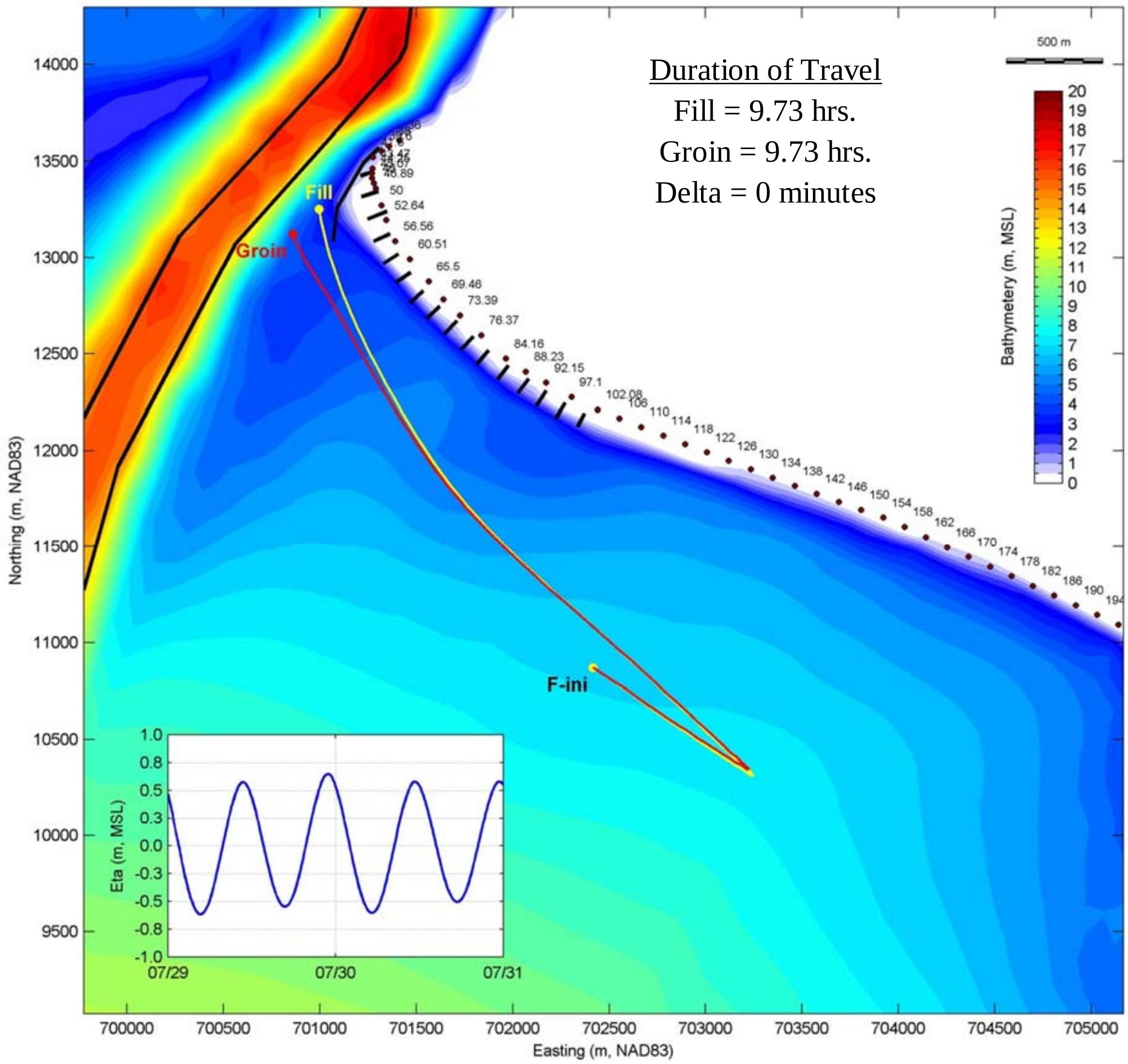


Figure 17: Drogue track F from neap tide deployment to inlet, with and without the terminal groin.

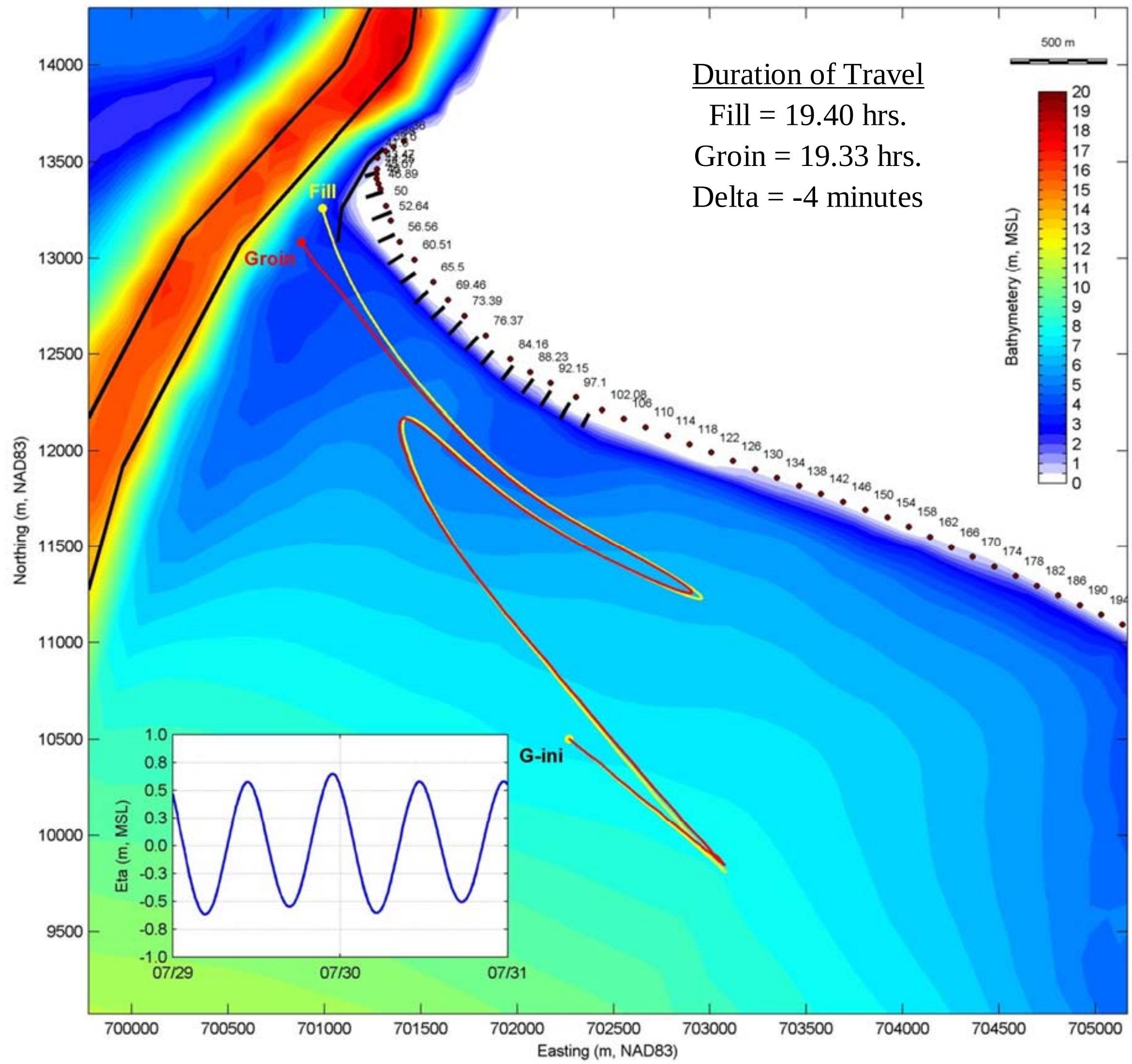


Figure 18: Drogue track G from neap tide deployment to inlet, with and without the terminal groin.

Spring Tide Releases. **Figures 19** through **25** compare individual drogue tracks computed under with and without terminal groin conditions for drogues released during a spring tide condition. The time required to reach the inlet is noted on each figure along with the tidal phase computed at Southport during the period of measurement. Travel times to the inlet varied between 1 and 59 hours again varying with respect to the distance from the inlet. Differences in travel time for with and without groin conditions varied between 8 minutes and 24.7 hours. Excluding that of drogue C (24.7 hours) differences in transit time following terminal structure construction range between 8 and 50 minutes, averaging about 25.2 minutes.

The large difference in transit time for drogue C is attributable to the fact that the particle managed to migrate onto the intertidal beach and effectively become 'stranded' significantly slowing the drouge's motion for a number of tidal oscillations – observable as the drogue path travels very near to the shoreline in the with groin scenario (see **Figure 21**). This stranding occurred east of station 130+00 where significant differences in the nearshore bathymetric profile are included in the model domain. These bathymetric variations are the result of differences in the beach fill sectional density as the beach fill is less voluminous to nonexistent here under without terminal groin conditions. The changes in travel time and particle path here are in response to nearshore bathymetric variations (i.e., less fill allowed the drogue to travel closer to shore and move more slowly) rather than hydraulic influences of the terminal structure. Once clear of this section of shoreline (west of station 130+00), the particles follow a similar path and timetable into the inlet.

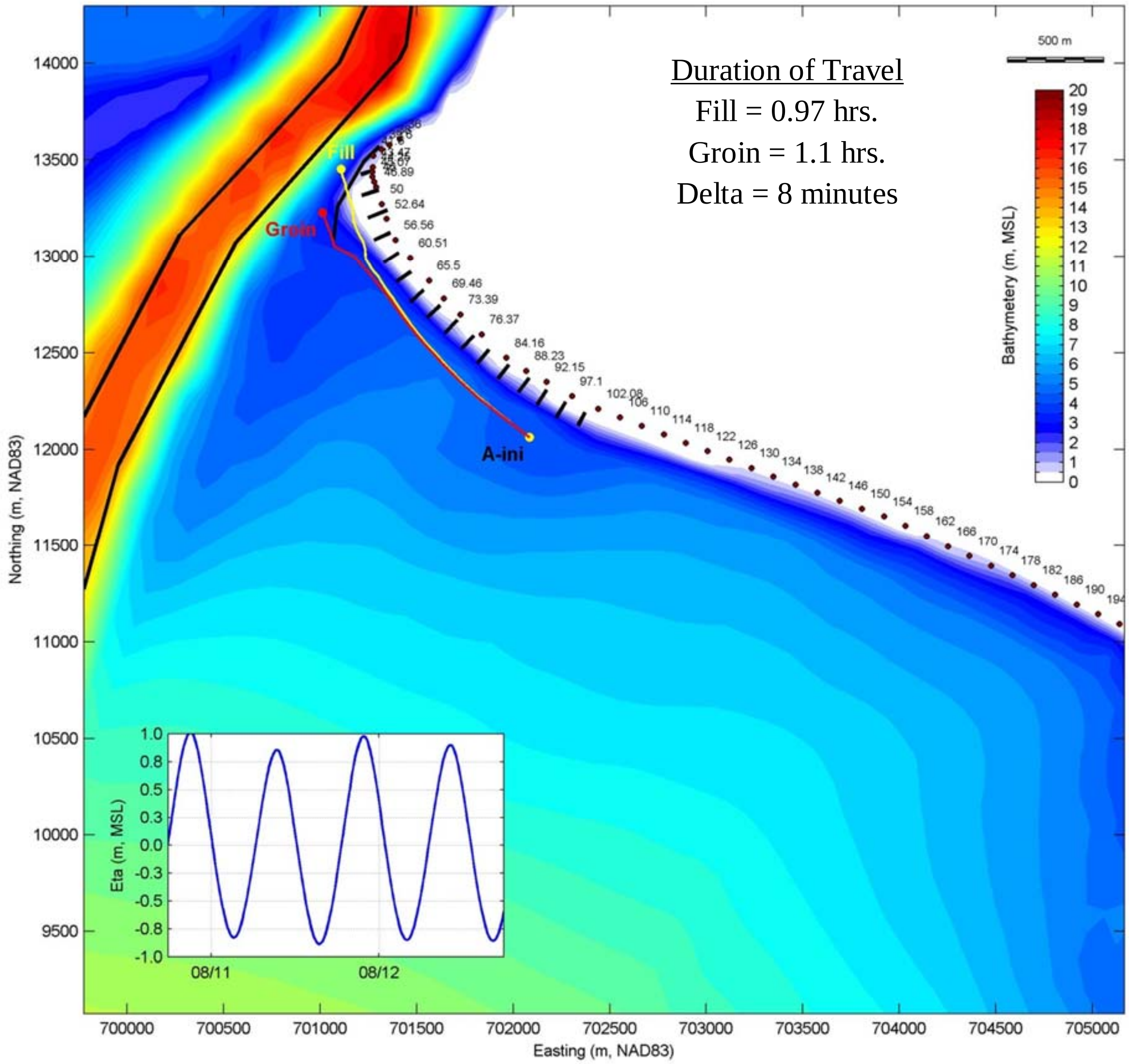


Figure 19: Drogue track A from spring tide deployment to inlet, with and without the terminal groin.

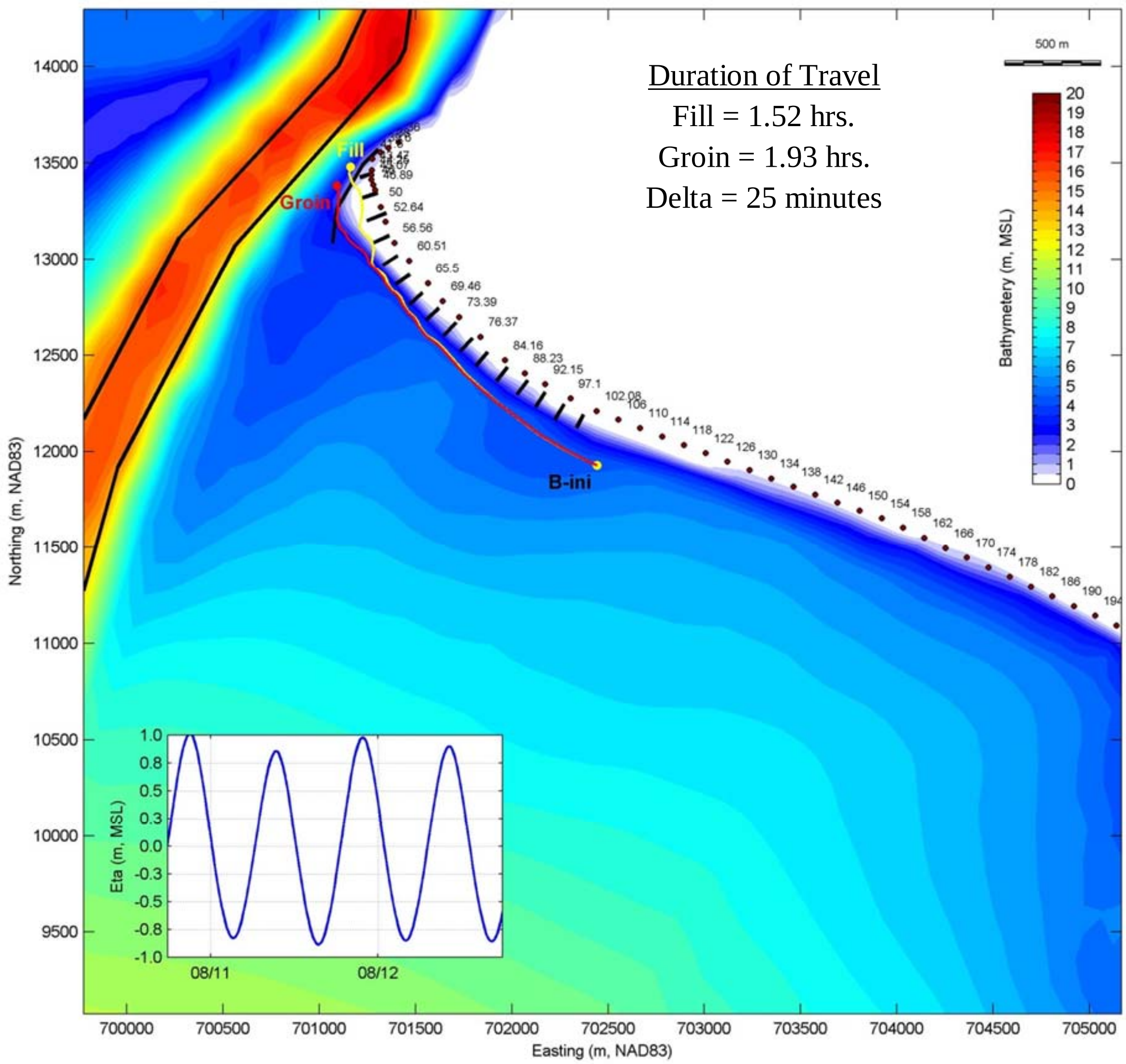


Figure 20: Drogue track B from spring tide deployment to inlet, with and without the terminal groin.

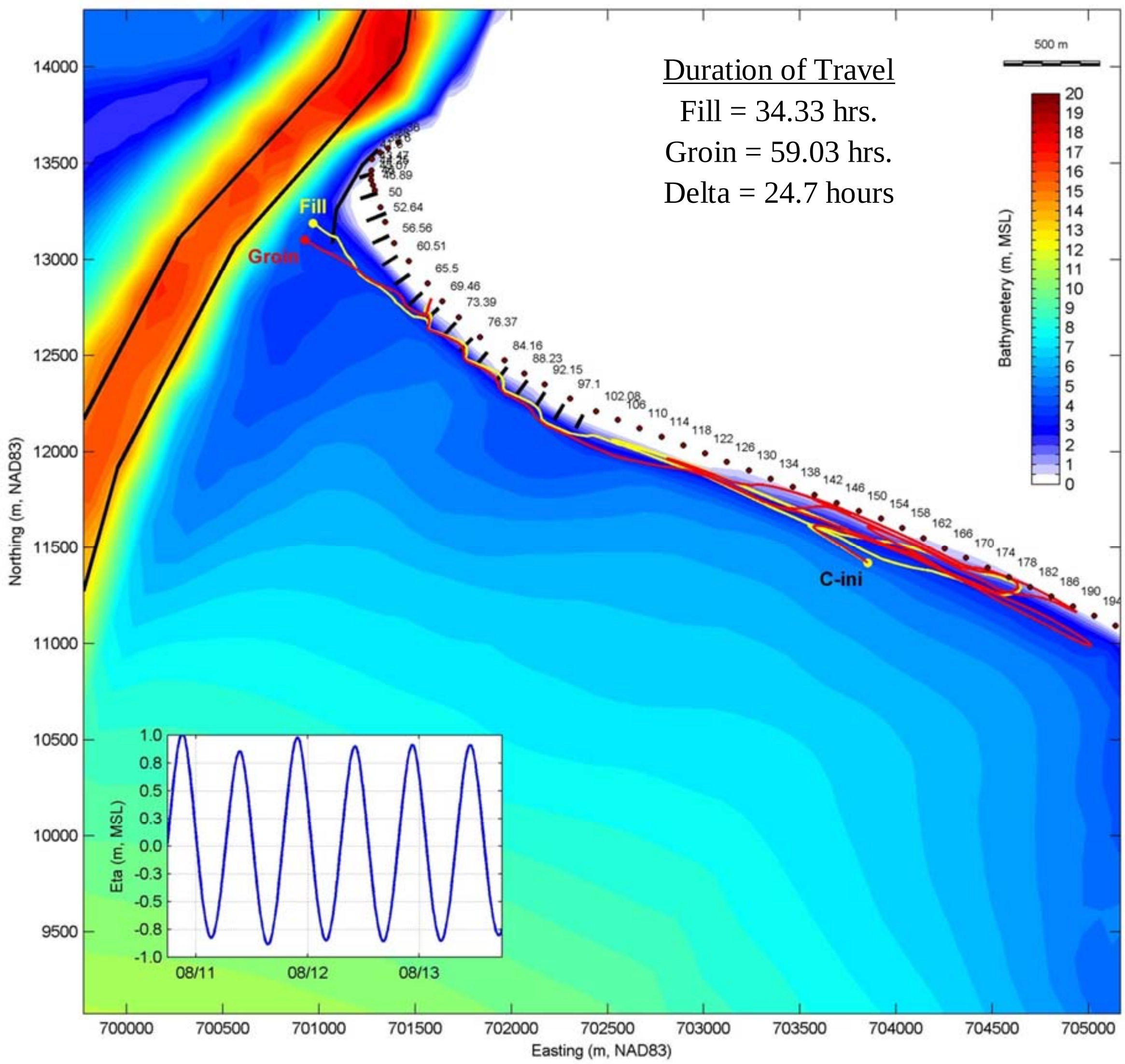


Figure 21: Drogue track C from spring tide deployment to inlet, with and without the terminal groin.

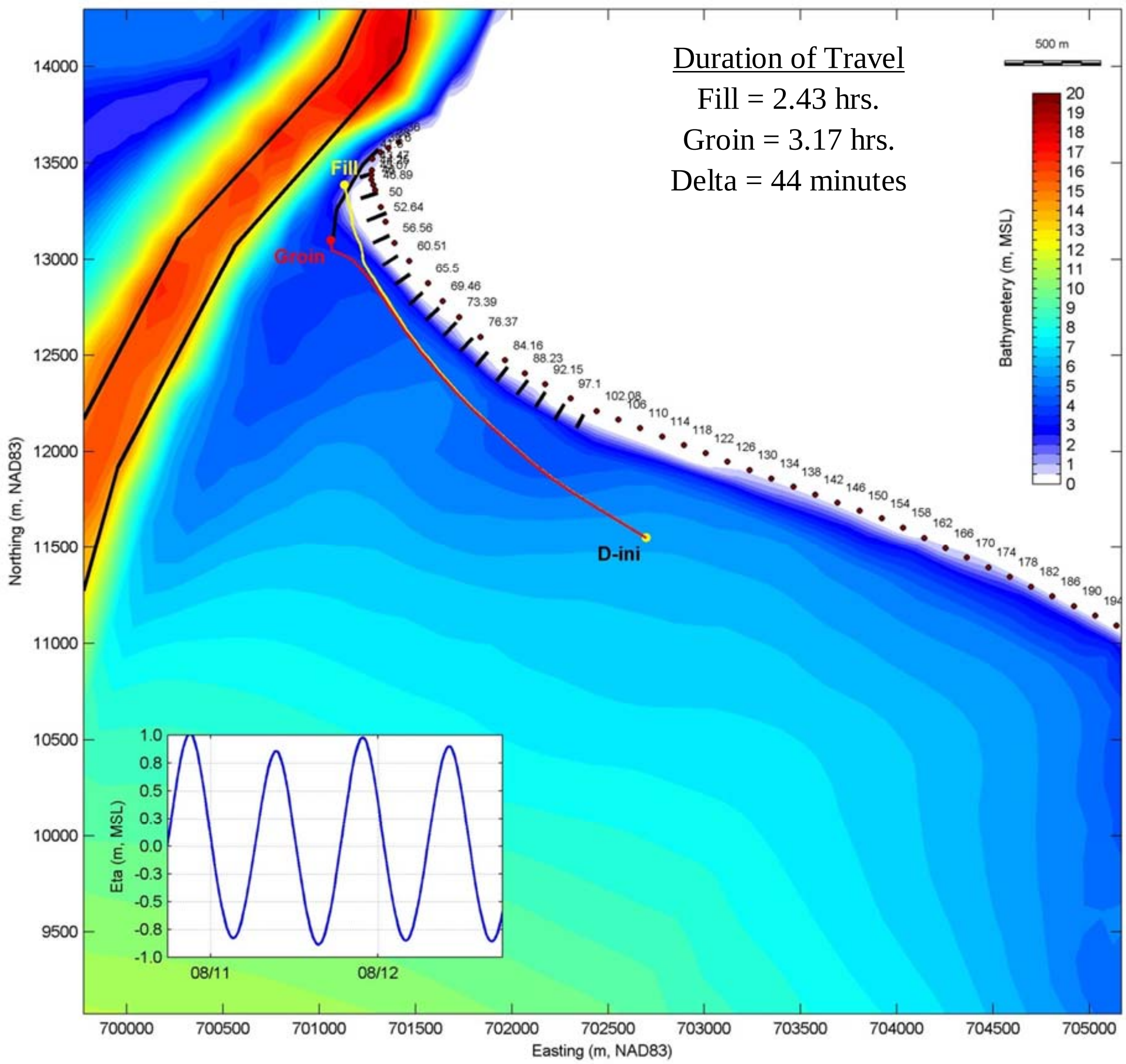


Figure 22: Drogue track D from spring tide deployment to inlet, with and without the terminal groin.

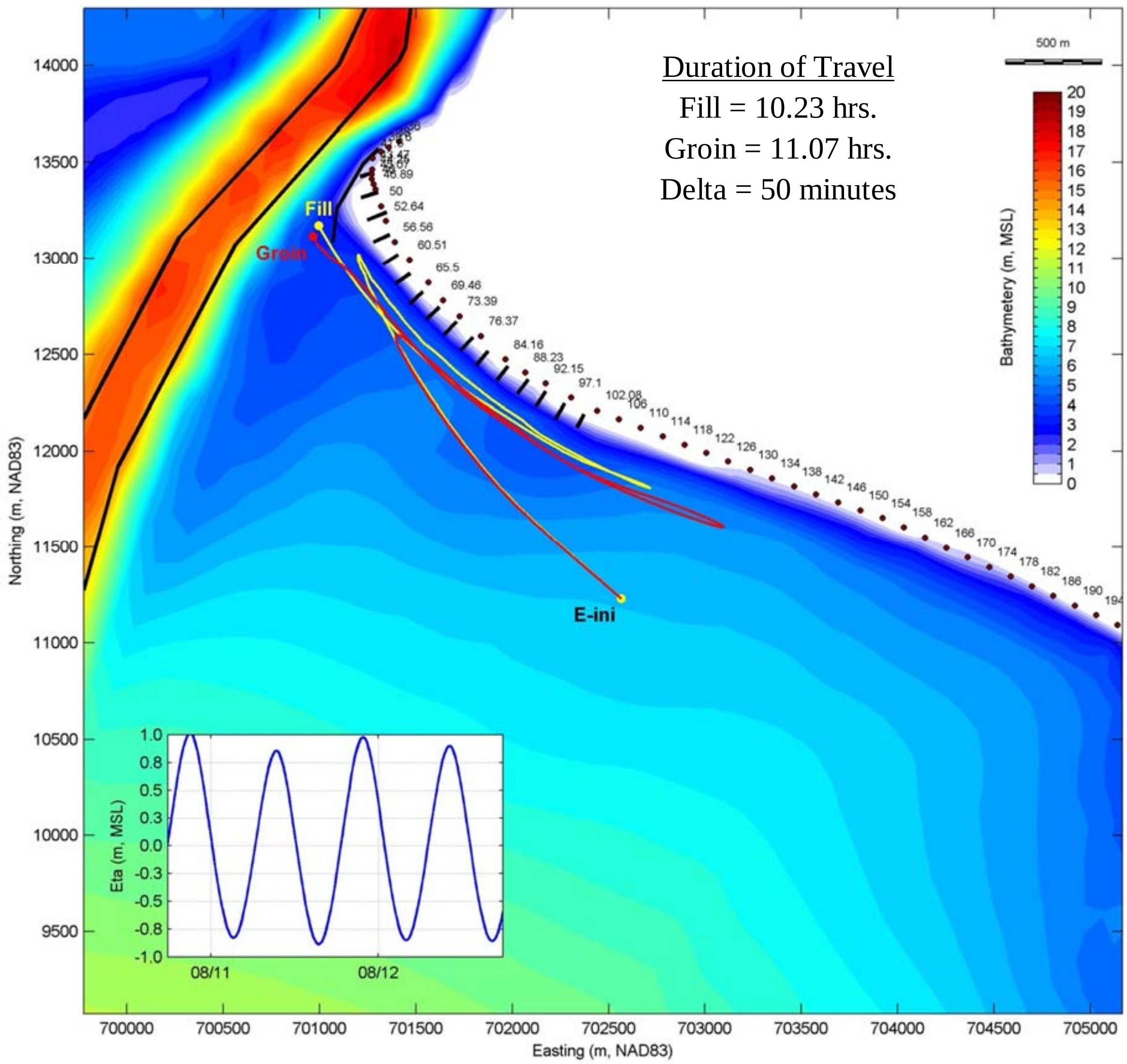


Figure 23: Drogue track E from spring tide deployment to inlet, with and without the terminal groin.

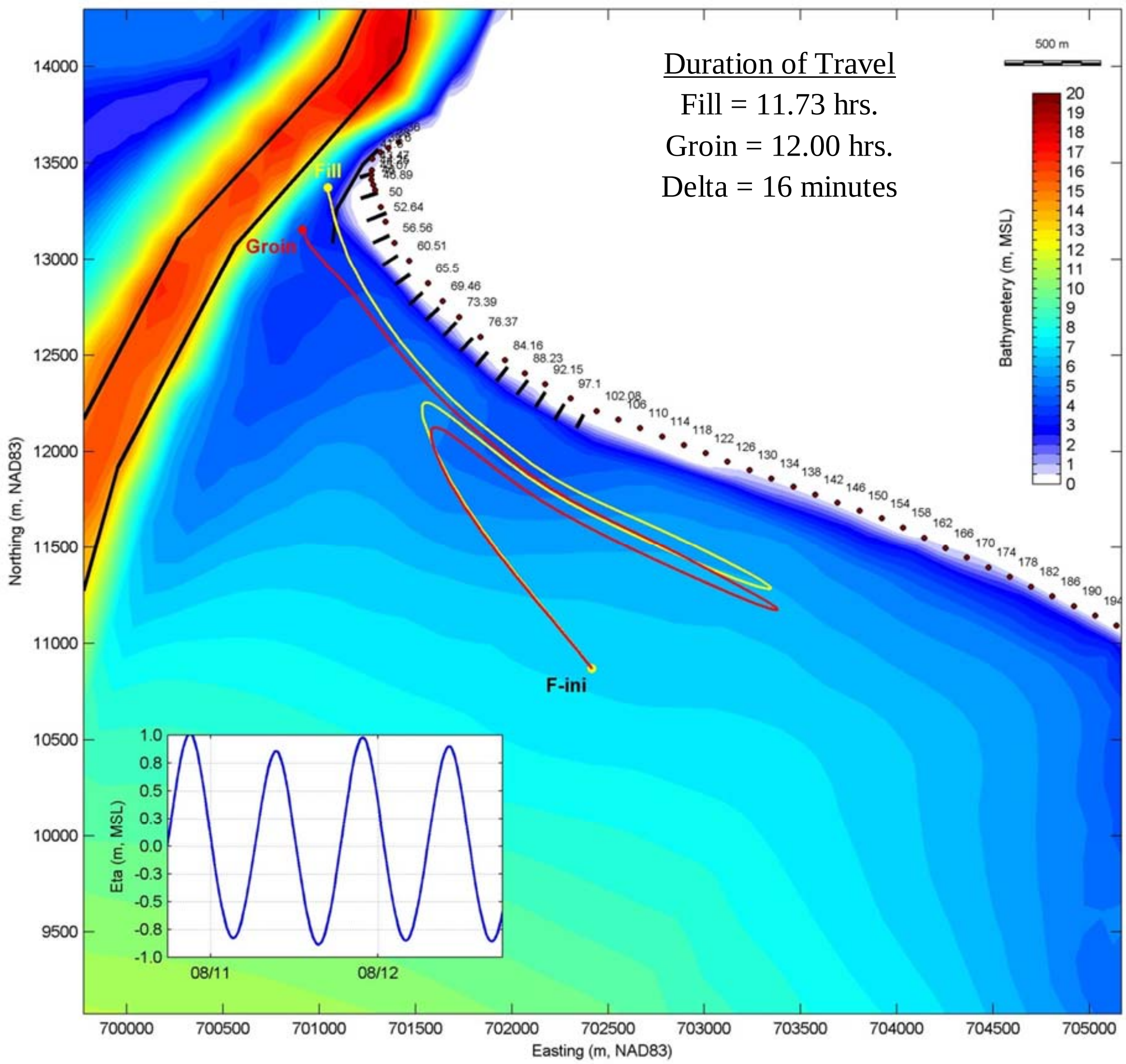


Figure 24: Drogue track F from spring tide deployment to inlet, with and without the terminal groin.

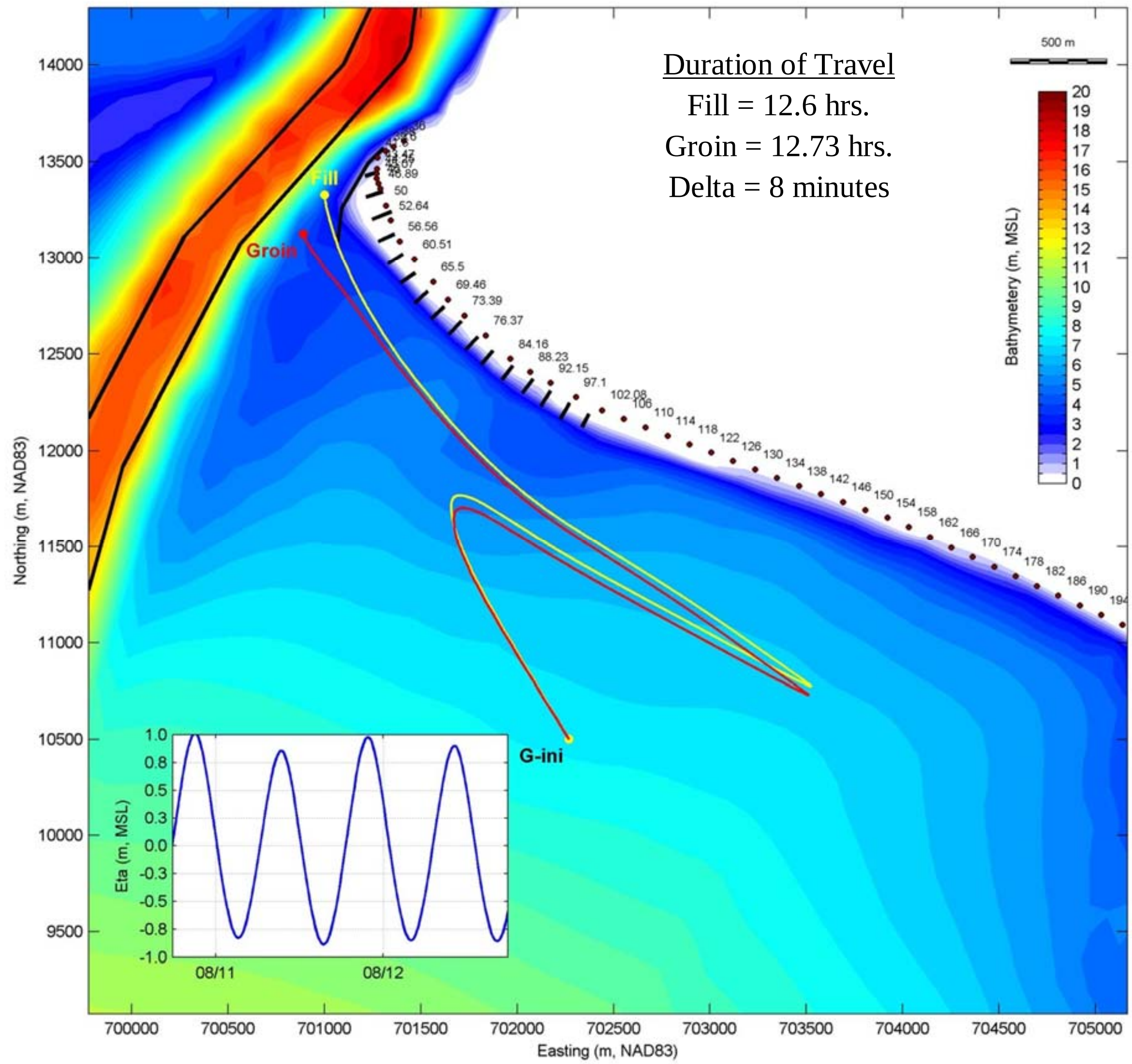


Figure 25: Drogue track G from spring tide deployment to inlet, with and without the terminal groin.

Particle Tracking. The Deflt3D particle tracking model was used to simulate the instantaneous release of a set number of particles contained in a specified amount of tracking agent. The particle tracking model is run independently of the hydrodynamic model and utilizes the hydrodynamic model results as input. Like the drogue tracking exercises, tracer particles are conservative in that there is no decay over time. Tracer particles were released twice, at time steps representing both spring and neap tide conditions and tracked throughout the remaining simulation run. The timing of tracer deployment was the same as used for the drogue analyses. The total number of particles was specified at 10,000 and the total mass of tracer was 2 kg. Particles were released east of the groin field and are represented and mapped as concentrations.

Neap Tide Condition. **Figures 26** through **33** plot the particle distribution at various intervals in time following neap tide insertion. In each figure, the beach fill only and the fill with terminal groin alternatives are plotted side by side one another in order to yield a comparative view at a given time step. The figures plot only the particle positions through the fifth day following initial release given that by day five the particles are quite well distributed throughout the predominantly tidally influenced areas of the model. The tidal stage is indicated by the red line on the water level plot in the upper left corner of each figure. The dominant current direction (ebb or flood) is denoted on each figure by the large red arrow.

The results suggest few significant differences in the range and concentrations of particles through time. The with-terminal groin result does indicate initial higher concentrations of particles in the intertidal nearshore principally east of the beach fill limit. The apparent stranding of particles in the intertidal beach here is consistent with the drogue tracking result. As the tracer particles begin to mobilize into the inlet, increased particle concentrations along this reach subside and gain consistency with the fill only concentrations within about two days following insertion.

Spring Tide Condition. **Figures 34** through **41** plot the particle distribution at various intervals in time following spring tide insertion. The results for both spring and neap tide insertion times are similar in that the terminal groin appears to have little influence over the transport patterns of the tracer particles. Specifically, under both conditions, particles which enter the inlet on a flood tide and do not enter the very shallow portions of the estuary are subsequently mobilized offshore on the following ebb tide. A portion of these particles are returned into the inlet on the following flood tide(s) eventually becoming well distributed throughout the river, estuary, and marsh areas after only a few days. Alternatively stated, the large scale motion paths of the particles appear to generally follow pathways similar to those computed for the residual tides shown in **Figures 3** and **4**. The presence of the terminal groin appears to have no significant limiting influence on the ability of particles to enter the estuary and ebb/flood transport pathways described above. The size of the modeled terminal groin pales in scale to that of the overall range of distributed particles the spatial extent of which does not materially differ between with and without terminal groin conditions.

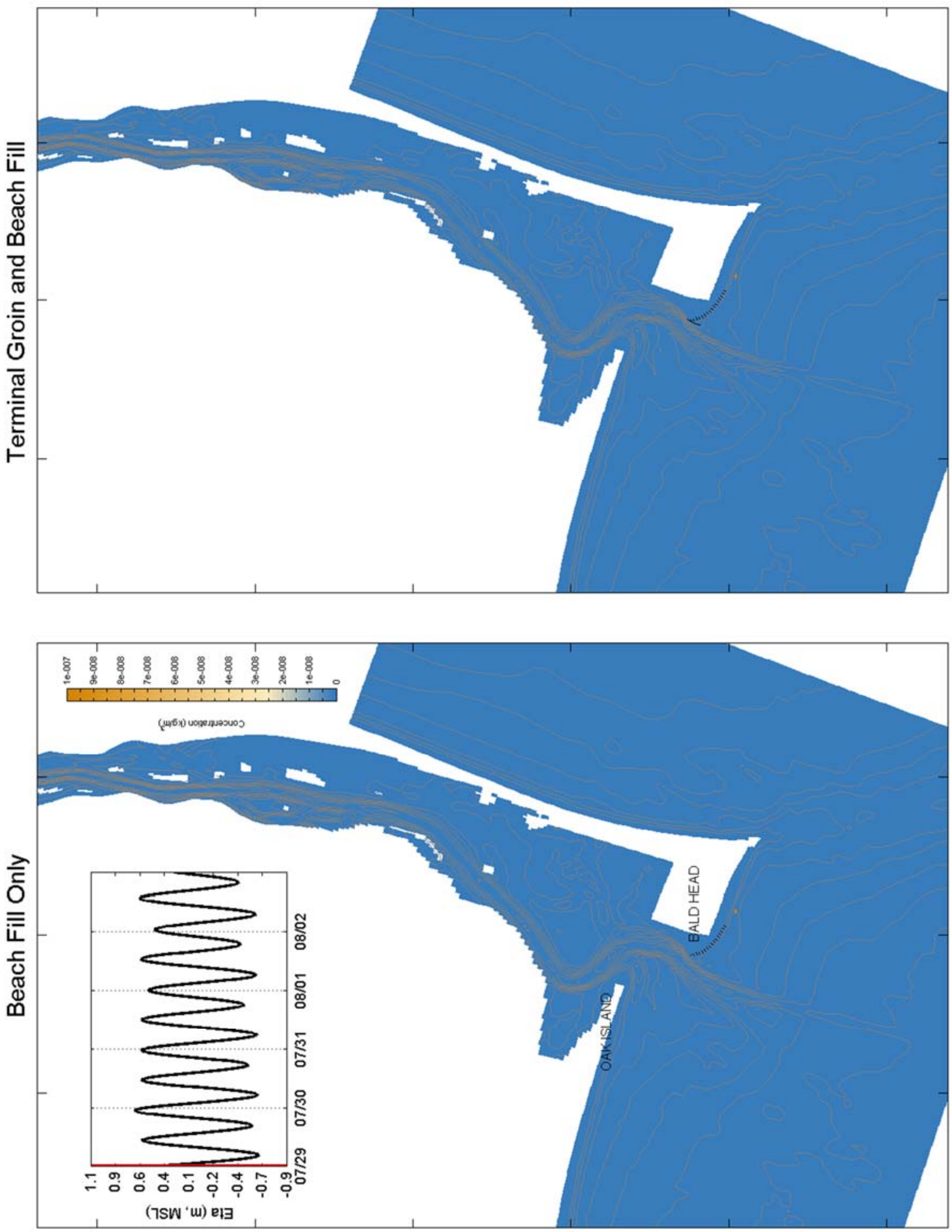


Figure 26: Particle concentration map 0 days following neap tide insertion.

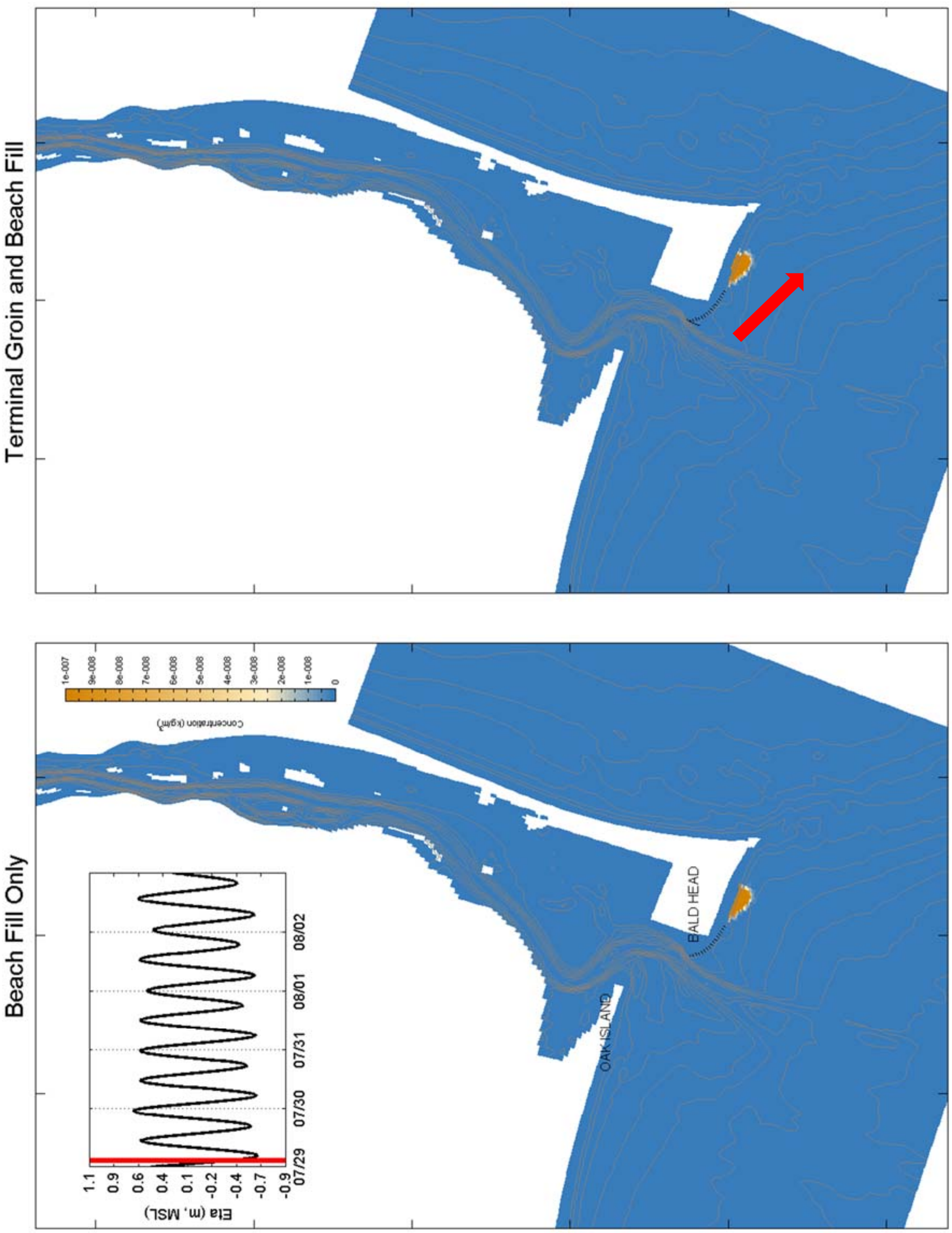


Figure 27: Particle concentration map hours following neap tide insertion.

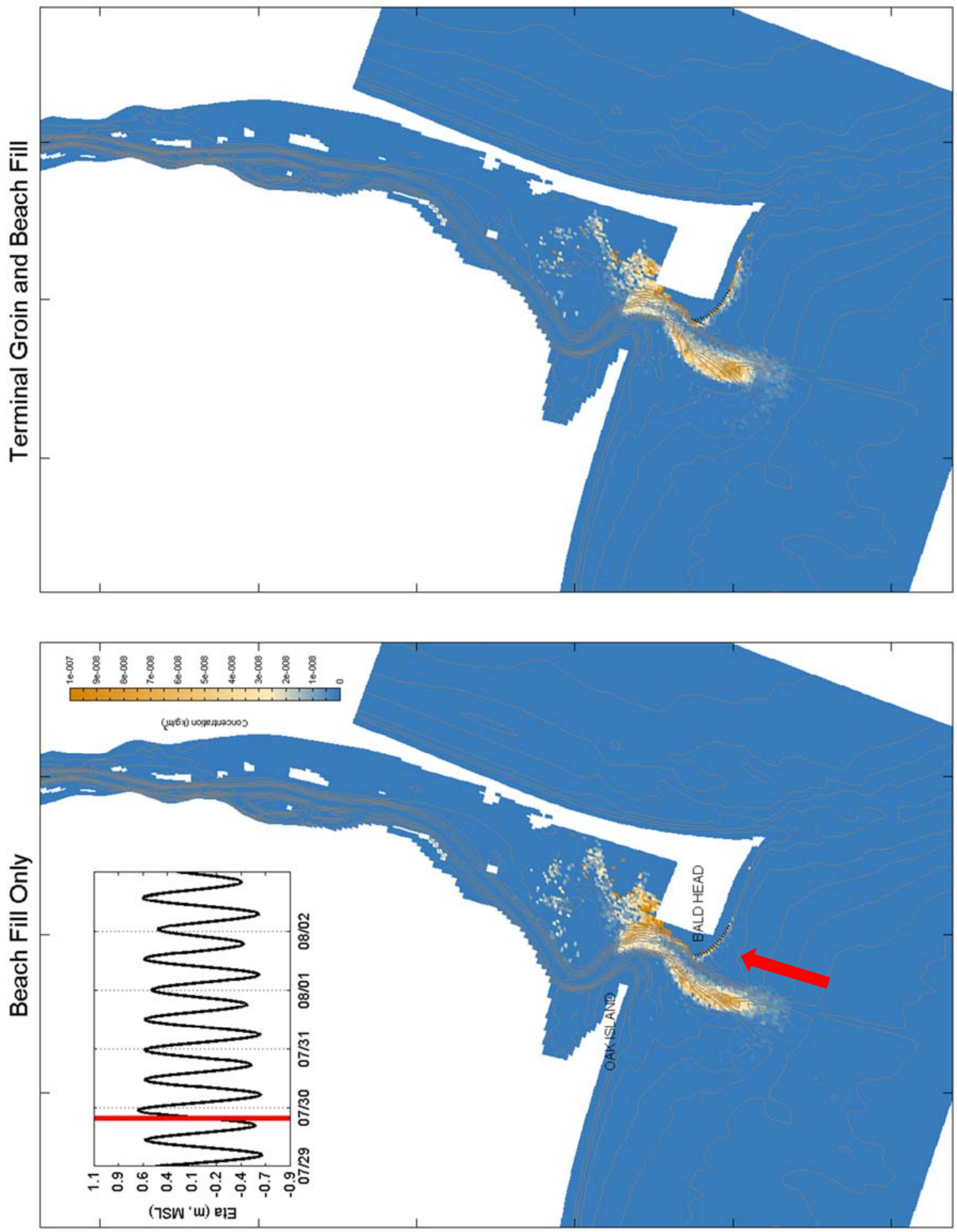


Figure 28: Particle concentration map about 1 day following neap tide insertion.

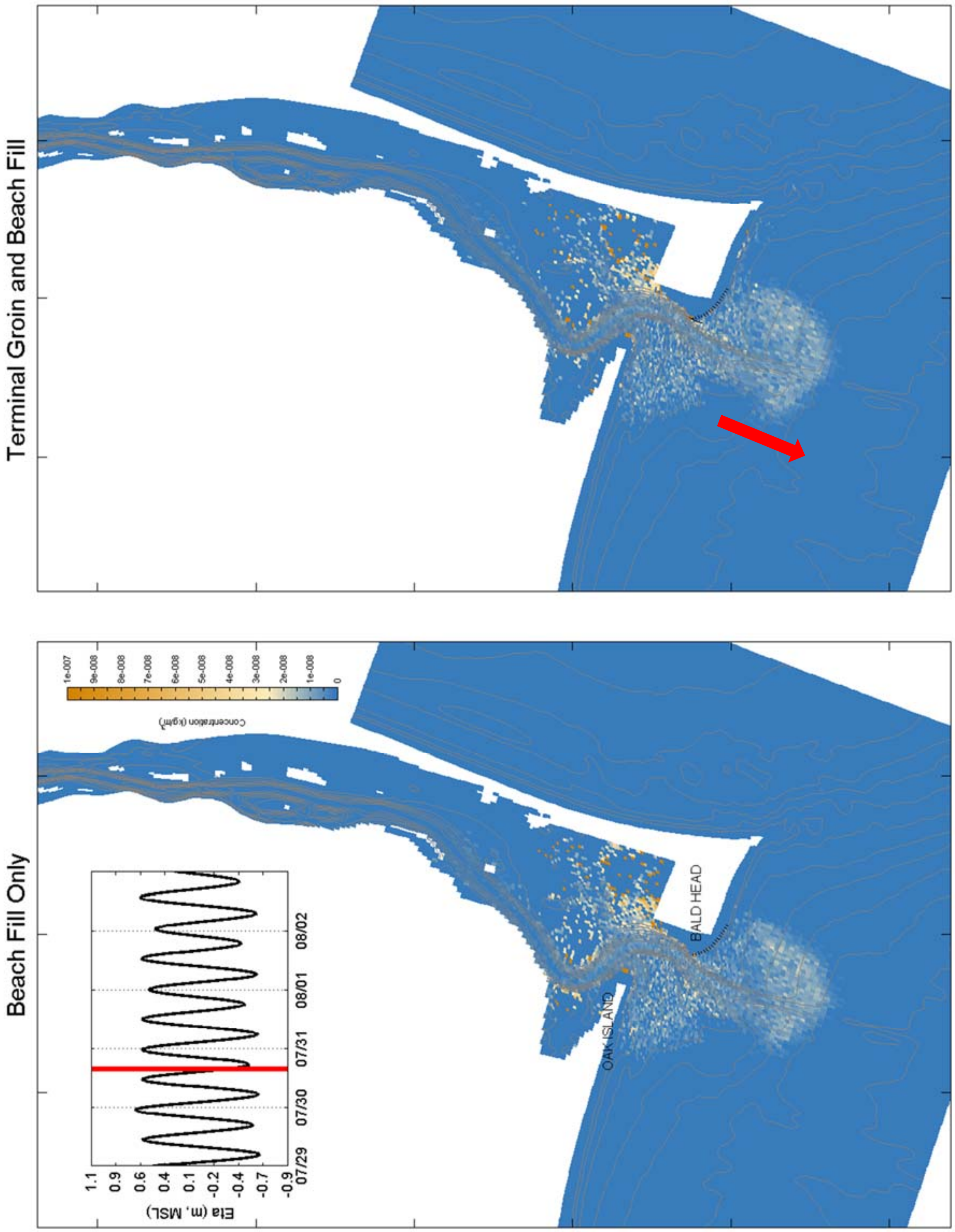


Figure 29: Particle concentration map about 1.7 days following neap tide insertion.

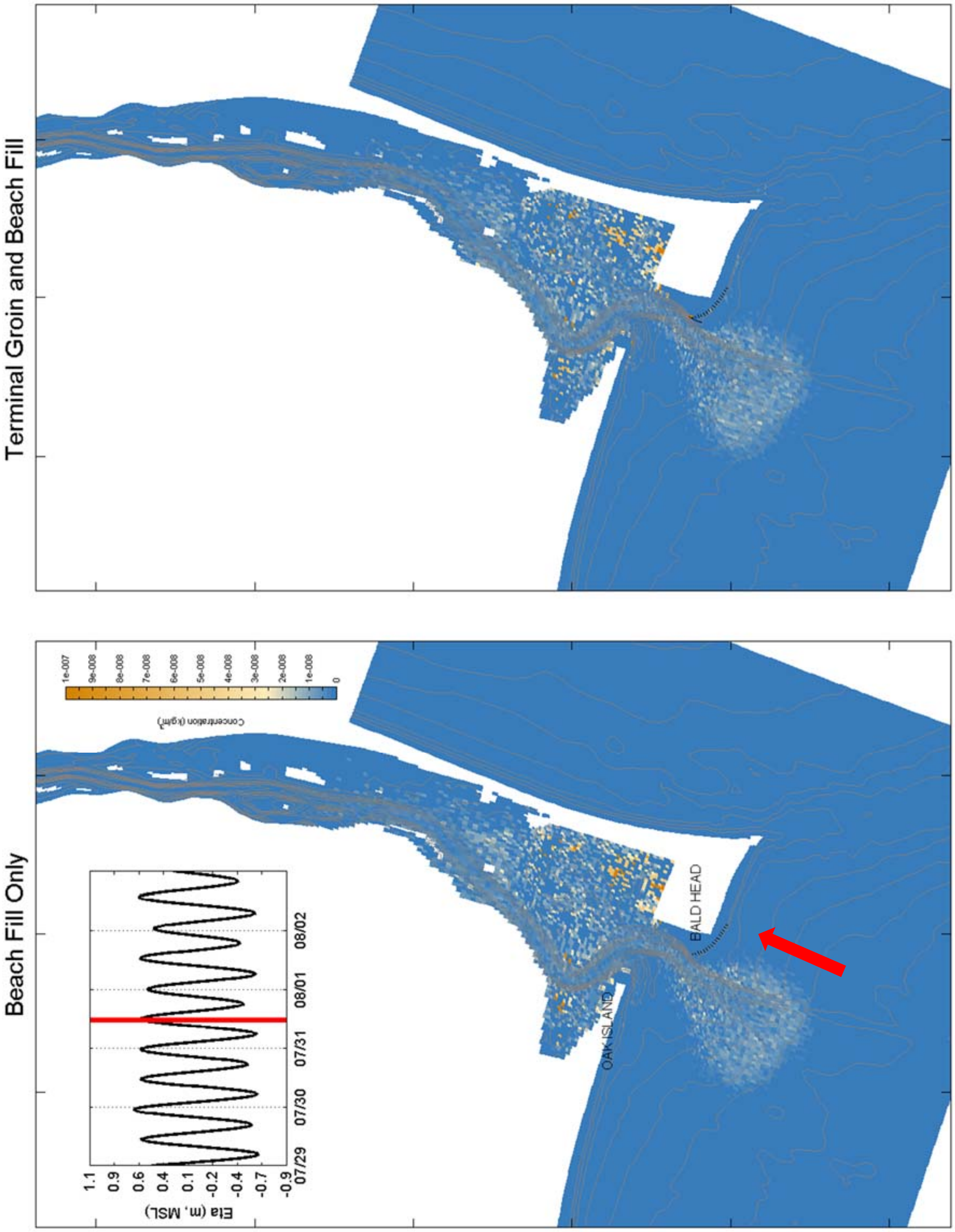


Figure 30: Particle concentration map about 2.5 days following neap tide insertion.

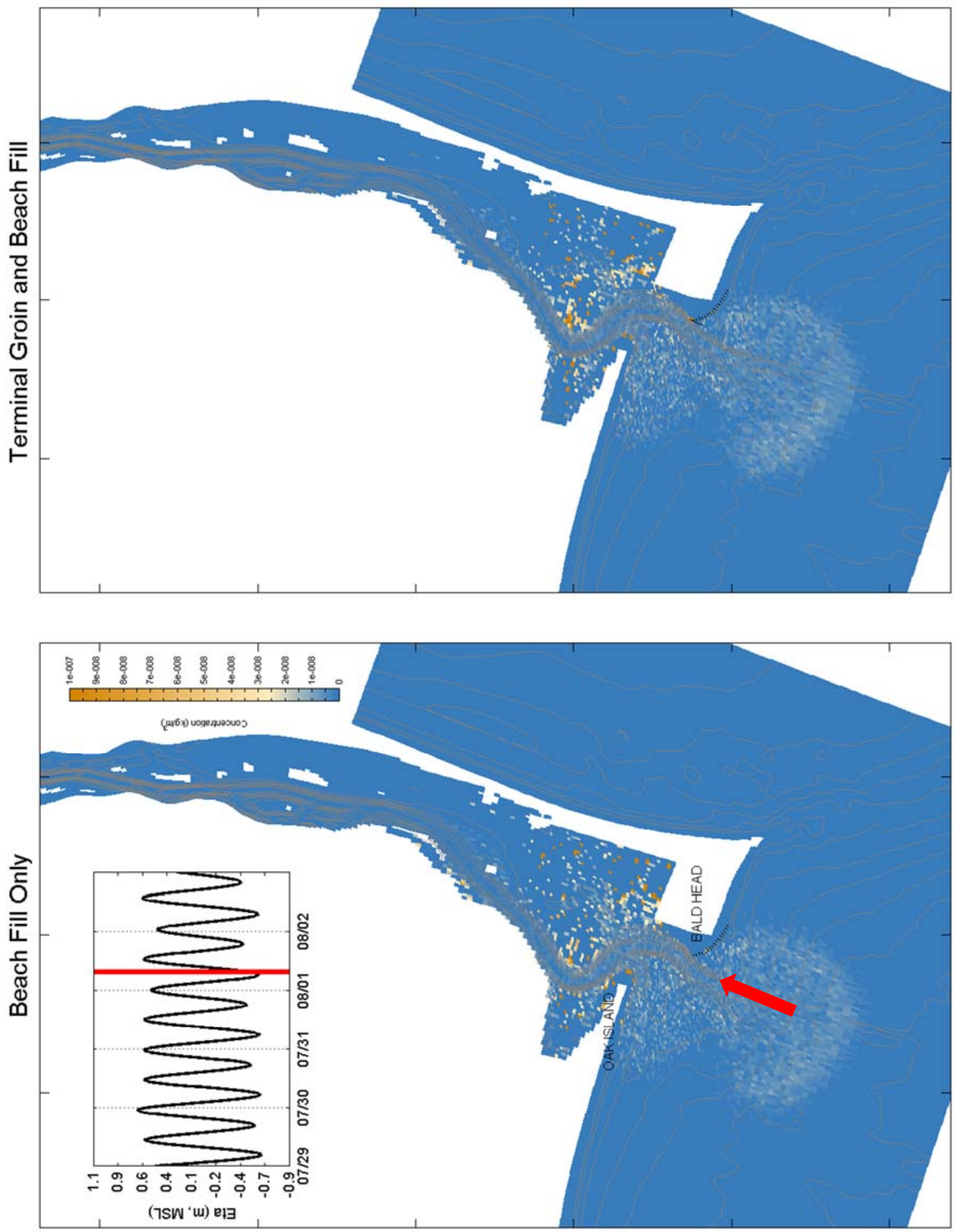


Figure 31: Particle concentration map 3.25 days following neap tide insertion.

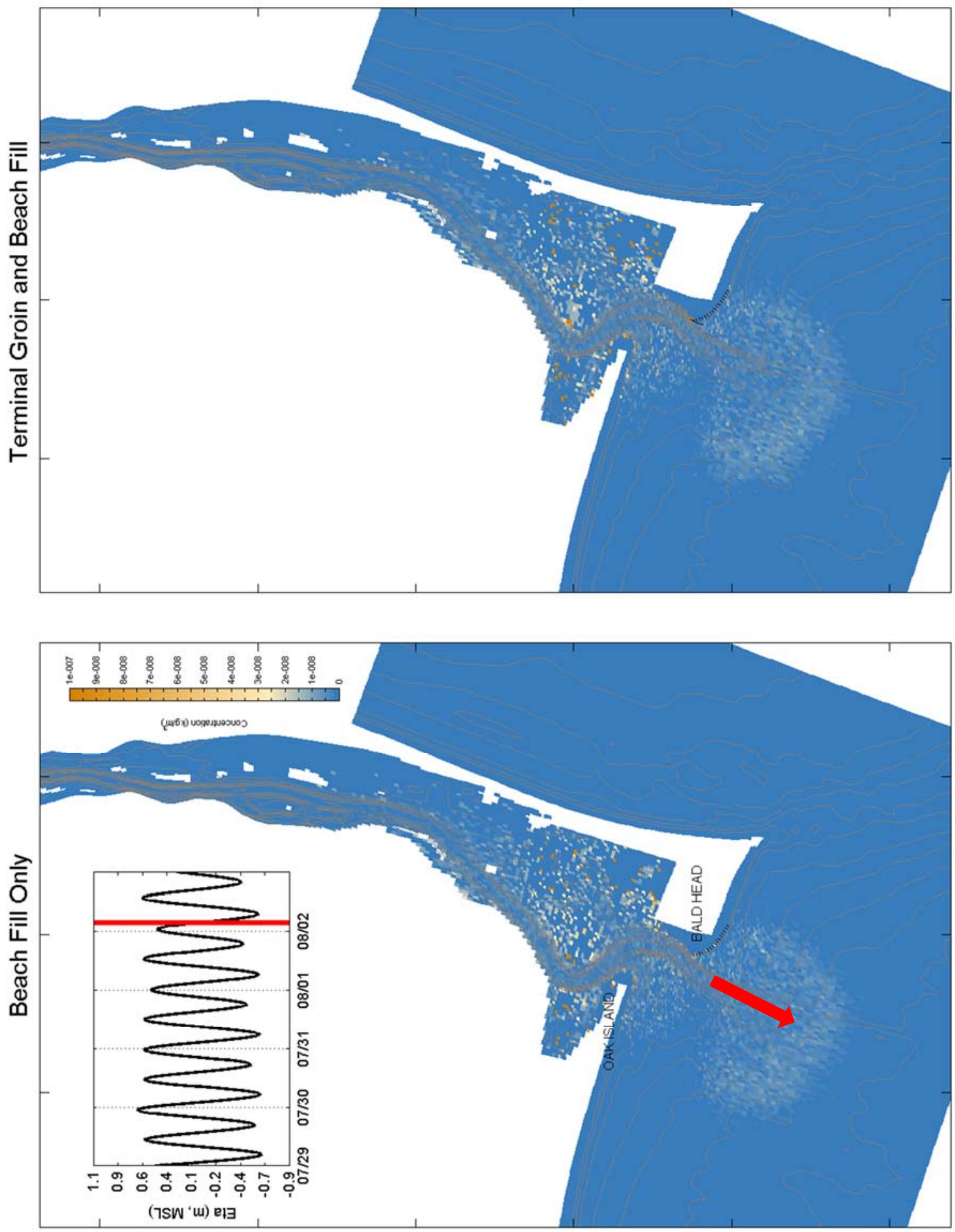


Figure 32: Particle concentration map about 4 days following neap tide insertion.

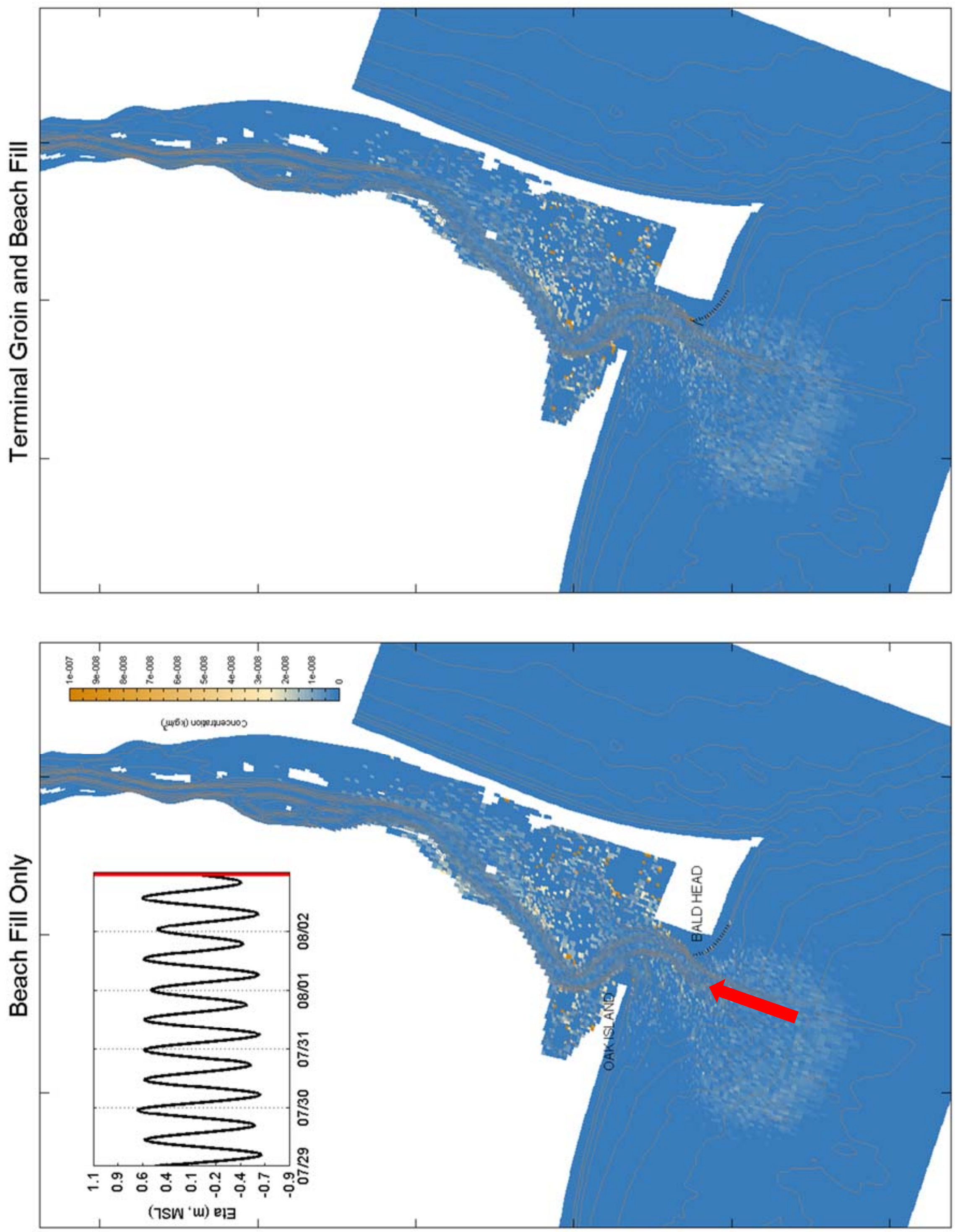


Figure 33: Particle concentration map 5 days following neap tide insertion.

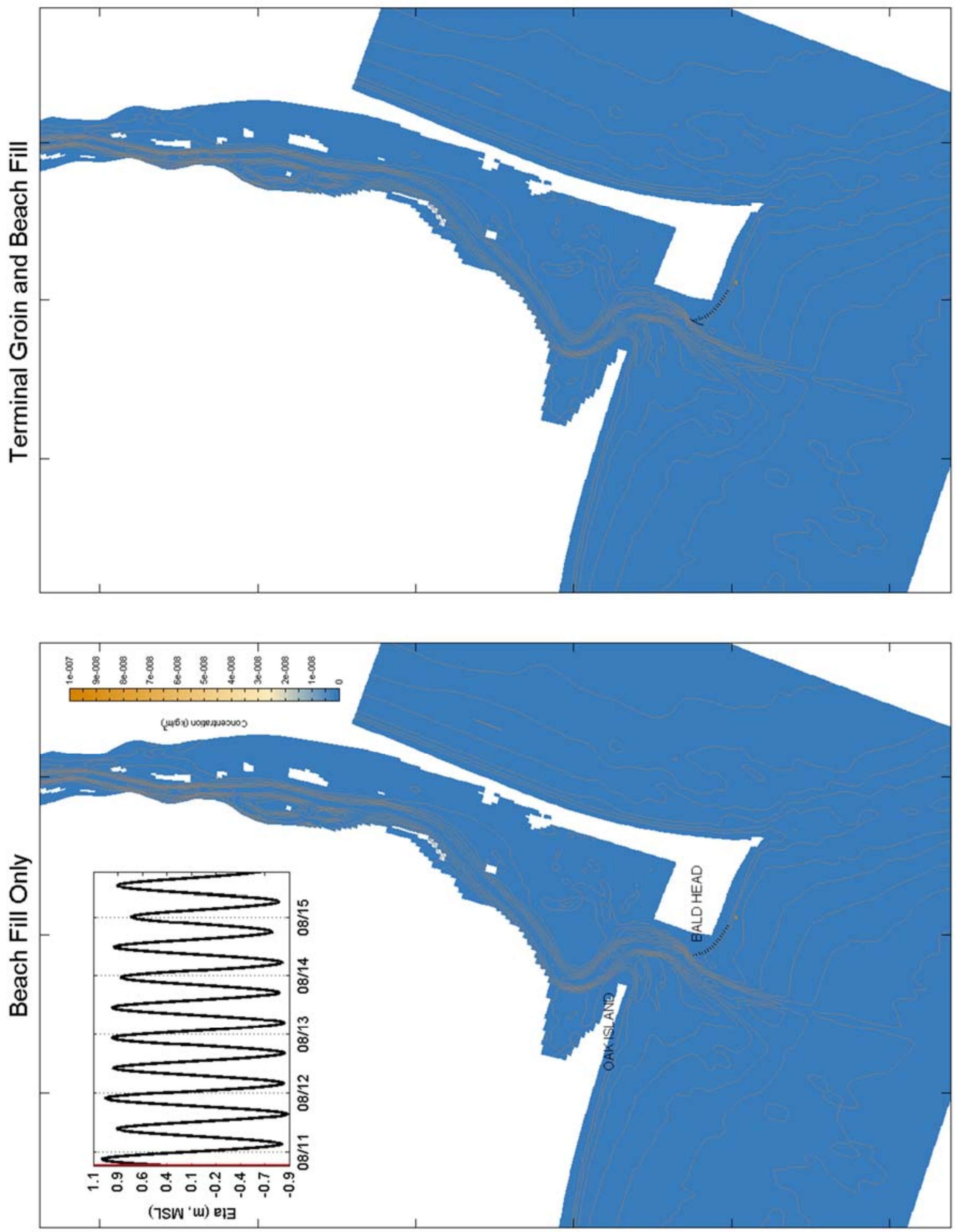


Figure 34: Particle concentration map 0 days following spring tide insertion.

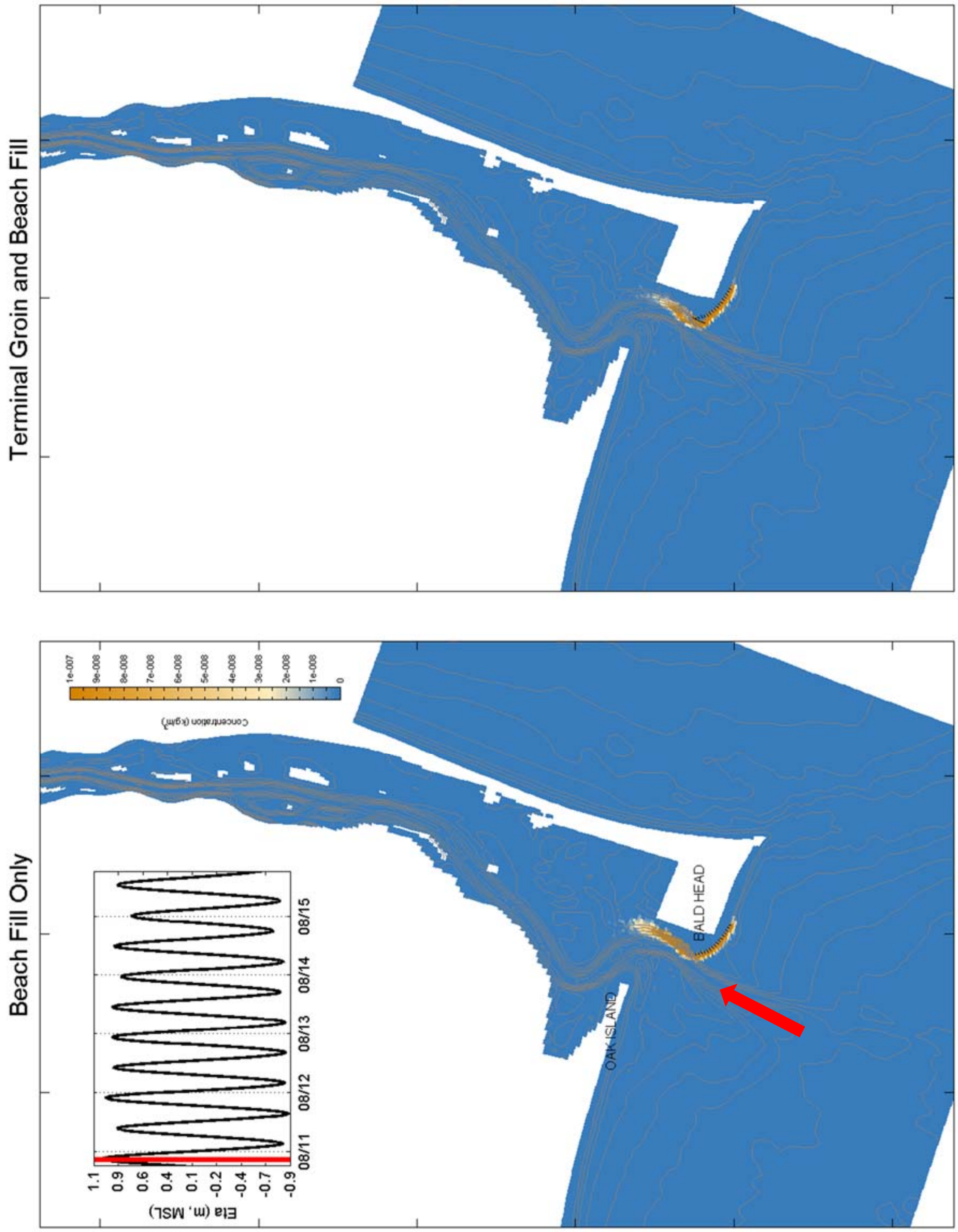


Figure 35: Particle concentration map hours following spring tide insertion.

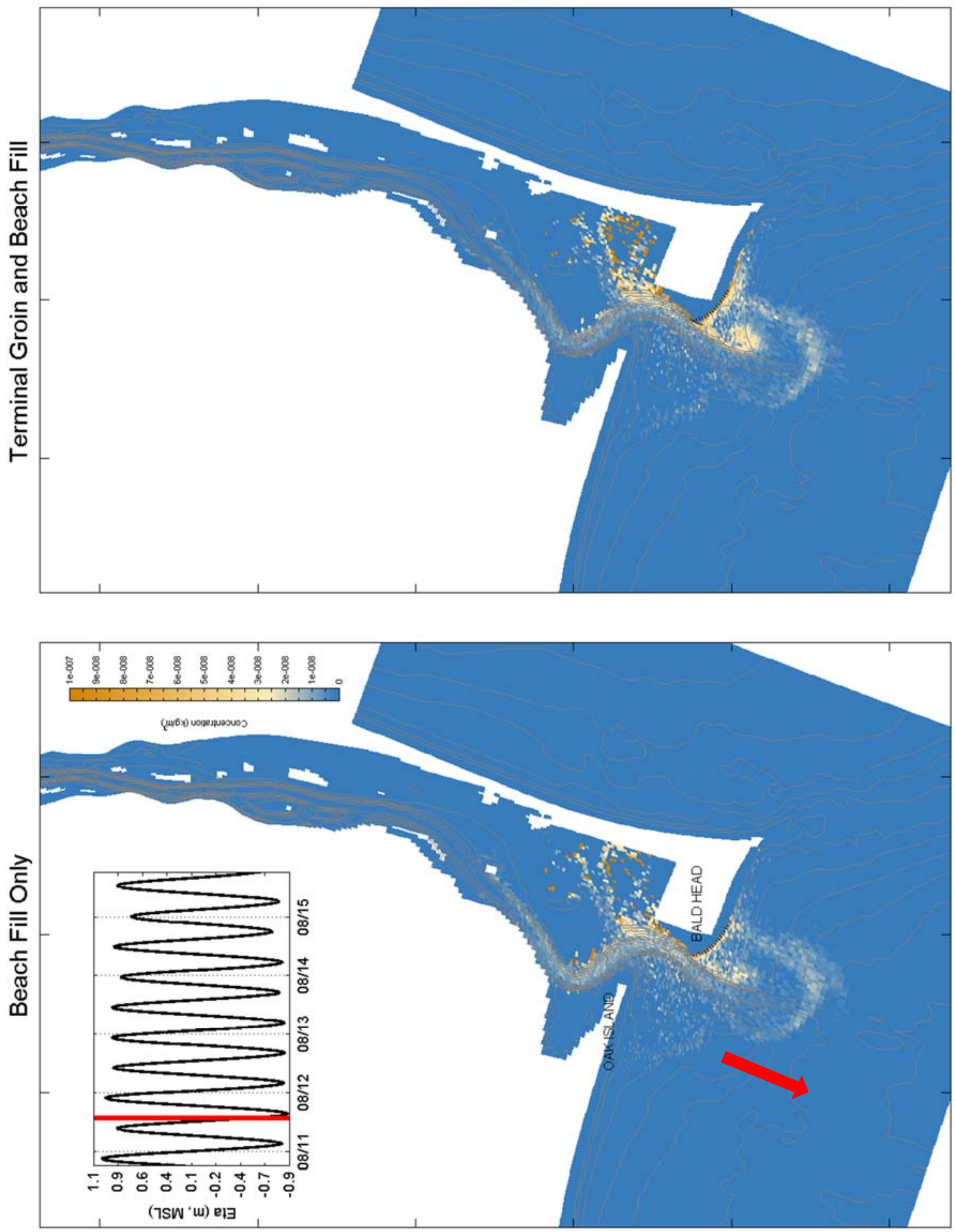


Figure 36: Particle concentration map about 1 day following spring tide insertion.

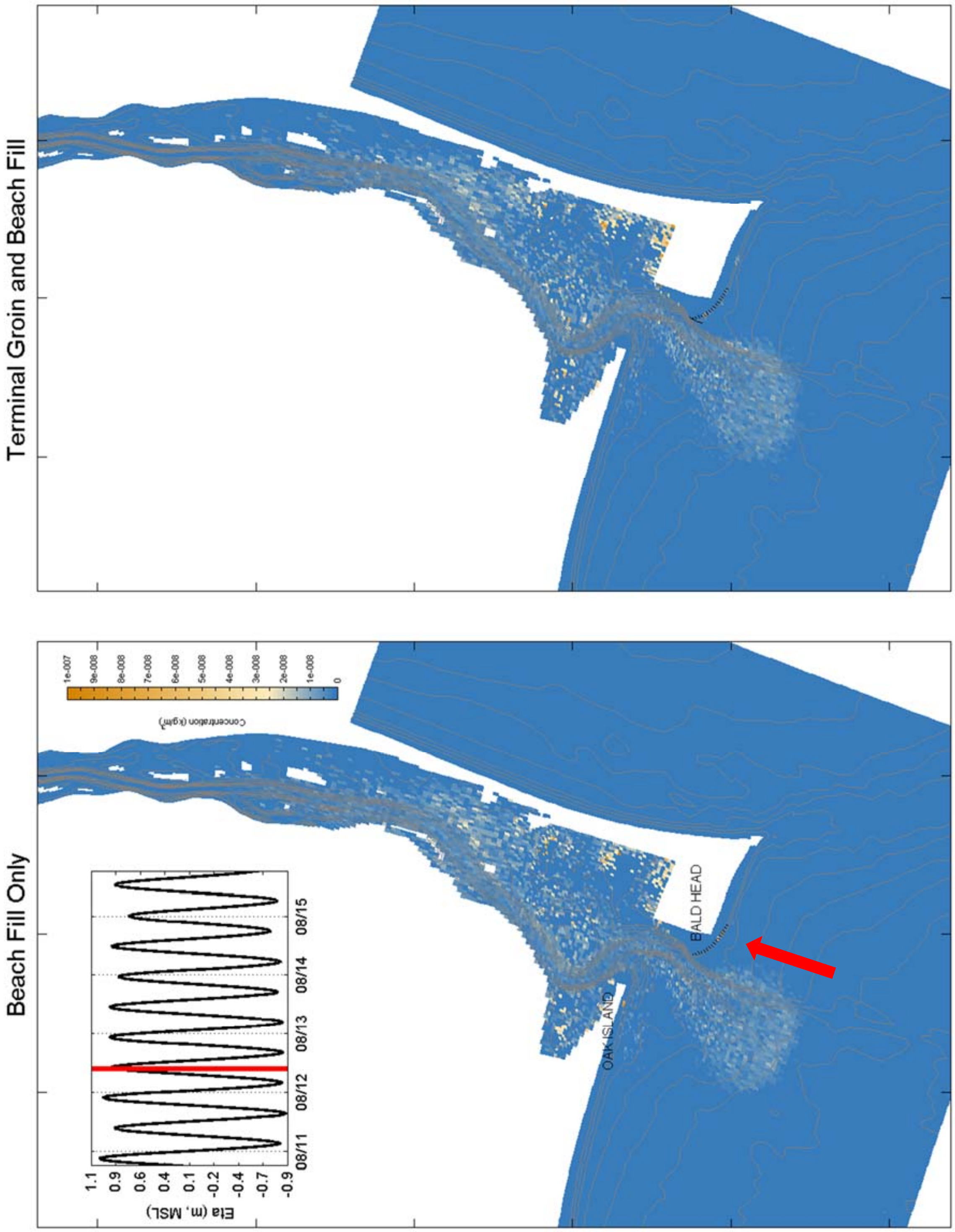


Figure 37: Particle concentration map about 1.7 days following spring tide insertion.

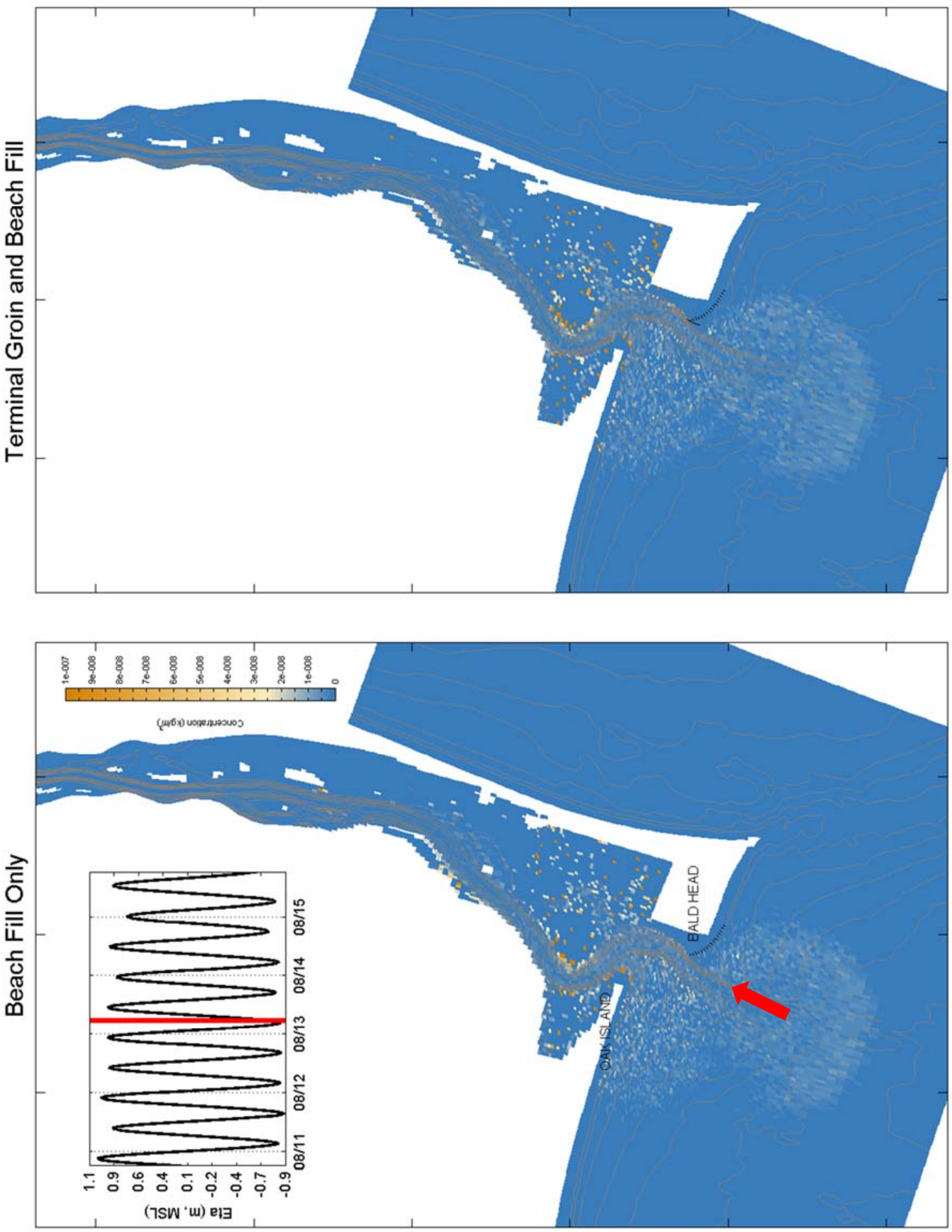


Figure 38: Particle concentration map about 2.5 days following spring tide insertion.

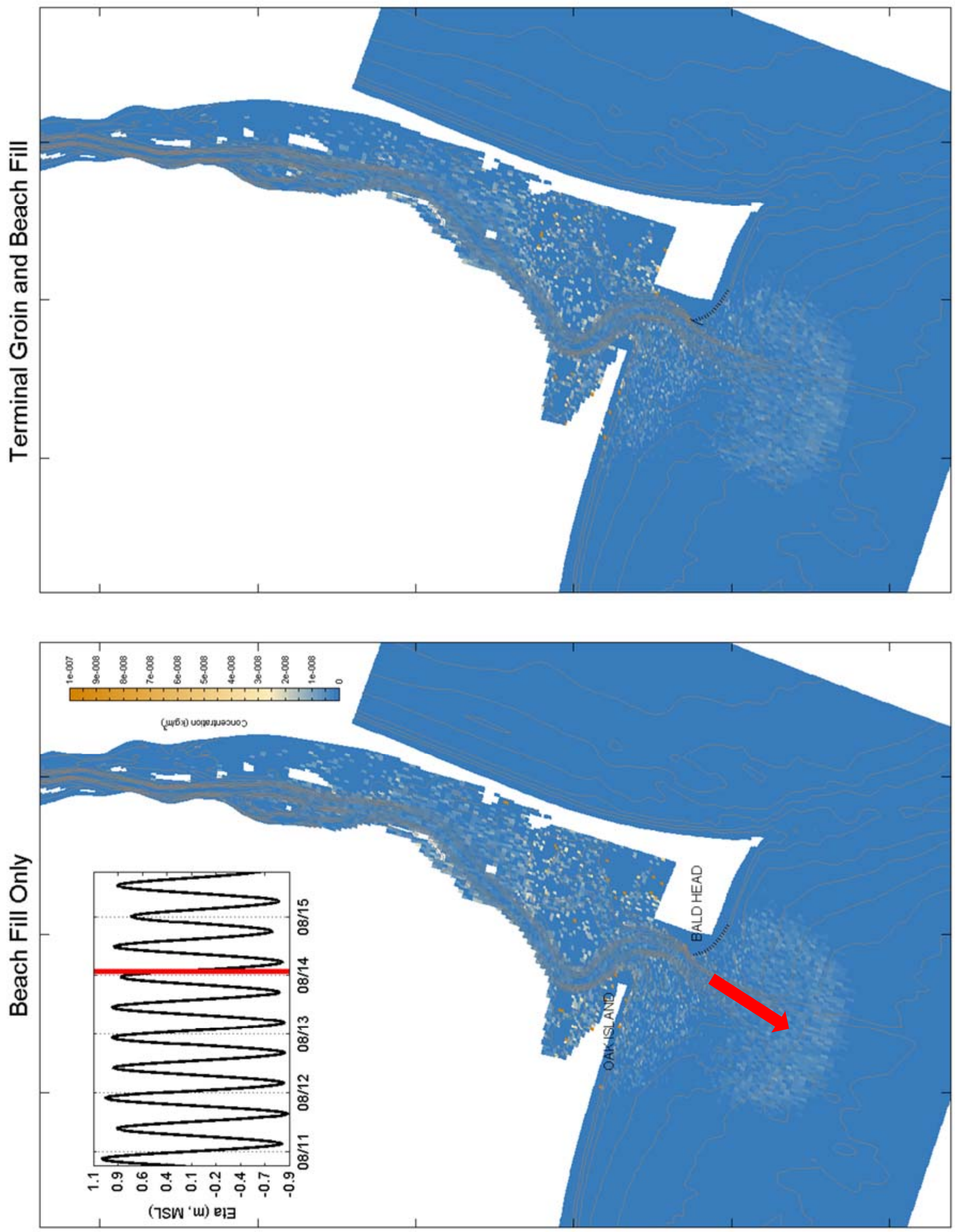


Figure 39: Particle concentration map about 3.25 days following spring tide insertion.

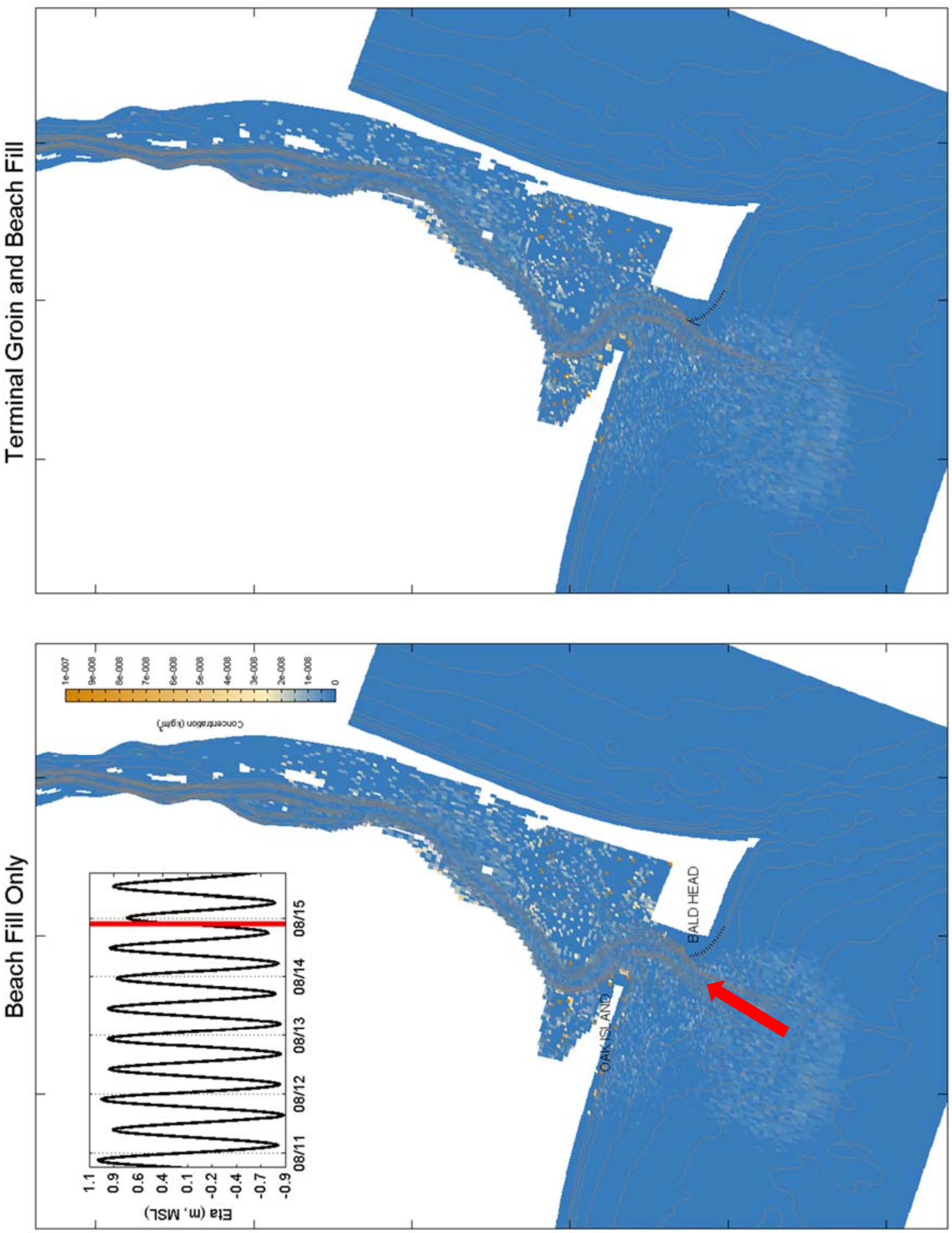


Figure 40: Particle concentration map about 4 days following spring tide insertion.

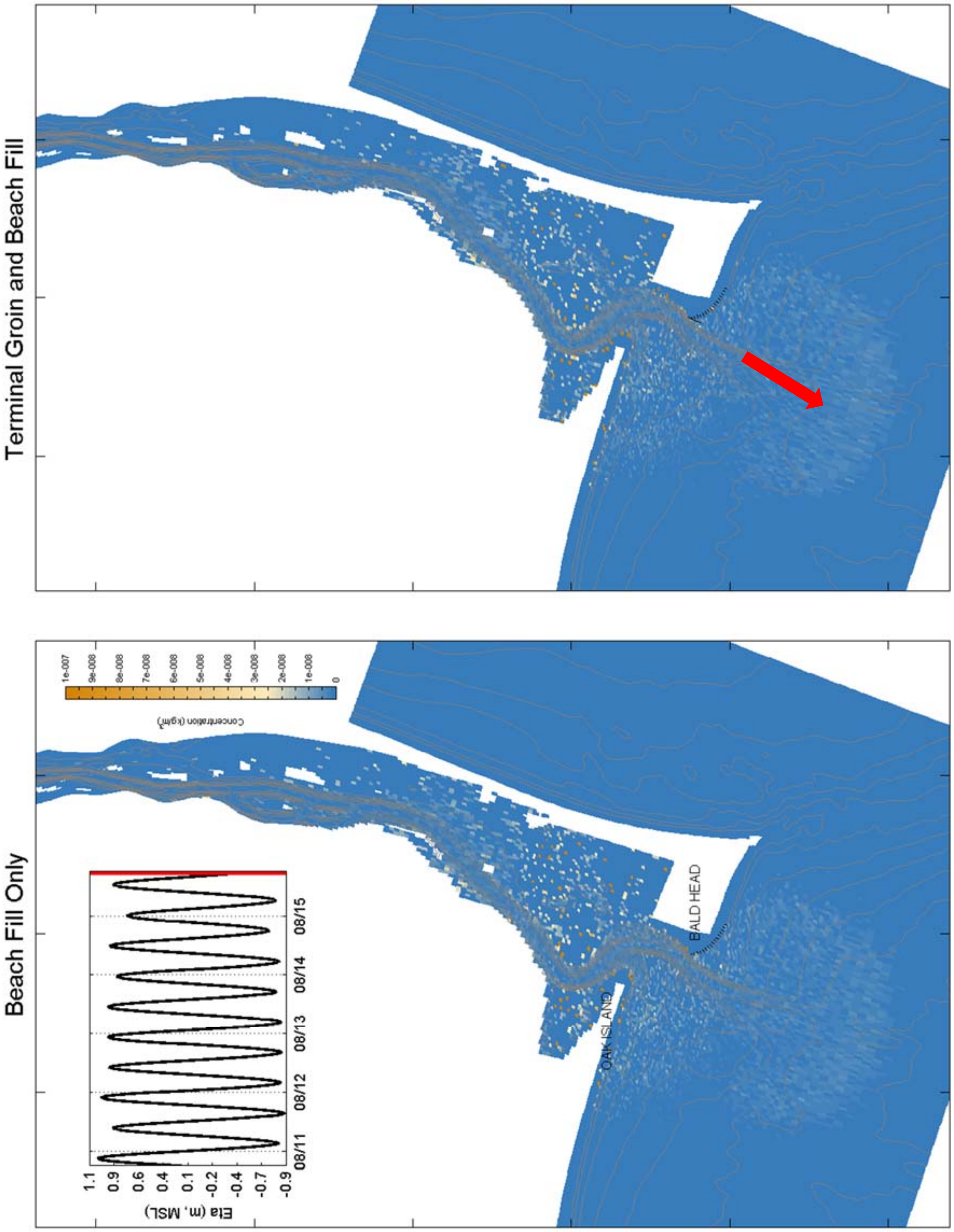


Figure 41: Particle concentration map 5 days following spring tide insertion.

APPENDIX S

U.S. FISH & WILDLIFE SERVICE
BIOLOGICAL OPINION

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Raleigh Field Office
Post Office Box 33726
Raleigh, North Carolina 27636-3726

June 19, 2014

Mr. Scott C. McLendon
Chief, Regulatory Division
Wilmington District, Corps of Engineers
69 Darlington Avenue
Wilmington, NC 28403-1343

Dear Mr. McLendon:

This document transmits the U.S. Fish and Wildlife Service's (Service) biological and conference opinions based on our review of the proposed terminal groin located in the Village of Bald Head Island, Brunswick County, NC, and its effects on piping plover (*Charadrius melodus melodus*), seabeach amaranth (*Amaranthus pumilus*), West Indian manatee (*Trichechus manatus*), and the green sea turtle (*Chelonia mydas*), leatherback sea turtle (*Dermochelys coriacea*), Kemp's ridley sea turtle (*Lepidochelys kempi*), hawksbill sea turtle (*Eretmochelys imbricata*), and the Northwest Atlantic loggerhead sea turtle population (*Caretta caretta*) in accordance with section 7 of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq.*). Your March 7, 2014 request for formal consultation was received on the same date.

These biological and conference opinions are based on information provided in the March 7, 2014 biological assessment (BA), the January 10, 2014 Draft Environmental Impact Statement (DEIS) for the Village of Bald Head Island (VBHI), the March 14, 2012 Public Notice, the January, 2012 project proposal, the April 24, 2012 scoping meeting, field investigations, and other sources of information. A complete administrative record of this consultation is on file at the Service's Raleigh Field Office. The Service has assigned Log number 2014-F-0204 to this consultation.

The Service concurs with the U.S. Army Corps of Engineers (Corps) determination of not likely to adversely affect (NLAA) for the Kemp's ridley and hawksbill sea turtles and West Indian manatee (**Table 1**). Concurrence for the Kemp's ridley and hawksbill sea turtle determinations is based upon data that have documented no nests of those species on Bald Head Island and the proposed conservation measures for sea turtles. Concurrence for the West Indian manatee determination is based upon a lack of data documenting the West Indian manatee in the Action Area, and the proposed conservation measures, which include implementation of the Service's Guidelines for Avoiding Impacts to the West Indian Manatee: Precautionary Measures for Construction Activities in North Carolina Waters.

Table 1. Species and Critical Habitat Evaluated for Effects from the Proposed Action but not discussed further in this Biological Opinion.

SPECIES OR CRITICAL HABITAT	PRESENT IN ACTION AREA	PRESENT IN ACTION AREA BUT "NOT LIKELY TO ADVERSELY AFFECT"
West Indian manatee	Possible	Yes
Kemp's Ridley Sea Turtle	Not documented	Yes
Hawksbill Sea Turtle	Not documented	Yes

CONSULTATION HISTORY

March 14, 2012 – The U.S. Army Corps of Engineers (Corps) issued a public notice concerning the proposal from VBHI.

April 24. 2012 – A Project Review Team (PRT) meeting was held concerning the project. USFWS participated by phone.

May 14, 2012 – USFWS provided comments in response to the public notice and PRT meeting.

September 12, 2012 – a second PRT meeting was held concerning the project. USFWS participated by phone.

January 10, 2014 – the Corps issued a public notice concerning development of the DEIS and draft BA. The Corps makes a determination in the public notice that the project may affect, but is not likely to adversely affect (MA/NLTAA), the piping plover, seabeach amaranth, West Indian manatee, and loggerhead, leatherback, green, Kemp's ridley, and hawksbill sea turtles.

February 13, 2014 – the Corps issued a public notice extending the commenting period on the DEIS to March 17, 2014.

February 28, 2014 – USFWS sent a letter to the Corps indicating our nonconcurrence with the determination of MA/NLTAA, recommending that the Corps initiate formal consultation.

February 28, 2014 – USFWS sent a letter to the Corps with comments to the DEIS.

March 7, 2014 – the Corps submitted a revised BA by email and requests initiation of formal consultation. However, the appendices were not included in the submittal.

March 18, 2014 – the USFWS requested, by phone and email, that the appendices be provided.

March 20, 2014 – the Corps submitted the appendices to the BA by email.

March 24, 2014 – the USFWS sent a letter to the Corps acknowledging receipt of a complete initiation package and establishing a date for completion of consultation as July 20, 2014.

April 15, 2014 – the USFWS met with the Mayor and Assistant Manager/Shoreline Protection Manager of VBHI to talk about the project and the consultation schedule.

May 19, 2014 – VBHI's consultant submitted additional draft conservation measures by email. After an email discussion, the consultant revised the additional draft conservation measures by email on May 20, 2014.

May 22, 2014 – the USFWS sent the draft reasonable and prudent measures and terms and conditions to the Corps and the North Carolina Wildlife Resources Commission (NCWRC) for consideration and comment.

May 29, 2014 – VBHI and the Corps provided comments by email and phone to the draft reasonable and prudent measures and terms and conditions.

June 5, 2014 – the USFWS sent revised draft reasonable and prudent measures and terms and conditions to the Corps for consideration and comment.

June 9, 2014 – VBHI and the Corps provided final comments by email to the draft reasonable and prudent measures and terms and conditions.

June 17, 2014 – by email, VBHI's consultant requested changes to the proposed Term and Conditions with respect to compaction monitoring.

June 17, 2014 – the Service discussed issues with compaction monitoring with Matthew Godfrey of NC WRC, and revised the draft reasonable and prudent measure and term and condition for compaction monitoring.

Table of Contents

Acronyms

Act	Endangered Species Act
BA	Biological Assessment
BO	Biological Opinion
CAFF	Council Conservation of Arctic Flora and Fauna
CBRA	Coastal Barrier Resources Act
CFR	Code of Federal Regulations
CH	Critical Habitat
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
Corps	U.S. Army Corps of Engineers
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DOI	U.S. Department of the Interior
DTRU	Dry Tortugas Recovery Unit
F	Fahrenheit
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FEMA	Federal Emergency Management Agency
FR	Federal Register
GCRU	Greater Caribbean Recovery Unit
HCP	Habitat Conservation Plan
IPCC	Intergovernmental Panel on Climate Change
ITP	Incidental Take Permit

LF	**Linear Feet**
MHW	**Mean High Water**
MHWL	**Mean High Water Line**
MLW	**Mean Low Water**
mtDNA	**Mitochondrial Deoxyribonucleic Acid**
NCWRC	**North Carolina Wildlife Resources Commission**
NGMRU	**Northern Gulf of Mexico Recovery Unit**
NMFS	**National Marine Fisheries Service**
NOAA	**National Oceanic and Atmospheric Administration**
NRU	**Northern Recovery Unit**
NWR	**National Wildlife Refuge**
PCE	**Primary Constituent Elements**
PFRU	**Peninsular Florida Recovery Unit**
SAJ	**South Atlantic Jacksonville**
SAM	**South Atlantic Mobile**
Service	**U.S. Fish and Wildlife Service**
SNBS	**Statewide Nesting Beach Survey**
TED	**Turtle Excluder Device**
TEWG	**Turtle Expert Working Group**
U.S.C.	**United States Code**
U.S.	**United States**
USEPA	**United States Environmental Protection Agency**

BIOLOGICAL AND CONFERENCE OPINIONS

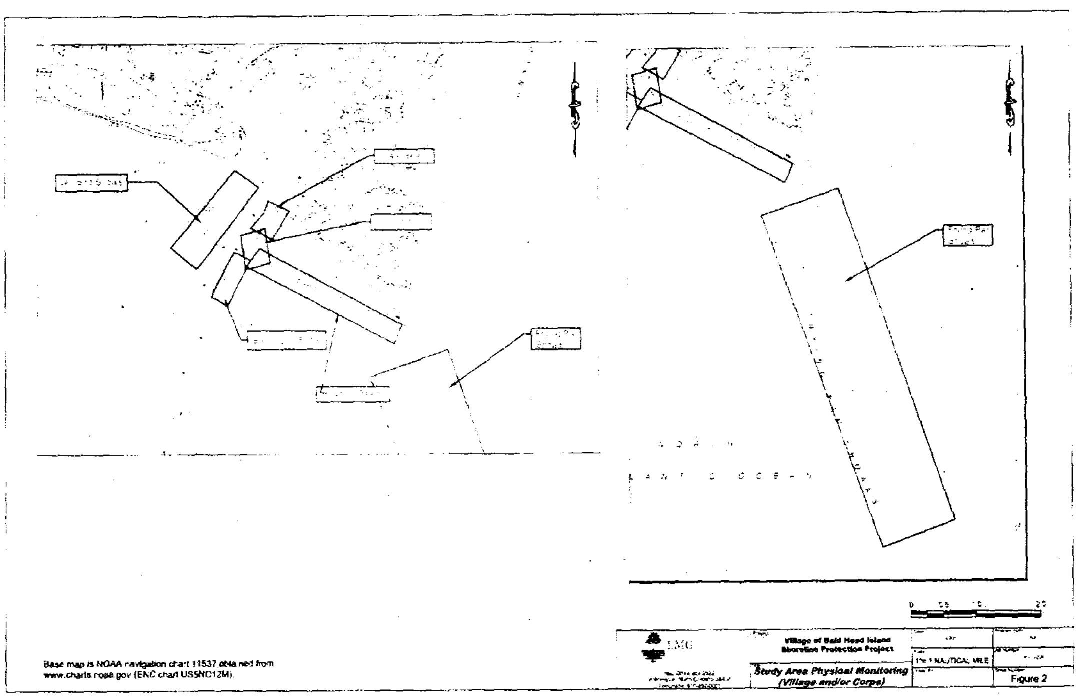
I. DESCRIPTION OF THE PROPOSED ACTION

A. Project Description

The purpose of the proposed project is to address on-going and chronic erosion at the western end of South Beach and to protect public infrastructure, roads, homes, businesses, a golf course, beaches, and other recreational assets. The BA notes that the groin is not intended to resolve erosion issues on the downdrift side. The proposed project is the preferred alternative in the January 10, 2014 DEIS (Alternative 5). The project includes the construction of a single, 1,900 linear-foot (lf) low-profile terminal groin, placement of a concurrent sand fillet, and the periodic placement of sand in the fillet from either scheduled federal disposal events (associated with the maintenance of the adjacent Wilmington Harbor Entrance Channel) and/or from Village-sponsored beach nourishment and disposal projects.

The Service has described the Action Area to include the shoreline of West Beach and South Beach and the adjacent Atlantic Ocean and Wilmington Harbor Channel on and near Bald Head Island, Brunswick County, North Carolina (**Figure 1**).

Figure 1. Action Area



(Source: LMG Group)

Land ownership within the Action Area is both public and private, and land use encompasses recreational, commercial and residential activities. Approximately 2,000 acres of Bald Head Island are developed, and the majority of the development is residential and recreational. The Action Area was relatively undeveloped until the 1980's. Since then, it has become heavily developed with homes, shops, and recreational facilities, including a golf course and a marina. In 1996, 16 sand-filled groin tubes were constructed on the westernmost portion of South Beach. The groinfield was replaced in 2005 and 2009. In the preferred alternative, sixteen sand-filled geotube groins currently located along South Beach are proposed to remain in place. The geotubes vary in length from 250 ft. to 350 ft. Each geotube is tapered and varies in height from 5.7 ft. to about 4 ft., at its seaward tip.

The permanent population of the Village of Bald Head Island rose relatively rapidly after development began in the 1980's, before leveling off at 158 in 2010. In July, 2012 the population of Bald Head Island was 162 (North Carolina Office of Budget and Management 2014). Many homes on the Island are non-permanent residences. According to the DEIS, an average of 5,000 people visit the Island on a typical summer weekend day.

B. Project Design

The groin will be constructed in two phases and will serve as a template for fill material placed eastward thereof. The design goal is to reduce inlet-directed sand loss (both short-term and long-term) and to allow for a more stable condition. Phase I involves the construction of an approximate 1,300 lf structure, concurrent with the construction of the sand fillet. The project includes approximately 12,600 lf of shoreline along portions of South Beach, and approximately 2,500 lf of shoreline is proposed to be affected by the disposal of sand. After 2 to 4 years of performance monitoring, Phase II would be constructed as needed. Phase II would extend the seaward end of the structure to complete the structure's overall design length of 1,900 lf. The project includes proposed maintenance of the 2,500 lf sand fillet at 3 years after the initial placement of sand and initiation of groin construction, and then on 9-year intervals for the life of the project (Years 12, 21, and 30 after initial sand placement).

The proposed source of the sand for the initial construction and for maintenance of the sand fillet is the Wilmington Harbor Sand Management Plan (SMP). However, sand from an alternate sand source may be necessary to ensure compliance with state law, which requires the placement and of a concurrent groin fillet. Additional potential sand source sites identified for creation and maintenance of the sand fillet for the project include 1) Jay Bird Shoals, 2) reaches of the Wilmington Harbor Channel demonstrated to contain beach-compatible material (i.e. Baldhead Shoal Channels 1 and 2, Smith Island Channel Range), 3) Bald Head Creek Shoals, and 4) Frying Pan Shoals. Future sand placement/maintenance for the groin fillet will be confined to the proposed site of the terminal groin and the shoreline area approximately 2,500 lf eastward of the groin.

According to the BA, the groin is designed as a low-crested, semi-permeable (leaky) structure, to allow sand transport to the "Point" and to West Beach. The cross-section and crest of the terminal groin would be constructed with a large void ratio, using large quarried granite stone of similar diameter. The groin will have a curvilinear orientation toward the east, but not a T-head. The offshore portion of the groin is expected to end 700 feet from the 2012 Mean Low Water (MLW) point. After construction and initial placement of the sand fillet, the location of MLW will be at or in the proximity of the groin head. No lighting is proposed on the groin. However, reflective markers may be required, particularly on the western side of the structure.

Rock-filled marine mattresses are proposed for the foundation for the most seaward portion of the groin, while a geogrid/geotextile fabric composite is proposed to be used as the foundation for the landward section of the groin. Equipment will be operated from sand work pads on the updrift side of the groin. Upland portions of the groin tieback will require excavation and backfilling of sand. Future fine-tuning of the groin structure may require the addition of, or removal of armor rock.

Federally-listed species under the purview of the Service occurring in the Action Area include the loggerhead sea turtle (*Caretta caretta*), green sea turtle (*Chelonia mydas*), leatherback sea turtle (*Dermochelys coriacea*), piping plover (*Charadrius melodus*), and seabeach amaranth (*Amaranthus pumilus*). The red knot (*Calidris canutus rufa*), which has been proposed for listing as threatened, also occurs in the Action Area. Whales, sturgeon, and sea turtles in the water are the jurisdiction of NMFS.

The Action Area includes approximately 12,600 linear feet of beach and inlet shoreline on Bald Head Island, from approximately Station 46+00 to station 152+00. The Action Area for direct impacts includes those sections of Bald Head Island where terminal groin construction, sediment disposal, and earthen manipulation will occur. The Action Area for indirect impacts, however, is much larger. Because sea turtles and piping plovers are highly mobile species, animals influenced by direct project impacts may move great distances from the actual project site. The range of these movements produced by the project constitute the Action Area for indirect impacts; for the purposes of this opinion it will be the entire length of South and West Beach for piping plovers, red knots, and sea turtles. The Action Area for seabeach amaranth is the area within the proposed project footprint.

C. Project Timing and Duration

The Applicant intends to complete construction of Phase 1 after updrift disposal has been completed by the Corps on South Beach. The Applicant proposes to take advantage of the federal sand disposal project by using a sand work pad to construct the groin, rather than a construction trestle. Based upon timing of past federal beach disposal events on Bald Head Island, the 2015 federal beach disposal is anticipated to be completed in April. The Applicant predicts that the majority of the groin construction activities will be conducted between May and September, 2015, well into the sea turtle and shorebird nesting seasons. If additional sand is needed from an alternate source to complete the sand fillet (as discussed above), the Applicant intends to delay the placement of additional sand until after November 1. However, sand placement may also occur during the sea turtle and shorebird nesting seasons.

D. Conservation Measures

To reduce the potential impacts of the proposed project on Federally-listed species, the Applicant has proposed the following Conservation Measures:

Conservation Measures – Loggerhead, Leatherback, and Green Sea Turtles

1. Only beach quality sand suitable for sea turtle nesting, successful incubation, and hatchling emergence shall be used for beach nourishment at the project site. Furthermore, sand of similar grain size and composition to that of the existing beach will be used to reduce any changes in physical characteristics of the beach that may affect nest survival. This material will meet the Technical Standards for Beach Fill Projects as published in the North Carolina Administrative Code (15A NCAC 07H .0312).

2. The Village of Bald Head Island will ensure that contractors performing the beach nourishment and dredging work fully understand sea turtle protection measures.

3. Intensive sea turtle nest monitoring will be performed by qualified personnel of the Bald Head Island Conservancy (Conservancy) within and immediately adjacent to the Project Area (including western South Beach and the Point). The monitoring will be performed throughout the portion of the construction time period occurring between May 1 and November 30 and will include the following elements:
   a. Monitoring within the work areas will be performed at night in a regular, routine fashion by qualified sea turtle monitoring personnel;
   b. Any nesting sea turtle encountered by Conservancy personnel will be tagged per standard operating procedures for the organization's Sea Turtle Protection Program

as permitted by the NCWRC. BHI Conservancy will relocate all nests in the Project Area to eastern South Beach or to East Beach within two to three hours of nesting. Note that it is likely that these nests would have been relocated regardless of the project's timeline because of severe erosion in this area. These nests will be relocated to more stable, suitable nesting habitat located further east to ensure that no sea turtle nests are impacted from construction activities;

c. For any nests that have not been relocated, monitoring for emerging nests or hatchlings shall be conducted prior to initiating work and regularly thereafter;
d. If nest or hatchlings are within an area obstructed by equipment or nourishment activities, hatchlings will be transported by qualified Conservancy personnel to an area outside of the work boundaries. The hatchlings will be released at least 15 feet above the current water line and allowed to crawl into the ocean.

4. Channel maintenance and beach disposal associated with the federal Sand Management Plan (SMP) are planned to be completed by April 30th.

5. Immediately after completion of this project and prior to May 1 for three subsequent years, sand compaction will be monitored in the area of restoration in accordance with a protocol agreed to by the Service, the State regulatory agency, and Bald Head Island. If required, the area will be tilled to a depth of 36 inches. All tilling activity shall be completed prior to May 1. A report on the results of compaction monitoring will be submitted to the Service prior to any tilling actions being taken. An annual summary of compaction assessments and the actions taken will be submitted to the Service. This condition will be evaluated annually and may be modified if necessary to address sand compaction problems identified during the previous year.

6. Visual surveys for escarpments along the Project Area shall be made immediately after completion of the beach nourishment project and prior to May 1 for three subsequent years. Results of the surveys will be submitted to the Service prior to any action being taken. Escarpments that interfere with sea turtle nesting or that exceed 18 inches in height for a distance of 100 feet will be leveled to the natural beach contour by May 1. The Service will be contacted immediately if subsequent reformation of escarpments that interfere with sea turtle nesting or that exceed 18 inches in height for a distance of 100 feet occurs during the nesting and hatching season to determine the appropriate action to be taken. If it is determined that escarpment leveling is required during the nesting or hatching season, the Service will provide a brief written authorization that describes methods to be used to reduce the likelihood of impacting existing nests. An annual summary of escarpment surveys and actions taken will be submitted to the Service.

7. Staging areas for construction equipment will be located primarily on the northern and western riverfront shorelines (and not on South Beach). All construction materials that are placed on the beach will be located as far landward as possible without compromising the integrity of the dune system. Temporary storage of construction materials on the beach will be in such a manner so as not to compromise the integrity of the dune systems.

8. To the maximum extent practicable, all excavations and temporary alteration of beach topography resulting from groin construction will be filled or leveled to the natural beach profile prior to dusk each day. During any periods when excavated trenches must remain on the beach at night above MHW, a barrier (e.g., hay bales, silt fencing) sufficient to prevent adult and hatchling sea turtles from accessing excavated trenches, etc., would be placed around the footprint of each groin segment.

9. The Applicant will seek to perform any dredging associated with the terminal groin fillet construction or maintenance, outside of the sea turtle moratorium – unless necessitated by an emergency condition.

10. The Applicant will limit all terminal groin construction activities to daylight hours only.

11. The Contractor will not utilize beach or structure lighting within the May 1 through November 30 timeframe except as may be required by the USCG for purposes of ensuring public safety.

Conservation Measures - Piping Plover and Red Knot

1. All construction equipment would be prohibited from entering upland beaches associated with the Cape Fear spit feature as well as East Beach. Additionally, a specific construction corridor for the terminal groin would be established. These actions would provide readily available substitute habitat areas for any birds displaced by construction activities.

2. To reduce changes in physical characteristics of the beach that may affect nourishment impacts on invertebrates, sand of similar grain size to the existing beach will be used.

3. Although the direct footprint of the terminal groin may result in a permanent loss of foraging habitat, beach nourishment and groin construction would occur within highly eroded areas and would ultimately increase foraging habitat within the Project Area.

Conservation Measures - Seabeach Amaranth

1. Beach disposal associated with the federal SMP would take place after November 15th, after amaranth plants have already released seeds.

Conservation Measures - West Indian Manatee

1. Proposed excavation work would be performed with a cutter suction dredge with sand pumped by submerged pipeline to the western end of Bald Head Island.

2. Groin construction would be spatially constrained to reduce the possibility of a collision.

3. The majority of the dredging would occur during fall and winter months when populations of manatees are lower.

4. The contractor will follow the Service's Guidelines for Avoiding Impacts to the West Indian Manatee: Precautionary Measures for Construction Activities in North Carolina Waters.

II. LOGGERHEAD, GREEN, AND LEATHERBACK SEA TURTLES

A. Status of the Species/Critical Habitat

1) Species/critical habitat description

Species/critical habitat description – Loggerhead Sea Turtle

The loggerhead sea turtle, which occurs throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans, was federally listed worldwide as a threatened species on July 28, 1978 (43 Federal Register (FR) 32800). On September 22, 2011, the loggerhead sea turtle's listing under the Act was revised from a single threatened species to nine distinct population segments (DPS) listed as either threatened or endangered. The nine DPSs and their statuses are:

Northwest Atlantic Ocean DPS – threatened
Northeast Atlantic Ocean – endangered
Mediterranean Sea DPS – endangered
South Atlantic Ocean DPS – threatened

North Pacific Ocean DPS – endangered
South Pacific Ocean DPS – endangered
North Indian Ocean DPS – endangered
Southwest Indian Ocean – threatened
Southeast Indo-Pacific Ocean DPS – threatened

The loggerhead sea turtle grows to an average weight of about 200 pounds and is characterized by a large head with blunt jaws. Adults and subadults have a reddish-brown carapace. Scales on the top of the head and top of the flippers are also reddish-brown with yellow on the borders. Hatchlings are a dull brown color (National Marine Fisheries Service (NMFS) 2009a). The loggerhead feeds on mollusks, crustaceans, fish, and other marine animals.

The loggerhead may be found hundreds of miles out to sea, as well as in inshore areas such as bays, lagoons, salt marshes, creeks, ship channels, and the mouths of large rivers. Coral reefs, rocky places, and ship wrecks are often used as feeding areas. Within the Northwest Atlantic, the majority of nesting activity occurs from April through September, with a peak in June and July (Williams-Walls et al. 1983; Dodd 1988; Weishampel et al. 2006). Nesting occurs within the Northwest Atlantic along the coasts of North America, Central America, northern South America, the Antilles, Bahamas, and Bermuda, but is concentrated in the southeastern United States and on the Yucatán Peninsula in Mexico on open beaches or along narrow bays having suitable sand (Sternberg 1981; Ehrhart 1989; Ehrhart et al. 2003; NMFS and Service 2008).

The Service is proposing to designate portions North Carolina beaches as critical habitat for the Northwest Atlantic (NWA) population of loggerhead sea turtles. Bald Head Island is located within Critical Habitat Unit LOGG-T-NC-06 (Baldhead Island, Brunswick County). From the Federal Register (FR) Notice (see http://www.regulations.gov/#!documentDetail;D=FWS-R4-ES-2012-0103-0001), this unit consists of 15.1 km (9.4 miles) of island shoreline along the Atlantic Ocean. The island is part of the Smith Island Complex, which is a barrier spit that includes Bald Head, Middle, and Bluff Islands. The island is separated from the mainland by the Atlantic Intracoastal Waterway, Cape Fear River, Battery Island Channel, Lower Swash Channel Range, Buzzard Bay, Smith Island Range, Southport Channel, and salt marsh. The unit extends from 33.91433 N, 77.94408 W (historic location of Corncake Inlet) to the mouth of the Cape Fear River. The unit includes lands from the MHW line to the toe of the secondary dune or developed structures.

In total, 1,189.9 kilometers (km) (739.3 miles) of loggerhead sea turtle nesting beaches are being proposed for designation as critical habitat in the States of North Carolina, South Carolina, Georgia, Florida, Alabama, and Mississippi. These beaches account for 48 percent of an estimated 2,464 km (1,531 miles) of coastal beach shoreline, and account for approximately 84 percent of the documented nesting (numbers of nests) within these six States. The proposed critical habitat has been identified by the recovery unit in which they are located. Recovery units are management subunits of a listed entity that are geographically or otherwise identifiable and essential to the recovery of the listed entity. Within the United States, four recovery units have been identified for the Northwest Atlantic population of the loggerhead sea turtle. The four recovery units for which we propose to designate terrestrial critical habitat are the Northern Recovery Unit (NRU), Peninsular Florida Recovery Unit (PFRU), Dry Tortugas Recovery Unit (DTRU), and Northern Gulf of Mexico Recovery Unit (NGMRU). For the NRU, the Service proposes to designate 393.7 km (244.7 miles) of Atlantic Ocean shoreline in North Carolina, South Carolina, and Georgia, encompassing approximately 86 percent of the documented nesting (numbers of nests) within the recovery unit.

Under the Act and its implementing regulations, the Service is required to identify the physical or biological features essential to the conservation of the loggerhead sea turtle in areas occupied at the time of listing, focusing on the features' primary constituent elements (PCEs). The Service considers PCEs to be those specific elements of the physical or biological features that provide for a species' life-history processes and are essential to the conservation of the species. Based on our current knowledge of the physical or biological features and habitat characteristics required to sustain the species' life-history processes, the Service has proposed that the terrestrial primary constituent elements specific to the Northwest Atlantic Ocean DPS of the loggerhead sea turtle are:

(1) Primary Constituent Element 1— Suitable nesting beach habitat that has (a) relatively unimpeded nearshore access from the ocean to the beach for nesting females and from the beach to the ocean for both post-nesting females and hatchlings and (b) is located above mean high water to avoid being inundated frequently by high tides.

(2) Primary Constituent Element 2— Sand that (a) allows for suitable nest construction, (b) is suitable for facilitating gas diffusion conducive to embryo development, and (c) is able to develop and maintain temperatures and a moisture content conducive to embryo development.

(3) Primary Constituent Element 3— Suitable nesting beach habitat with sufficient darkness to ensure nesting turtles are not deterred from emerging onto the beach and hatchlings and post-nesting females orient to the sea.

Species/critical habitat description - Green Sea Turtle

The green sea turtle was federally listed on July 28, 1978 (43 FR 32800). Breeding populations of the green turtle in Florida and along the Pacific Coast of Mexico are listed as endangered; all other populations are listed as threatened. The green sea turtle has a worldwide distribution in tropical and subtropical waters.

The green sea turtle grows to a maximum size of about 4 feet and a weight of 440 pounds. It has a heart-shaped shell, small head, and single-clawed flippers. The carapace is smooth and colored gray, green, brown, and black. Hatchlings are black on top and white on the bottom (NMFS 2009b). Hatchling green turtles eat a variety of plants and animals, but adults feed almost exclusively on seagrasses and marine algae.

Major green turtle nesting colonies in the Atlantic occur on Ascension Island, Aves Island, Costa Rica, and Surinam. Within the U.S., green turtles nest in small numbers in the U.S. Virgin Islands and Puerto Rico, and in larger numbers along the east coast of Florida, particularly in Brevard, Indian River, St. Lucie, Martin, Palm Beach, and Broward Counties (NMFS and Service 1991). Nests have been documented, in smaller numbers, north of these Counties, from Volusia through Nassau Counties in Florida, as well as in Georgia, South Carolina, North Carolina, and as far north as Delaware in 2011. Nests have been documented in smaller numbers south of Broward County in Miami-Dade. Nesting also has been documented along the Gulf coast of Florida from Escambia County through Franklin County in northwest Florida and from Pinellas County through Monroe County in southwest Florida (FWC/FWRI 2010b).

Green sea turtles are generally found in fairly shallow waters (except when migrating) inside reefs, bays, and inlets. The green turtle is attracted to lagoons and shoals with an abundance of marine grass and algae. Open beaches with a sloping platform and minimal disturbance are required for nesting.

Critical habitat for the green sea turtle has been designated for the waters surrounding Culebra Island, Puerto Rico, and its outlying keys. No designated critical habitat is present in the Action Area.

Species/critical habitat description - Leatherback Sea Turtle

The leatherback sea turtle was federally listed as an endangered species on June 2, 1970 (35 FR 8491). Leatherbacks have the widest distribution of the sea turtles with nonbreeding animals recorded as far north as the British Isles and the Maritime Provinces of Canada and as far south as Argentina and the Cape of Good Hope (Pritchard 1992). Foraging leatherback excursions have been documented into higher-latitude subpolar waters. They have evolved physiological and anatomical adaptations (Frair et al. 1972; Greer et al. 1973) that allow them to exploit waters far colder than any other sea turtle species would be capable of surviving.

The adult leatherback can reach 4 to 8 feet in length and weigh 500 to 2,000 pounds. The carapace is distinguished by a rubber-like texture, about 1.6 inches thick, made primarily of tough, oil-saturated connective tissue. Hatchlings are dorsally mostly black and are covered with tiny scales; the flippers are edged in white, and rows of white scales appear as stripes along the length of the back (NMFS 2009c). Jellyfish are the main staple of its diet, but it is also known to feed on sea urchins, squid, crustaceans, tunicates, fish, blue-green algae, and floating seaweed. This is the largest, deepest diving of all sea turtle species.

Leatherback turtle nesting grounds are distributed worldwide in the Atlantic, Pacific, and Indian Oceans on beaches in the tropics and subtropics. The Pacific Coast of Mexico historically supported the world's largest known concentration of nesting leatherbacks. The leatherback turtle regularly nests in the U.S. Caribbean in Puerto Rico and the U.S. Virgin Islands. Along the U.S. Atlantic coast, most nesting occurs in Florida (NMFS and Service 1992). Nesting has also been reported in Georgia, South Carolina, and North Carolina (Rabon et al. 2003) and in Texas (Shaver 2008). Adult females require sandy nesting beaches backed with vegetation and sloped sufficiently so the distance to dry sand is limited. Their preferred beaches have proximity to deep water and generally rough seas.

Marine and terrestrial critical habitat for the leatherback sea turtle has been designated at Sandy Point on the western end of the island of St. Croix, U.S. Virgin Islands (50 Code of Federal Regulations (CFR) 17.95). There is no designated critical habitat in North Carolina.

2) Life history

Life History – Loggerhead Sea Turtle

Loggerheads are long-lived, slow-growing animals that use multiple habitats across entire ocean basins throughout their life history. This complex life history encompasses terrestrial, nearshore, and open ocean habitats. The three basic ecosystems in which loggerheads live are the:

1. Terrestrial zone (supralittoral) - the nesting beach where both oviposition (egg laying) and embryonic development and hatching occur.

2. Neritic zone - the inshore marine environment (from the surface to the sea floor) where water depths do not exceed 656 feet. The neritic zone generally includes the continental shelf, but in areas where the continental shelf is very narrow or nonexistent, the neritic zone conventionally extends to areas where water depths are less than 656 feet.

3. Oceanic zone - the vast open ocean environment (from the surface to the sea floor) where water depths are greater than 656 feet.

Maximum intrinsic growth rates of sea turtles are limited by the extremely long duration of the juvenile stage and fecundity. Loggerheads require high survival rates in the juvenile and adult stages, common constraints critical to maintaining long-lived, slow-growing species, to achieve positive or stable long-term population growth (Congdon et al. 1993; Heppell 1998; Crouse 1999; Heppell et al. 1999; 2003; Musick 1999).

Numbers of nests and nesting females are often highly variable from year to year due to a number of factors including environmental stochasticity, periodicity in ocean conditions, anthropogenic effects, and density-dependent and density-independent factors affecting survival, somatic growth, and reproduction (Meylan 1982; Hays 2000; Chaloupka 2001; Solow et al. 2002). Despite these sources of variation, and because female turtles exhibit strong nest site fidelity, a nesting beach survey can provide a valuable assessment of changes in the adult female population, provided that the study is sufficiently long and effort and methods are standardized (Meylan 1982; Gerrodette and Brandon 2000; Reina et al. 2002). **Table 2** summarizes key life history characteristics for loggerheads nesting in the U.S.

Loggerheads nest on ocean beaches and occasionally on estuarine shorelines with suitable sand. Nests are typically laid between the high tide line and the dune front (Routa 1968; Witherington 1986; Hailman and Elowson 1992). Wood and Bjorndal (2000) evaluated four environmental factors (slope, temperature, moisture, and salinity) and found that slope had the greatest influence on loggerhead nest-site selection on a beach in Florida. Loggerheads appear to prefer relatively narrow, steeply sloped, coarse-grained beaches, although nearshore contours may also play a role in nesting beach site selection (Provancha and Ehrhart 1987).

The warmer the sand surrounding the egg chamber, the faster the embryos develop (Mrosovsky and Yntema 1980). Sand temperatures prevailing during the middle third of the incubation period also determine the sex of hatchling sea turtles (Mrosovsky and Yntema 1980). Incubation temperatures near the upper end of the tolerable range produce only female hatchlings while incubation temperatures near the lower end of the tolerable range produce only male hatchlings.

Table 2. Typical values of life history parameters for loggerheads nesting in the U.S. (NMFS and Service 2008).

Life History Trait	**Data**
Clutch size (mean)	100-126 eggs[1]
Incubation duration (varies depending on time of year and latitude)	Range = 42-75 days[2,3]
Pivotal temperature (incubation temperature that produces an equal number of males and females)	84°F[5]
Nest productivity (emerged hatchlings/total eggs) x 100 (varies depending on site specific factors)	45-70 percent[2,6]
Clutch frequency (number of nests/female/season)	3-4 nests[7]
Internesting interval (number of days between successive nests within a season)	12-15 days[8]
Juvenile (<34 inches Curved Carapace Length) sex ratio	65-70 percent female[4]
Remigration interval (number of years between successive nesting migrations)	2.5-3.7 years[9]
Nesting season	late April-early September
Hatching season	late June-early November
Age at sexual maturity	32-35 years[10]
Life span	>57 years[11]

1 Dodd (1988).
2 Dodd and Mackinnon (1999, 2000, 2001, 2002, 2003, 2004).
3 Witherington (2006) (information based on nests monitored throughout Florida beaches in 2005, n = 865).
4 NMFS (2001); Foley (2005).
5 Mrosovsky (1988).
6 Witherington (2006) (information based on nests monitored throughout Florida beaches in 2005, n = 1,680).
7 Murphy and Hopkins (1984); Frazer and Richardson (1985); Hawkes et al. 2005; Scott 2006.
8 Caldwell (1962), Dodd (1988).
9 Richardson et al. (1978); Bjorndal et al. (1983).
10 Snover (2005).
11 Dahlen et al. (2000).

Loggerhead hatchlings pip and escape from their eggs over a 1- to 3-day interval and move upward and out of the nest over a 2- to 4-day interval (Christens 1990). The time from pipping to emergence ranges from 4 to 7 days with an average of 4.1 days (Godfrey and Mrosovsky 1997). Hatchlings emerge from their nests en masse almost exclusively at night, and presumably using decreasing sand temperature as a cue (Hendrickson 1958; Mrosovsky 1968; Witherington et al. 1990). Moran et al. (1999) concluded that a lowering of sand temperatures below a critical threshold, which most typically occurs after nightfall, is the most probable trigger for hatchling emergence from a nest. After an initial emergence, there may be secondary emergences on subsequent nights (Carr and Ogren 1960; Witherington 1986; Ernest and Martin 1993; Houghton and Hays 2001).

Hatchlings use a progression of orientation cues to guide their movement from the nest to the marine environments where they spend their early years (Lohmann and Lohmann 2003). Hatchlings first use light cues to find the ocean. On naturally lighted beaches without artificial lighting, ambient light from the open sky creates a relatively bright horizon compared to the dark silhouette of the dune and vegetation landward of the nest. This contrast guides the hatchlings to the ocean (Daniel and Smith 1947; Limpus 1971; Salmon et al. 1992; Witherington and Martin 1996; Witherington 1997; Stewart and Wyneken 2004).

Life history - Green Sea Turtle

Green sea turtles deposit from one to nine clutches within a nesting season, but the overall average is about 3.3 nests. The interval between nesting events within a season varies around a mean of about 13 days (Hirth 1997). Mean clutch size varies widely among populations. Clutch size varies from 75 to 200 eggs with incubation requiring 48 to 70 days, depending on incubation temperatures. Only occasionally do females produce clutches in successive years. Usually two or more years intervene between breeding seasons (NMFS and Service 1991). Age at sexual maturity is believed to be 20 to 50 years (Hirth 1997).

Life History – Leatherback Sea Turtle

Leatherbacks nest an average of five to seven times within a nesting season, with an observed maximum of 11 nests (NMFS and Service 1992). The interval between nesting events within a season is about 9 to 10 days. Clutch size averages 80 to 85 yolked eggs, with the addition of usually a few dozen smaller, yolkless eggs, mostly laid toward the end of the clutch (Pritchard 1992). Nesting migration intervals of 2 to 3 years were observed in leatherbacks nesting on the Sandy Point National Wildlife Refuge, St. Croix, U.S. Virgin Islands (McDonald and Dutton 1996). Leatherbacks are believed to reach sexual maturity in 13 to 16 years (Dutton et al. 2005; Jones et al. 2011).

3) Population dynamics

Population Dynamics – Loggerhead Sea Turtle

The loggerhead occurs throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans (Dodd 1988). However, the majority of loggerhead nesting is at the western rims of the Atlantic and Indian Oceans. The most recent reviews show that only two loggerhead nesting beaches have greater than 10,000 females nesting per year (Baldwin et al. 2003; Ehrhart et al. 2003; Kamezaki et al. 2003; Limpus and Limpus 2003; Margaritoulis et al. 2003): Peninsular Florida (U.S.) and Masirah (Oman). Those beaches with 1,000 to 9,999 females nesting each year are Georgia through North Carolina (U.S.), Quintana Roo and Yucatán (Mexico), Cape Verde Islands (Cape Verde, eastern Atlantic off Africa), and Western Australia (Australia).

The major nesting concentrations in the U.S. are found in South Florida. However, loggerheads nest from Texas to Virginia. Since 2000, the annual number of loggerhead nests in NC has fluctuated between 333 in 2004 to 1,260 in 2013 (Godfrey, unpublished data). Total estimated nesting in the U.S. has fluctuated between 49,000 and 90,000 nests per year from 1999-2010 (NMFS and Service 2008; FWC/FWRI 2010a). Adult loggerheads are known to make considerable migrations between foraging areas and nesting beaches (Schroeder et al. 2003; Foley et al. 2008). During non-nesting years, adult females from U.S. beaches are distributed in waters off the eastern U.S. and throughout the Gulf of Mexico, Bahamas, Greater Antilles, and Yucatán.

From a global perspective, the U.S. nesting aggregation is of paramount importance to the survival of the species, as is the population that nests on islands in the Arabian Sea off Oman (Ross 1982; Ehrhart 1989; Baldwin et al. 2003).

Population dynamics - Green Sea Turtle

There are an estimated 150,000 females that nest each year in 46 sites throughout the world (NMFS and Service 2007a). In the U.S. Atlantic, the majority of nesting occurs in Florida, where about 100 to 1,000 females are estimated to nest annually (FWC 2009c). In North Carolina, between 4 and 44 green sea turtle nests are laid annually (Godfrey, unpublished data). In the U.S. Pacific, over 90 percent of nesting throughout the Hawaiian archipelago occurs at the French Frigate Shoals, where about 200 to 700 females nest each year (NMFS and Service 1998a). Elsewhere in the U.S. Pacific, nesting takes place at scattered locations in the Commonwealth of the Northern Marianas, Guam, and American Samoa. In the western Pacific, the largest green turtle nesting aggregation in the world occurs on Raine Island, Australia, where thousands of females nest nightly in an average nesting season (Limpus et al. 1993). In the Indian Ocean, major nesting beaches occur in Oman where 30,000 females are reported to nest annually (Ross and Barwani 1995).

Population dynamics – Leatherback Sea Turtle

A dramatic drop in nesting numbers has been recorded on major nesting beaches in the Pacific. Spotila et al. (2000) have highlighted the dramatic decline and possible extirpation of leatherbacks in the Pacific.

The East Pacific and Malaysia leatherback populations have collapsed. Spotila et al. (1996) estimated that only 34,500 females nested annually worldwide in 1995, which is a dramatic decline from the 115,000 estimated in 1980 (Pritchard 1982). In the eastern Pacific, the major nesting beaches occur in Costa Rica and Mexico. At Playa Grande, Costa Rica, considered the most important nesting beach in the eastern Pacific, numbers have dropped from 1,367 leatherbacks in 1988-1989 to an average of 188 females nesting between 2000-2001 and 2003-2004. In Pacific Mexico, 1982 aerial surveys of adult female leatherbacks indicated this area had become the most important leatherback nesting beach in the world. Tens of thousands of nests were laid on the beaches in 1980s, but during the 2003-2004 seasons a total of 120 nests were recorded. In the western Pacific, the major nesting beaches lie in Papua New Guinea, Papua, Indonesia, and the Solomon Islands. These are some of the last remaining significant nesting assemblages in the Pacific. Compiled nesting data estimated approximately 5,000 to 9,200 nests annually with 75 percent of the nests being laid in Papua, Indonesia.

However, the most recent population size estimate for the North Atlantic alone is a range of 34,000 to 94,000 adult leatherbacks (TEWG 2007). During recent years in Florida, the total number of leatherback nests counted as part of the SNBS program ranged from 540 to 1,797 from 2006-2010 (FWC/FWRI 2010a). Assuming a clutch frequency (number of nests/female/season) of 4.2 in Florida (Stewart 2007), these nests were produced by a range of 128 to 428 females in a given year.

Nesting in the Southern Caribbean occurs in the Guianas (Guyana, Suriname, and French Guiana), Trinidad, Dominica, and Venezuela. The largest nesting populations at present occur in the western Atlantic in French Guiana with nesting varying between a low of 5,029 nests in 1967 to a high of 63,294 nests in 2005, which represents a 92 percent increase since 1967 (TEWG 2007). Trinidad supports an estimated 6,000 leatherbacks nesting annually, which represents more than 80 percent of the nesting in the insular Caribbean Sea. Leatherback nesting along the Caribbean Central American coast takes place between Honduras and Colombia. In Atlantic Costa Rica, at Tortuguero, the number of nests laid annually between 1995 and 2006 was estimated to range from 199 to 1,623. Modeling of the Atlantic Costa Rica data indicated that the nesting population has decreased by 67.8 percent over this time period.

In Puerto Rico, the main nesting areas are at Fajardo (Northeast Ecological Corridor) and Maunabo on the main island of Puerto Rico and on the islands of Culebra and Vieques. Between 1993 and 2010, the number of nests in the Fajardo area ranged from 51 to 456. In the Maunabo area, the number of nests recorded between 2001 and 2010 ranged from a low of 53 in 2002 to a high of 260 in 2009 (Diez 2011). On the island of Culebra, the number of nests ranged from a low 41 in 1996 to a high of 395 in 1997 (Diez 2011). On beaches managed by the Commonwealth of Puerto Rico on the island of Vieques, the Puerto Rico Department of Natural and Environmental Resources recorded annually 14-61 leatherback nests between 1991 and 2000; 145 nests in 2002; 24 in 2003; and 37 in 2005 (Diez 2011). The number of leatherback sea turtle nests recorded on Vieques Island beaches managed by the Service ranged between 13 and 163 during 2001-2010. Using the numbers of nests recorded in Puerto Rico between 1984 and 2005, the Turtle Expert Working Group (2007) estimated a population growth of approximately 10 percent per year. Recorded leatherback nesting on the Sandy Point National Wildlife Refuge on the island of St. Croix, U.S. Virgin Islands, between 1982 and 2010, ranged from a low of 82 in 1986 to a high of 1,008 in 2001 (Garner and Garner 2010). Using the number of observed females at Sandy Point from 1986 to 2004, the Turtle Expert Working Group (2007) estimated a population growth of approximately 10 percent per year. In the British Virgin Islands, annual nest numbers have increased in Tortola from zero to six nests per year in the late 1980s to 35 to 65 nests per year in the 2000s (TEWG 2007).

The most important nesting beach for leatherbacks in the eastern Atlantic lies in Gabon, Africa. It was estimated there were 30,000 nests along 60 miles of Mayumba Beach in southern Gabon during the 1999-2000 nesting season (Billes et al. 2000). Some nesting has been reported in Mauritania, Senegal, the Bijagos Archipelago of Guinea-Bissau, Turtle Islands and Sherbro Island of Sierra Leone, Liberia, Togo, Benin, Nigeria, Cameroon, Sao Tome and Principe, continental Equatorial Guinea, Islands of Corisco in the Gulf of Guinea and the Democratic Republic of the Congo, and Angola. In addition, a large nesting population is found on the island of Bioko (Equatorial Guinea) (Fretey et al. 2007). In North Carolina between the year 2000 and 2013, as many as 9 nests were laid per year (Godfrey, unpublished data).

4) Status and distribution

Status and Distribution – All Sea Turtles

Reason for Listing: There are many threats to sea turtles, including nest destruction from natural events, such as tidal surges and hurricanes, or eggs lost to predation by raccoons, foxes, ghost-crabs, and other animals. However, human activity has significantly contributed to the decline of sea turtle populations along the Atlantic Coast and in the Gulf of Mexico (NRC 1990). These factors include the modification, degradation, or loss of nesting habitat by coastal development, artificial lighting, beach driving, and marine pollution and debris. Furthermore, the overharvest of eggs for food, intentional killing of adults and immature turtles for their shells and skin, and accidental drowning in commercial fishing gear are primarily responsible for the worldwide decline in sea turtle populations.

Status and Distribution – Loggerhead Sea Turtle

Range-wide Trend: Five recovery units have been identified in the Northwest Atlantic based on genetic differences and a combination of geographic distribution of nesting densities, geographic separation, and geopolitical boundaries (NMFS and Service 2008). Recovery units are subunits of a listed species that are geographically or otherwise identifiable and essential to the recovery of the species. Recovery units are individually necessary to conserve genetic robustness, demographic robustness, important life history stages, or some other feature necessary for long-term sustainability of the species. The five recovery units identified in the Northwest Atlantic are:

1. Northern Recovery Unit (NRU) - defined as loggerheads originating from nesting beaches from the Florida-Georgia border through southern Virginia (the northern extent of the nesting range);

2. Peninsula Florida Recovery Unit (PFRU) - defined as loggerheads originating from nesting beaches from the Florida-Georgia border through Pinellas County on the west coast of Florida, excluding the islands west of Key West, Florida;

3. Dry Tortugas Recovery Unit (DTRU) - defined as loggerheads originating from nesting beaches throughout the islands located west of Key West, Florida;

4. Northern Gulf of Mexico Recovery Unit (NGMRU) - defined as loggerheads originating from nesting beaches from Franklin County on the northwest Gulf coast of Florida through Texas; and

5. Greater Caribbean Recovery Unit (GCRU) - composed of loggerheads originating from all other nesting assemblages within the Greater Caribbean (Mexico through French Guiana, The Bahamas, Lesser Antilles, and Greater Antilles).

The mtDNA analyses show that there is limited exchange of females among these recovery units (Ehrhart 1989; Foote et al. 2000; NMFS 2001; Hawkes et al. 2005). Male-mediated gene flow appears to be keeping the subpopulations genetically similar on a nuclear DNA level (Francisco-Pearce 2001).

Historically, the literature has suggested that the northern U.S. nesting beaches (NRU and NGMRU) produce a relatively high percentage of males and the more southern nesting beaches (PFRU, DTRU, and GCRU) a relatively high percentage of females (e.g., Hanson et al. 1998; NMFS 2001; Mrosovsky and Provancha 1989). The NRU and NGMRU were believed to play an important role in providing males to mate with females from the more female-dominated subpopulations to the south. However, in 2002 and 2003, researchers studied loggerhead sex ratios for two of the U.S. nesting subpopulations, the northern and southern subpopulations (NGU and PFRU, respectively) (Blair 2005; Wyneken et al. 2005). The study produced interesting results. In 2002, the northern beaches produced more females and the southern beaches produced more males than previously believed. However, the opposite was true in 2003 with the northern beaches producing more males and the southern beaches producing more females in keeping with prior literature. Wyneken et al. (2005) speculated that the 2002 result may have been anomalous; however, the study did point out the potential for males to be produced on the southern beaches. Although this study revealed that more males may be produced on southern recovery unit beaches than previously believed, the Service maintains that the NRU and NGMRU play an important role in the production of males to mate with females from the more southern recovery units.

The NRU is the second largest loggerhead recovery unit within the Northwest Atlantic Ocean DPS. Annual nest totals from northern beaches averaged 5446 nests from 2006 to 2011, a period of near-complete surveys of NRU nesting beaches, representing approximately 1,328 nesting females per year (4.1 nests per female, Murphy and Hopkins 1984) (NMFS and Service 2008). In 2008, nesting in Georgia reached what was a new record at that time (1,646 nests), with a downturn in 2009, followed by yet another record in 2011 (1,987 nests). South Carolina had the two highest years of nesting in the 2000s in 2009 (2,183 nests) and 2010 (3,141 nests). The previous high for that 11-year span was 1,433 nests in 2003. North Carolina had 947 nests in 2011, which is above the average of 765. The Georgia, South Carolina, and North Carolina nesting data come from the seaturtle.org Sea Turtle Nest Monitoring System, which is populated with data input by the State agencies. The loggerhead nesting trend from daily beach surveys was declining significantly at 1.3 percent annually from 1983 to 2007 (NMFS and USFWS, 2008). Overall, there is strong statistical data to suggest the NRU has experienced a long-term decline (NMFS and Service 2008). Currently, however, nesting for the NRU is showing possible signs of stabilizing (76 FR 58868, September 22, 2011).

Recovery Criteria (only the Demographic Recovery Criteria are presented below; for the Listing Factor Recovery Criteria, see NMFS and Service 2008)

1. Number of Nests and Number of Nesting Females
   a. Northern Recovery Unit
      i. There is statistical confidence (95 percent) that the annual rate of increase over a generation time of 50 years is 2 percent or greater resulting in a total annual number of nests of 14,000 or greater for this recovery unit (approximate distribution of nests is North Carolina =14 percent [2,000 nests], South Carolina =66 percent [9,200 nests], and Georgia =20 percent [2,800 nests]); and
      ii. This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

   b. Peninsular Florida Recovery Unit
      i. There is statistical confidence (95 percent) that the annual rate of increase over a generation time of 50 years is statistically detectable (one percent) resulting in a total annual number of nests of 106,100 or greater for this recovery unit; and
      ii. This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

   c. Dry Tortugas Recovery Unit
      i. There is statistical confidence (95 percent) that the annual rate of increase over a generation time of 50 years is three percent or greater resulting in a total annual number of nests of 1,100 or greater for this recovery unit; and
      ii. This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

   d. Northern Gulf of Mexico Recovery Unit
      i. There is statistical confidence (95 percent) that the annual rate of increase over a generation time of 50 years is three percent or greater resulting in a total annual number of nests of 4,000 or greater for this recovery unit (approximate distribution of nests (2002-2007) is Florida= 92 percent [3,700 nests] and Alabama =8 percent [300 nests]); and

ii. This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

e. Greater Caribbean Recovery Unit
   i. The total annual number of nests at a minimum of three nesting assemblages, averaging greater than 100 nests annually (e.g., Yucatán, Mexico; Cay Sal Bank, Bahamas) has increased over a generation time of 50 years; and
   ii. This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

2. Trends in Abundance on Foraging Grounds
A network of in-water sites, both oceanic and neritic across the foraging range is established and monitoring is implemented to measure abundance. There is statistical confidence (95 percent) that a composite estimate of relative abundance from these sites is increasing for at least one generation.

3. Trends in Neritic Strandings Relative to In-water Abundance
Stranding trends are not increasing at a rate greater than the trends in in-water relative abundance for similar age classes for at least one generation.

Status and distribution - Green Sea Turtle

Range-wide Trend: Annual nest totals documented as part of the Florida SNBS program from 1989-2010 have ranged from 435 nests laid in 1993 to 13,225 in 2010. Nesting occurs in 26 counties with a peak along the east coast, from Volusia through Broward Counties. Although the SNBS program provides information on distribution and total abundance statewide, it cannot be used to assess trends because of variable survey effort. Therefore, green turtle nesting trends are best assessed using standardized nest counts made at INBS sites surveyed with constant effort over time (1989-2010). Green sea turtle nesting in Florida is increasing based on 22 years (1989-2010) of INBS data from throughout the state ((FWC/FWRI 2010b). The increase in nesting in Florida is likely a result of several factors, including: (1) a Florida statute enacted in the early 1970s that prohibited the killing of green turtles in Florida; (2) the species listing under the Act afforded complete protection to eggs, juveniles, and adults in all U.S. waters; (3) the passage of Florida's constitutional net ban amendment in 1994 and its subsequent enactment, making it illegal to use any gillnets or other entangling nets in State waters; (4) the likelihood that the majority of Florida green turtles reside within Florida waters where they are fully protected; (5) the protections afforded Florida green turtles while they inhabit the waters of other nations that have enacted strong sea turtle conservation measures (e.g., Bermuda); and (6) the listing of the species on Appendix I of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which stopped international trade and reduced incentives for illegal trade from the U.S (NMFS and Service 2007a).

Recovery Criteria

The U.S. Atlantic population of green sea turtles can be considered for delisting if, over a period of 25 years, the following conditions are met:

1. The level of nesting in Florida has increased to an average of 5,000 nests per year for at least six years. Nesting data must be based on standardized surveys;

2. At least 25 percent (65 miles) of all available nesting beaches (260 miles) is in public ownership and encompasses at least 50 percent of the nesting activity;

3. A reduction in stage class mortality is reflected in higher counts of individuals on foraging grounds; and

4. All priority one tasks identified in the recovery plan have been successfully implemented.

Status and distribution - Leatherback Sea Turtle

Range-wide Trend: Pritchard (1982) estimated 115,000 nesting females worldwide, of which 60 percent nested along the Pacific coast of Mexico. Declines in leatherback nesting have occurred over the last two decades along the Pacific coasts of Mexico and Costa Rica. The Mexican leatherback nesting population, once considered to be the world's largest leatherback nesting population (historically estimated to be 65 percent of the worldwide population), is now less than 1 percent of its estimated size in 1980. Spotila et al. (1996) estimated the number of leatherback sea turtles nesting on 28 beaches throughout the world from the literature and from communications with investigators studying those beaches. The estimated worldwide population of leatherbacks in 1995 was about 34,500 females on these beaches with a lower limit of about 26,200, and an upper limit of about 42,900. This is less than one-third the 1980 estimate of 115,000. Leatherbacks are rare in the Indian Ocean and in very low numbers in the western Pacific Ocean. The most recent population size estimate for the North Atlantic is a range of 34,000 to 94,000 adult leatherbacks (TEWG 2007). The largest population is in the western Atlantic. Using an age-based demographic model, Spotila et al. (1996) determined that leatherback populations in the Indian Ocean and western Pacific Ocean cannot withstand even moderate levels of adult mortality and that the Atlantic populations are being exploited at a rate that cannot be sustained. They concluded that leatherbacks are on the road to extinction and further population declines can be expected unless action is taken to reduce adult mortality and increase survival of eggs and hatchlings.

In the western Atlantic, the U.S., nesting populations occur in Florida, Puerto Rico, and the U.S. Virgin Islands. In Florida, the SNBS program documented an increase in leatherback nesting numbers from 98 nests in 1989 to between 453 and 1,747 nests per season in the early 2000s (FWC 2009a; Stewart and Johnson 2006). Although the SNBS program provides information on distribution and total abundance statewide, it cannot be used to assess trends because of variable survey effort. Therefore, leatherback nesting trends are best assessed using standardized nest counts made at INBS sites surveyed with constant effort over time (1989-2010). Under the INBS program, approximately 30 percent of Florida's SNBS beach length is surveyed. The INBS nest counts represent approximately 34 percent of known leatherback nesting in Florida. An analysis of the INBS data has shown an exponential increase in leatherback sea turtle nesting in Florida since 1989. From 1989 through 2010, the annual number of leatherback sea turtle nests at the core set of index beaches ranged from 27 to 615 (FWC 2010b). Using the numbers of nests recorded from 1979 through 2009, Stewart et al. (2011) estimated a population growth of approximately 10.2 percent per year. In Puerto Rico, the main nesting areas are at Fajardo (Northeast Ecological Corridor) and Maunabo on the main island and on the islands of Culebra and Vieques. Nesting ranged from 51 to 456 nests between 2001 and 2010 (Diez 2011). In the U.S. Virgin Islands, leatherback nesting on Sandy Point National Wildlife Refuge on the island of St. Croix ranged from 143 to 1,008 nests between 1990 and 2005 (TEWG 2007; NMFS and Service 2007b).

Recovery Criteria

The U.S. Atlantic population of leatherbacks can be considered for delisting if the following conditions are met:

1. The adult female population increases over the next 25 years, as evidenced by a statistically significant trend in the number of nests at Culebra, Puerto Rico, St. Croix, U.S. Virgin Islands, and along the east coast of Florida;
2. Nesting habitat encompassing at least 75 percent of nesting activity in U.S. Virgin Islands, Puerto Rico, and Florida is in public ownership; and
3. All priority one tasks identified in the recovery plan have been successfully implemented.

5) Analysis of the species/critical habitat likely to be affected

Barrier islands and inlets are complex and dynamic coastal systems that are continually responding to sediment supply, waves, and fluctuations in sea level. The location and shape of the beaches of barrier islands perpetually adjusts to these physical forces. Waves that strike a barrier island at an angle, for instance, generate a longshore current that carries sediment along the shoreline. Cross-shore currents carry sediment perpendicular to the shoreline. Wind moves sediment across the dry beach, dunes and island interior. During storm events, overwash may breach the island at dune gaps or other weak spots, depositing sediments on the interior and back sides of islands, increasing island elevation and accreting the soundside shoreline.

Tidal inlets play a vital role in the dynamics and processes of barrier islands. Sediment is transferred across inlets from island to island via the tidal shoals or deltas. The longshore sediment transport often causes barrier spits to accrete, shifting inlets towards the neighboring island. Flood tidal shoals that are left behind by the migrating inlet are typically incorporated into the soundside shoreline and marshes of the island, widening it considerably. Many inlets have a cycle of inlet migration, breaching of the barrier spit during a storm, and closure of the old inlet with the new breach becoming the new inlet. Barrier spits tend to be low in elevation, sparse in vegetation, and repeatedly submerged by high and storm tides.

The Service and the NMFS share Federal jurisdiction for sea turtles under the Act. The Service has responsibility for sea turtles on the nesting beach. NMFS has jurisdiction for sea turtles in the marine environment.

In accordance with the Act, the Service completes consultations with all Federal agencies for actions that may adversely affect sea turtles on the nesting beach. The Service's analysis only addresses activities that may impact nesting sea turtles, their nests and eggs, and hatchlings as they emerge from the nest and crawl to the sea. NMFS assesses and consults with Federal agencies concerning potential impacts to sea turtles in the marine environment, including updrift and downdrift nearshore areas affected by sand placement projects on the beach.

The proposed action has the potential to adversely affect nesting females, nests, and hatchlings on the beach within the proposed Action Area. Potential effects include destruction of nests deposited within the boundaries of the proposed project, harassment in the form of disturbing or interfering with female turtles attempting to nest within the construction area or on adjacent beaches as a result of construction activities, disorientation of hatchling turtles on beaches adjacent to the construction area as they emerge from the nest and crawl to the water as a result of project lighting or presence of the groin, and behavior modification of nesting females during the nesting season resulting in false crawls or situations where they choose marginal or unsuitable nesting areas to deposit eggs due to escarpment formation or presence of the groin within the Action Area. The quality of the placed sand could affect the ability of female turtles to nest, the suitability of the nest incubation environment, and the ability of hatchlings to emerge from the nest. The presence of the groin could affect the movement of sand by altering the natural coastal processes and could affect the ability of female turtles to nest, the suitability of the nest incubation environment, and the ability of hatchlings to emerge from the nest and crawl to the ocean.

Some individuals in a population are more "valuable" than others in terms of the number of offspring they are expected to produce. An individual's potential for contributing offspring to future generations is its reproductive value. Because of delayed sexual maturity, reproductive longevity, and low survivorship in early life stages, nesting females are of high value to a population. The loss of a nesting female in a small recovery unit would represent a significant loss to the recovery unit. The reproductive value for a nesting female has been estimated to be approximately 253 times greater than an egg or a hatchling (NMFS and Service 2008). However, the construction of a groin and sand placement action includes avoidance and minimization measures that reduce the possibility of mortality of a nesting female on the beach as a result of the project. Therefore, we do not anticipate the loss of any nesting females on the beach as a result of the project.

With regard to indirect loss of eggs and hatchlings, on most beaches, nesting success typically declines for the first year or two following sand placement, even though more nesting habitat is available for turtles (Trindell et al. 1998; Ernest and Martin 1999; Herren 1999). Reduced nesting success on constructed beaches has been attributed to increased sand compaction, escarpment formation, and changes in beach profile (Nelson et al. 1987; Crain et al. 1995; Lutcavage et al. 1997; Steinitz et al. 1998; Ernest and Martin 1999; Rumbold et al. 2001). In addition, even though constructed beaches are wider, nests deposited there may experience higher rates of wash out than those on relatively narrow, steeply sloped beaches (Ernest and Martin 1999). This occurs because nests on constructed beaches are more broadly distributed than those on natural beaches, where they tend to be clustered near the base of the dune. Nests laid closest to the waterline on constructed beaches may be lost during the first year or two following construction as the beach undergoes an equilibration process during which seaward portions of the beach are lost to erosion. As a result, the project may be anticipated to result in decreased nesting and loss of nests that are laid within the Action Area for two subsequent nesting seasons following the completion of the proposed sand placement. However, it is unknown whether nests that would have been laid in an Action Area during the two subsequent nesting seasons had the project not occurred are actually lost from the population, or if nesting is simply displaced to adjacent beaches. Regardless, eggs and hatchlings have a low reproductive value; each egg or hatchling has been estimated to have only 0.004 percent of the value of a nesting female (NMFS and Service 2008). Thus, even if the majority of the eggs and hatchlings that would have been produced on the project beach are not realized for up to 2 years following project completion, the Service would not expect this loss to have a significant effect on the recovery and survival of the species, for the following reasons: 1) some nesting is likely just displaced to adjacent non-project beaches, 2) not all eggs will produce hatchlings, and 3) destruction and/or failure of nests will not always result from a sand placement project. A variety of natural and unknown factors negatively affect incubating egg clutches, including tidal inundation, storm events, and predation.

During project construction, direct mortality of the developing embryos in nests within the Action Area may occur for nests that are missed and not relocated or marked for avoidance. The exact number of these missed nests is not known. However, in two separate monitoring programs on the east coast of Florida where hand digging was performed to confirm the presence of nests and thus reduce the chance of missing nests through misinterpretation, trained observers still missed about 6 to 8 percent of the nests because of natural elements (Martin 1992; Ernest and Martin 1993). This must be considered a conservative number, because missed nests are not always accounted for. In another study, Schroeder (1994) found that even under the best of conditions, about 7 percent of nests can be misidentified as false crawls by highly experienced sea turtle nest surveyors. Missed nests are usually identified by signs of hatchling emergences or egg or hatchling predation in areas where no nest was previously documented. Signs of hatchling emergence are very easily obliterated by the same elements that interfere with detection of nests. Regardless, eggs and hatchlings have a low reproductive value; each egg or hatchling has been estimated to have only 0.004 percent of the value of a nesting female (NMFS and Service 2008). Thus, even if, for example, the number of missed nests approaches twice the rate mentioned above, the Service would not expect this loss to have a significant effect on the recovery and survival of the species, for the following reasons: 1) not all eggs in all unmarked nests will produce hatchlings, and 2) destruction and/or failure of a missed nest will not always result from a construction project. A variety of natural and unknown factors negatively affect incubating egg clutches, including tidal inundation, storm events, predation, accretion of sand, and erosional processes. The loss of all life stages of sea turtles including eggs are considered "take" and minimization measures are required to avoid and minimize all life stages. During project construction, predators of eggs and nestlings may be attracted to the Action Area due to food waste from the construction crew.

The presence of the groin may create a physical obstacle to nesting sea turtles. The impact of nesting females interacting with the groin in the marine environment will be analyzed by NMFS in their consultation. As a result, the groin is anticipated to result in decreased nesting and loss of nests that do get laid within the Action Area for all subsequent nesting seasons following the completion of the proposed project. However, it is unknown whether nests that would have been laid in the Action Area had the project not occurred are actually lost from the population, or if nesting is simply displaced to adjacent beaches. Regardless, eggs and hatchlings have a low reproductive value; each egg or hatchling has been estimated to have only 0.004 percent of the value of a nesting female (NMFS and Service 2008). The Service would not expect this loss to have a significant effect on the recovery and survival of the species, for the following reasons: 1) some nesting is likely just displaced to adjacent non-project beaches, 2) not all eggs will produce hatchlings, and 3) destruction and/or failure of nests will not always result from the construction project. A variety of natural and unknown factors negatively affect incubating egg clutches, including tidal inundation, storm events, and predation.

The DEIS states that the terminal groin was designed to be permeable to minimize impacts both updrift and downdrift of the structure. The Applicant's engineer believes that the proposed structure will be allow continued northward sand transport along the Point toward West Beach. In particular, the first phase of construction would result in a more downdrift transport to West Beach than the second phase. However, the groin is not expected to resolve historical and ongoing erosion issues on the downdrift side, and may exacerbate downdrift erosion. The DEIS states that, similar to pre-project condition, direct sand placement may still be needed on West Beach after construction of the project to address erosion.

The interaction between the groin and the hydrodynamics of tide and current often results in the alteration of the beach profile seaward and in the immediate vicinity of the structure (Pilkey and Wright 1988; Terchunian 1988; Tait and Griggs 1990; Plant and Griggs 1992); including increased erosion seaward of structures, increased longshore currents that move sand away from the area, loss of interaction between the dune and ocean, and concentration of wave energy at the ends of an armoring structure (Schroeder and Mosier 1996). These changes or combination of changes can have various detrimental effects on sea turtles and their nesting habitat.

B. ENVIRONMENTAL BASELINE

1) Status of sea turtle species within the Action Area

The loggerhead sea turtle nesting and hatching season for North Carolina beaches extends from May 1 through November 15. Incubation ranges from about 45 to 95 days. See **Table 3** for data on observed loggerhead sea turtle nests on Bald Head Island. Data was provided in the BA from the Bald Head Island Conservancy.

Table 3. Number of loggerhead nests observed between 1980 and 2011 on Bald Head Island.

Year	Number of Loggerhead Nests
1980	72
1981	91
1982	96
1983	148
1984	126
1985	132
1986	195
1987	94
1988	113
1989	111
1990	183
1991	181
1992	138
1993	71
1994	120
1995	88
1996	99
1997	75
1998	88
1999	107
2000	44
2001	77
2002	75
2003	77
2004	41
2005	48
2006	63
2007	57
2008	104
2009	36
2010	72
2011	95

The green sea turtle nesting and hatching season North Carolina Beaches extends from May 15 through November 15. Incubation ranges from about 45 to 75 days. See **Table 4** for data on observed green sea turtle nests on Bald Head Island. Data was provided in the BA from the Bald Head Island Conservancy.

Table 4. Number of green sea turtle nests observed between 1992 and 2011 on Bald Head Island.

Year	Number of Green Sea Turtle Nests
1992	1
1993	0
1994	2
1995	0
1996	0
1997	0
1998	2
1999	1
2000	7
2001	0
2002	4
2003	0
2004	0
2005	0
2006	1
2007	0
2008	0
2009	1
2010	2
2011	4

The leatherback sea turtle nesting and hatching season on North Carolina Beaches extends from May 15 through November 15. Incubation ranges from about 55 to 75 days. There was one leatherback nest reported on Bald Head Island in 2010, on East Beach south of Fort Fisher.

2) Factors affecting the species environment within the Action Area

A wide range of recent and on-going beach disturbance activities have altered the proposed Action Area and, to a greater extent, the North Carolina coastline, and many more are proposed along the coastline for the near future. **Table 5** lists the most recent projects, within the past 5 years.

Table 5. Actions that have occurred in the Action Area in the last five years.

Year	Species Impacted	Project Type	Anticipated Take
2012/2013	Loggerhead, green, and leatherback sea turtle, piping plover, red knot, seabeach amaranth	Sand Nourishment from Corps Wilmington Harbor Sand Management Plan	2-4 miles of shoreline
2012	Loggerhead, green, and leatherback sea turtle, piping plover, red knot, seabeach amaranth	Dredging of Bald Head Creek and nourishment of South Beach	2,150-7,150 lf
2011	Loggerhead, green, and leatherback sea turtle, piping plover, red knot, seabeach amaranth	Sand Bag Revetment	350 lf
2009/2010	Loggerhead, green, and leatherback sea turtle, piping plover, red knot, seabeach amaranth	Beach Nourishment and replacement of 16 sand-filled groin tubes	4 miles of shoreline (5,300 lf of shoreline for the groinfield).

Nourishment activities widen beaches, change their sedimentology and stratigraphy, alter coastal processes and often plug dune gaps and remove overwash areas.

Inlet dredging activities alter the sediment dynamics on adjacent shorelines and stabilize these dynamic environments; beach disposal of dredge material further alters the natural habitat adjacent to inlets. Estuarine dredging of navigational channels can alter water circulation patterns and sediment transport pathways, as well as increase the frequency and magnitude of boat wakes; sound-side sand or mud flats may be impacted by increased erosion rates as a result. Historically there has been a Federal navigation project in the Wilmington Harbor Channel for over a century, and since 2001 the sediment has been disposed on Bald Head Island every few years.

Beach scraping can artificially steepen beaches, stabilize dune scarps, plug dune gaps, and redistribute sediment distribution patterns. Artificial dune building, often a product of beach scraping, removes low-lying overwash areas and dune gaps. As chronic erosion catches up to structures throughout the Action Area, artificial dune systems are constructed and maintained to protect beachfront structures either by sand fencing or fill placement. Beach scraping or bulldozing has been frequent on North Carolina beaches in recent years, in response to storms and the continuing retreat of the shoreline with rising sea level. These activities primarily occur during the winter months. Artificial dune or berm systems have been constructed and maintained in several areas. These dunes make the artificial dune ridge function like a seawall that blocks natural beach retreat, evolution, and overwash.

Inlet stabilization projects, such as jetties and groins, reduce the dynamics of overwash areas adjacent to inlets.

The Service and NMFS share Federal jurisdiction for sea turtles under the Act. The Service has responsibility for sea turtles on the nesting beach. NMFS has jurisdiction for sea turtles in the marine environment. Activities proposed in this formal consultation would involve only impacts to sea turtles in the terrestrial environment, which includes the following life stages: nesting sea turtles, nests and eggs, and hatchlings as they emerge from the nest and crawl to the sea.

<u>*Threats to Sea Turtles*</u>

Coastal Development

Loss of sea turtle nesting habitat related to coastal development has had the greatest impact on nesting sea turtles. Beachfront development not only causes the loss of suitable nesting habitat, but can result in the disruption of powerful coastal processes accelerating erosion and interrupting the natural shoreline migration (National Research Council 1990b). This may in turn cause the need to protect upland structures and infrastructure by armoring, groin placement, beach emergency berm construction and repair, and beach nourishment, all of which cause changes in, additional loss of, or impact to the remaining sea turtle habitat.

Hurricanes and Storms

Hurricanes and other large storms were probably responsible for maintaining coastal beach habitat upon which sea turtles depend through repeated cycles of destruction, alteration, and recovery of beach and dune habitat. Hurricanes and large storms generally produce damaging winds, storm tides and surges, and rain, which can result in severe erosion of the beach and dune systems. Overwash and blowouts are common on barrier islands.

Hurricanes and other storms can result in the direct loss of sea turtle nests, either by erosion or washing away of the nests by wave action and inundation or "drowning" of the eggs or pre-emergent hatchlings within the nest, or indirectly by causing the loss of nesting habitat. Depending on their frequency, storms can affect sea turtles on either a short-term basis (nests lost for one season and/or temporary loss of nesting habitat) or long term, if frequent (habitat unable to recover). The manner in which hurricanes affect sea turtle nesting also depends on their characteristics (winds, storm surge, rainfall), the time of year (within or outside of the nesting season), and where the northeast edge of the hurricane crosses land.

Because of the limited remaining nesting habitat in a natural state with no immediate development landward of the sandy beach, frequent or successive severe weather events could threaten the ability of certain sea turtle populations to survive and recover. Sea turtles evolved under natural coastal environmental events such as hurricanes. The extensive amount of predevelopment coastal beach and dune habitat allowed sea turtles to survive even the most severe hurricane events. It is only within the last 20 to 30 years that the combination of habitat loss to beachfront development and destruction of remaining habitat by hurricanes has increased the threat to sea turtle survival and recovery. On developed beaches, typically little space remains for sandy beaches to become reestablished after periodic storms. While the beach itself moves landward during such storms, reconstruction or persistence of structures at their pre-storm locations can result in a loss of nesting habitat.

Erosion

A critically eroded area is a segment of shoreline where natural processes or human activity have caused or contributed to erosion and recession of the beach or dune system to such a degree that upland development, recreational interests, wildlife habitat, or important cultural resources are threatened or lost. It is important to note that for an erosion problem area to be critical there must be an existing threat to or loss of one of four specific interests – upland development, recreation, wildlife habitat, or important cultural resources.

Beachfront Lighting

Artificial lights along a beach can deter females from coming ashore to nest or misdirect females trying to return to the surf after a nesting event. A significant reduction in sea turtle nesting activity has been documented on beaches illuminated with artificial lights (Witherington 1992). Artificial beachfront lighting may also cause disorientation (loss of bearings) and misorientation (incorrect orientation) of sea turtle hatchlings. Visual signs are the primary sea-finding mechanism for hatchlings (Mrosovsky and Carr 1967; Mrosovsky and Shettleworth 1968; Dickerson and Nelson 1989; Witherington and Bjorndal 1991). Artificial beachfront lighting is a documented cause of hatchling disorientation and misorientation on nesting beaches (Philibosian 1976; Mann 1977; Witherington and Martin 1996). The emergence from the nest and crawl to the sea is one of the most critical periods of a sea turtle's life. Hatchlings that do not make it to the sea quickly become food for ghost crabs, birds, and other predators, or become dehydrated and may never reach the sea. In addition, research has documented significant reduction in sea turtle nesting activity on beaches illuminated with artificial lights (Witherington 1992). During the 2010 sea turtle nesting season in Florida, over 47,000 turtle hatchlings were documented as being disoriented (FWC/FWRI 2011).

Predation

Predation of sea turtle eggs and hatchlings by native and introduced species occurs on almost all nesting beaches. Predation by a variety of predators can considerably decrease sea turtle nest hatching success. The most common predators in the southeastern U.S. are ghost crabs (*Ocypode quadrata*), raccoons (*Procyon lotor*), feral hogs (*Sus scrofa*), foxes (*Urocyon cinereoargenteus* and *Vulpes vulpes*), coyotes (*Canis latrans*), armadillos (*Dasypus novemcinctus*), and fire ants (*Solenopsis invicta*) (Dodd 1988; Stancyk 1995). In the absence of nest protection programs in a number of locations throughout the southeast U.S., raccoons may depredate up to 96 percent of all nests deposited on a beach (Davis and Whiting 1977; Hopkins and Murphy 1980; Stancyk et al. 1980; Talbert et al. 1980; Schroeder 1981; Labisky et al. 1986).

Beach Driving

The operation of motor vehicles on the beach affects sea turtle nesting by interrupting or striking a female turtle on the beach, headlights disorienting or misorienting emergent hatchlings, vehicles running over hatchlings attempting to reach the ocean, and vehicle tracks traversing the beach that interfere with hatchlings crawling to the ocean. Hatchlings appear to become diverted not because they cannot physically climb out of the rut (Hughes and Caine 1994), but because the sides of the track cast a shadow and the hatchlings lose their line of sight to the ocean horizon (Mann 1977). The extended period of travel required to negotiate tire tracks and ruts may increase the susceptibility of hatchlings to dehydration and depredation during migration to the ocean (Hosier et al. 1981). Driving on the beach can cause sand compaction which may result in adverse impacts on nest site selection, digging behavior, clutch viability, and emergence by hatchlings, decreasing nest success and directly killing pre-emergent hatchlings (Mann 1977; Nelson and Dickerson 1987; Nelson 1988).

The physical changes and loss of plant cover caused by vehicles on dunes can lead to various degrees of instability, and therefore encourage dune migration. As vehicles move either up or down a slope, sand is displaced downward, lowering the trail. Since the vehicles also inhibit plant growth, and open the area to wind erosion, dunes may become unstable, and begin to migrate. Unvegetated sand dunes may continue to migrate across stable areas as long as vehicle traffic continues. Vehicular traffic through dune breaches or low dunes on an eroding beach may cause an accelerated rate of overwash and beach erosion (Godfrey et al. 1978). If driving is required, the area where the least amount of impact occurs is the beach between the low and high tide water lines. Vegetation on the dunes can quickly reestablish provided the mechanical impact is removed.

Climate Change

The varying and dynamic elements of climate science are inherently long term, complex, and interrelated. Regardless of the underlying causes of climate change, glacial melting and expansion of warming oceans are causing sea level rise, although its extent or rate cannot as yet be predicted with certainty. At present, the science is not exact enough to precisely predict when and where climate impacts will occur. Although we may know the direction of change, it may not be possible to predict its precise timing or magnitude. These impacts may take place gradually or episodically in major leaps.

Climate change is evident from observations of increases in average global air and ocean temperatures, widespread melting of snow and ice, and rising sea level, according to the Intergovernmental Panel on Climate Change Report (IPCC 2007a). The IPCC Report (2007a) describes changes in natural ecosystems with potential widespread effects on many organisms, including marine mammals and migratory birds. The potential for rapid climate change poses a significant challenge for fish and wildlife conservation. Species' abundance and distribution are dynamic, relative to a variety of factors, including climate. As climate changes, the abundance and distribution of fish and wildlife will also change. Highly specialized or endemic species are likely to be most susceptible to the stresses of changing climate. Based on these findings and other similar studies, the U.S. Department of the Interior (DOI) requires agencies under its direction to consider potential climate change effects as part of their long-range planning activities (Service 2007).

In the southeastern U.S., climatic change could amplify current land management challenges involving habitat fragmentation, urbanization, invasive species, disease, parasites, and water management. Global warming will be a particular challenge for endangered, threatened, and other "at risk" species. It is difficult to estimate, with any degree of precision, which species will be affected by climate change or exactly how they will be affected. The Service will use Strategic Habitat Conservation planning, an adaptive science-driven process that begins with explicit trust resource population objectives, as the framework for adjusting our management strategies in response to climate change (Service 2006). As the level of information increases relative to the effects of global climate change on sea turtles and its designated critical habitat, the Service will have a better basis to address the nature and magnitude of this potential threat and will more effectively evaluate these effects to the range-wide status of sea turtles.

Temperatures are predicted to rise from 1.6°F to 9°F for North America by the end of this century (IPCC 2007a, b). Alterations of thermal sand characteristics could result in highly female-biased sex ratios because sea turtles exhibit temperature dependent sex determination (e.g., Glen and Mrosovsky 2004; Hawkes et al. 2008).

Along developed coastlines, and especially in areas where shoreline protection structures have been constructed to limit shoreline movement, rising sea levels will cause severe effects on nesting females and their eggs. Erosion control structures can result in the permanent loss of dry nesting beach or deter nesting females from reaching suitable nesting sites (National Research Council 1990a). Nesting females may deposit eggs seaward of the erosion control structures potentially subjecting them to repeated tidal inundation or washout by waves and tidal action.

Based on the present level of available information concerning the effects of global climate change on the status of sea turtles and their designated critical habitat, the Service acknowledges the potential for changes to occur in the Action Area, but presently has no basis to evaluate if or how these changes are affecting sea turtles or their designated critical habitat. Nor does our present knowledge allow the Service to project what the future effects from global climate change may be or the magnitude of these potential effects.

Recreational Beach Use

Human presence on or adjacent to the beach at night during the nesting season, particularly recreational activities, can reduce the quality of nesting habitat by deterring or disturbing and causing nesting turtles to avoid otherwise suitable habitat. In addition, human foot traffic can make a beach less suitable for nesting and hatchling emergence by increasing sand compaction and creating obstacles to hatchlings attempting to reach the ocean (Hosier et al. 1981).

The use and storage of lounge chairs, cabanas, umbrellas, catamarans, and other types of recreational equipment on the beach at night can also make otherwise suitable nesting habitat unsuitable by hampering or deterring nesting by adult females and trapping or impeding hatchlings during their nest to sea migration. The documentation of non-nesting emergences (also referred to as false crawls) at these obstacles is becoming increasingly common as more recreational beach equipment is left on the beach at night. Sobel (2002) describes nesting turtles being deterred by wooden lounge chairs that prevented access to the upper beach.

Sand Placement

Sand placement projects may result in changes in sand density (compaction), beach shear resistance (hardness), beach moisture content, beach slope, sand color, sand grain size, sand grain shape, and sand grain mineral content if the placed sand is dissimilar from the original beach sand (Nelson and Dickerson 1988a). These changes could result in adverse impacts on sea turtle nest site selection, digging behavior, clutch viability, and hatchling emergence (Nelson and Dickerson 1987; Nelson 1988).

Beach nourishment projects create an elevated, wider, and unnatural flat slope berm. Sea turtles nest closer to the water the first few years after nourishment because of the altered profile (and perhaps unnatural sediment grain size distribution) (Ernest and Martin 1999; Trindell 2005)

Beach compaction and unnatural beach profiles resulting from beach nourishment activities could negatively impact sea turtles regardless of the timing of projects. Sand compaction may increase the length of time required for female sea turtles to excavate nests and cause increased physiological stress to the animals (Nelson and Dickerson 1988b). These impacts can be minimized by using suitable sand.

A change in sediment color on a beach could change the natural incubation temperatures of sea turtle nests in an area, which, in turn, could alter natural sex ratios. To provide the most suitable sediment for nesting sea turtles, the color of the nourished sediments should resemble the natural beach sand in the area. Natural reworking of sediments and bleaching from exposure to the sun would help to lighten dark nourishment sediments; however, the timeframe for sediment mixing and bleaching to occur could be critical to a successful sea turtle nesting season.

In-water and Shoreline Alterations

Many navigable mainland or barrier island tidal inlets along the Atlantic and Gulf of Mexico coasts are stabilized with jetties or groins. Jetties are built perpendicular to the shoreline and extend through the entire nearshore zone and past the breaker zone to prevent or decrease sand deposition in the channel (Kaufman and Pilkey 1979). Groins are also shore-perpendicular structures that are designed to trap sand that would otherwise be transported by longshore currents and can cause downdrift erosion (Kaufman and Pilkey 1979).

These in-water structures have profound effects on adjacent beaches (Kaufman and Pilkey 1979). Jetties and groins placed to stabilize a beach or inlet prevent normal sand transport, resulting in accretion of sand on updrift beaches and acceleration of beach erosion downdrift of the structures (Komar 1983; Pilkey et al. 1984). Witherington et al. (2005) found a significant negative relationship between loggerhead nesting density and distance from the nearest of 17 ocean inlets on the Atlantic coast of Florida. The effect of inlets in lowering nesting density was observed both updrift and downdrift of the inlets, leading researchers to propose that beach instability from both erosion and accretion may discourage sea turtle nesting.

Following construction, the presence of groins and jetties may interfere with nesting turtle access to the beach, result in a change in beach profile and width (downdrift erosion, loss of sandy berms, and escarpment formation), trap hatchlings, and concentrate predatory fishes, resulting in higher probabilities of hatchling predation. In addition to decreasing nesting habitat suitability, construction or repair of groins and jetties during the nesting season may result in the destruction of nests, disturbance of females attempting to nest, and disorientation of emerging hatchlings from project lighting.

C. EFFECTS OF THE ACTION

1) Factors to be considered

Proximity of action: Construction of the groin and sand placement activities would occur within and adjacent to nesting habitat for sea turtles and dune habitats that ensure the stability and integrity of the nesting beach. Specifically, the project would potentially impact loggerhead, green, and leatherback nesting females, their nests, and hatchling sea turtles.

Distribution: Construction and presence of the groin and sand placement activities may impact nesting and hatchling sea turtles and sea turtle nests occurring along South Beach, West Beach, and the "Point," adjacent to the Atlantic Ocean and mouth of the Cape Fear River.

The Service expects the proposed construction activities could directly and indirectly affect the availability of habitat for nesting and hatchling sea turtles.

Timing: The timing of the sand placement activities and construction of the groin could directly and indirectly impact nesting females, their nests, and hatchling sea turtles when conducted between May 1 and November 15. The presence of the groin and future sand placement activities could directly and indirectly impact nesting females, their nests, and hatchling sea turtles for each subsequent nesting season within the Action Area.

Nature of the effect: The effects of the construction and presence of the groin and sand placement activities may change the nesting behavior of adult female sea turtles, diminish nesting success, and cause reduced hatching and emerging success. Sand placement can also change the incubation conditions within the nest. Any decrease in productivity and/or survival rates would contribute to the vulnerability of the sea turtles nesting in the southeastern United States.

Duration: The construction of the groin is to be a one-time activity and may take between 3 and 7 months to complete. The sand placement activity is likely to be a multiple-year activity, and each sand placement project may take between 3 and 7 months to complete. Thus, the direct effects would be expected to be short-term in duration. Indirect effects from the activity may continue to impact nesting and hatchling sea turtles and sea turtle nests in subsequent nesting seasons. In addition, the placement of the groin represents a long-term impact since the groin could be in place for many years.

Time to complete the project construction varies depending on the project size, weather, and other factors (equipment mobilization and break downs, availability of fuel, lawsuits, etc.). According to Corps estimations, project work (including the Corps SMP sand disposal) could take as little as 8 months or as long as one year.

Disturbance frequency: Sea turtle populations in the southeastern United States may experience decreased nesting success, hatching success, and hatchling emerging success that could result from the construction and sand placement activities being conducted at night during one nesting season, or during the earlier or later parts of one or two nesting seasons.

The frequency of maintenance dredging activities varies greatly, and can be as often as annually or semiannually, depending on the rate of shoaling and funding availability. Sand placement activities as a result of shore protection activities typically occur once every 3 to 5 years. Dredging and sand placement typically occurs during the winter work window, but can occur at any time during the year based on availability of funding and of dredges to conduct the work. The disturbance frequency related to groin and jetty repair and replacement varies greatly based on the original construction methodology, the construction materials, and the conditions under which the structure is placed.

Disturbance intensity and severity: Depending on the timing of the construction and sand placement activities during the sea turtle nesting season, effects to the sea turtle populations in the southeastern United States could be important. The placement of the groin represents a long-term impact within the Action Area since the groin could be in place for many years.

2) Analyses for effects of the action

The Action Area encompasses 12,600 linear feet of shoreline on the Atlantic coast of North Carolina.

Beneficial Effects: Groins constructed in appropriate high erosion areas, or to offset the effects of shoreline armoring, may reestablish a beach where none currently exists, stabilize the beach in rapidly eroding areas and reduce the potential for escarpment formation, reduce destruction of nests from erosion, and reduce the need for future sand placement events by extending the interval between sand placement events. However, caution should be exercised to avoid automatically assuming the reestablishment of a beach will wholly benefit sea turtle populations without determining the extent of the groin effect on nesting and hatchling sea turtle behavior.

The placement of sand on a beach with reduced dry foredune habitat may increase sea turtle nesting habitat if the placed sand is highly compatible (i.e., grain size, shape, color, etc.) with naturally occurring beach sediments in the area, and compaction and escarpment remediation measures are incorporated into the project. In addition, a nourished beach that is designed and constructed to mimic a natural beach system may benefit sea turtles more than an eroding beach it replaces.

Direct Effects: Potential adverse effects during the project construction phase include disturbance of existing nests, which may have been missed by surveyors and thus not marked for avoidance, disturbance of females attempting to nest, and disorientation of emerging hatchlings. In addition, heavy equipment will be required to re-distribute the sand to the original natural beach template and to construct the groin. This equipment will have to traverse the beach portion of the Action Area, which could result in harm to nesting sea turtles, their nests, and emerging hatchlings. In addition, for groin construction, a trench will be excavated on the beach and may be present during the night for some portion of construction, creating a potential threat to nesting females and emerging hatchlings.

Following construction, the presence of the groin has the potential to adversely affect sea turtles. For instance, they may interfere with the egress and ingress of adult females at nesting sites; alter downdrift beach profiles through erosion, escarpment formation, and loss of berms; trap or obstruct hatchlings during a critical life-history stage; increase hatchling and adult female energy expenditure in attempts to overcome the structures; and attract additional predatory fish or concentrate existing predatory fish, thereby increasing the potential of hatchling predation.

Placement of sand on a beach in and of itself may not provide suitable nesting habitat for sea turtles. Although sand placement activities may increase the potential nesting area, significant negative impacts to sea turtles may result if protective measures are not incorporated during project construction. Sand placement activities during the nesting season can cause increased loss of eggs and hatchlings and, along with other mortality sources, may significantly impact the long-term survival of the species. For instance, projects conducted during the nesting and hatching season could result in the loss of sea turtles through disruption of adult nesting activity and by burial or crushing of nests or hatchlings. While a nest monitoring and egg relocation program would reduce these impacts, nests may be inadvertently missed (when crawls are obscured by rainfall, wind, or tides) or misidentified as false crawls during daily patrols. In addition, nests may be destroyed by operations at night prior to beach patrols being performed. Even under the best of conditions, about 7 percent of the nests can be misidentified as false crawls by experienced sea turtle nest surveyors (Schroeder 1994).

a. Equipment during construction

The use of heavy machinery on beaches during a construction project may also have adverse effects on sea turtles. Equipment left on the nesting beach overnight can create barriers to nesting females emerging from the surf and crawling up the beach, causing a higher incidence of false crawls and unnecessary energy expenditure.

The operation of motor vehicles or equipment on the beach to complete the project work at night affects sea turtle nesting by: interrupting or colliding with a nesting turtle on the beach, headlights disorienting or misorienting emergent hatchlings, vehicles running over hatchlings attempting to reach the ocean, and vehicle ruts on the beach interfering with hatchlings crawling to the ocean. Apparently, hatchlings become diverted not because they cannot physically climb out of a rut (Hughes and Caine 1994), but because the sides of the track cast a shadow and the hatchlings lose their line of sight to the ocean horizon (Mann 1977). The extended period of travel required to negotiate tire ruts may increase the susceptibility of hatchlings to dehydration and depredation during migration to the ocean (Hosier et al. 1981). Driving directly above or over incubating egg clutches or on the beach can cause sand compaction, which may result in adverse impacts on nest site selection, digging behavior, clutch viability, and emergence by hatchlings, as well as directly kill pre-emergent hatchlings (Mann 1977; Nelson and Dickerson 1987; Nelson 1988).

The physical changes and loss of plant cover caused by vehicles on vegetated areas or dunes can lead to various degrees of instability and cause dune migration. As vehicles move over the sand, sand is displaced downward, lowering the substrate. Since the vehicles also inhibit plant growth, and open the area to wind erosion, the beach and dunes may become unstable. Vehicular traffic on the beach or through dune breaches or low dunes may cause acceleration of overwash and erosion (Godfrey et al. 1978). Driving along the beachfront should be between the low and high tide water lines. To minimize the impacts to the beach, dunes, and dune vegetation, transport and access to the construction sites should be from the road to the maximum extent possible. However, if vehicular access to the beach is necessary, the areas for vehicle and equipment usage should be designated and marked.

b. Artificial lighting as a result of an unnatural beach slope on the adjacent beach

Visual cues are the primary sea-finding mechanism for hatchling sea turtles (Mrosovsky and Carr 1967; Mrosovsky and Shettleworth 1968; Dickerson and Nelson 1989; Witherington and Bjorndal 1991). When artificial lighting is present on or near the beach, it can misdirect hatchlings once they emerge from their nests and prevent them from reaching the ocean (Philibosian 1976; Mann 1977; FWC 2007). In addition, a significant reduction in sea turtle nesting activity has been documented on beaches illuminated with artificial lights (Witherington 1992). Therefore, construction lights along a project beach and on the dredging vessel may deter females from coming ashore to nest, misdirect females trying to return to the surf after a nesting event, and misdirect emergent hatchlings from adjacent non-project beaches.

The unnatural sloped beach adjacent to the structure exposes sea turtles and their nests to lights that were less visible, or not visible, from nesting areas before the sand placement activity, leading to a higher mortality of hatchlings. Review of over 10 years of empirical information from beach nourishment projects indicates that the number of sea turtles impacted by lights increases on the post-construction berm. A review of selected nourished beaches in Florida (South Brevard, North Brevard, Captiva Island, Ocean Ridge, Boca Raton, Town of Palm Beach, Longboat Key, and Bonita Beach) indicated disorientation reporting increased by approximately 300 percent the first nesting season after project construction and up to 542 percent the second year compared to pre-nourishment reports (Trindell et al. 2005).

Specific examples of increased lighting disorientations after a sand placement project include Brevard and Palm Beach Counties, Florida. A sand placement project in Brevard County, completed in 2002, showed an increase of 130 percent in disorientations in the nourished area. Disorientations on beaches in the County that were not nourished remained constant (Trindell 2007). This same result was also documented in 2003 when another beach in Brevard County was nourished and the disorientations increased by 480 percent (Trindell 2007). Installing appropriate beachfront lighting is the most effective method to decrease the number of disorientations on any developed beach including nourished beaches. A shoreline protection project was constructed at Ocean Ridge in Palm Beach County, Florida, between August 1997 and April 1998. Lighting disorientation events increased after nourishment. In spite of continued aggressive efforts to identify and correct lighting violations in 1998 and 1999, 86 percent of the disorientation reports were in the nourished area in 1998 and 66 percent of the reports were in the nourished area in 1999 (Howard and Davis 1999).

c. Entrapment/physical obstruction

Groins have the potential to interfere with the egress or ingress of adult females at nesting sites where they may proceed around them successfully, abort nesting for that night, or move to another section of beach to nest. This may cause an increase in energy expenditure, and, if the body of the groin is exposed, may act as a barrier between beach segments and also prevent nesting on the adjacent beach. In general, the groin is exposed to dissipate wave energy and facilitate sand bypass, functioning in many cases to stabilize the beach and adjacent areas.

Typically, sea turtles emerge from the nest at night when lower sand temperatures elicit an increase in hatchling activity (Witherington et al. 1990). After emergence, approximately 20 to 120 hatchlings crawl en *masse* immediately to the surf, using predominately visual cues to orient them (Witherington and Salmon 1992; Lohmann et al. 1997). Upon reaching the water, sea turtle hatchlings orient themselves into the waves and begin a period of hyperactive swimming activity, or swim frenzy, which lasts for approximately 24 hours (Salmon and Wyneken 1987; Wyneken et al. 1990; Witherington 1991). The swim frenzy effectively moves the hatchling quickly away from shallow, predator rich, nearshore waters to the relative safety of deeper water (Gyuris 1994; Wyneken et al. 2000). The first hour of a hatchling's life is precarious and predation is high, but threats decrease as hatchlings distance themselves from their natal beaches (Stancyk 1995; Pilcher et al. 2000). Delays in hatchling migration (both on the beach and in the water) can cause added expenditures of energy and an increase of time spent in predator rich nearshore waters. On rare occasions hatchlings will encounter natural nearshore features that are similar to the emergent structures proposed for this project. However, observations of hatchling behavior during an encounter with a sand bar at low tide, a natural shore-parallel barrier, showed the hatchlings maintained their shore-perpendicular path seaward, by crawling over the sand bar versus deviating from this path to swim around the sand bar through the trough, an easier alternative. In spite of the groin design features, the groin may adversely affect sea turtle hatchlings by serving as a barrier or obstruction to sea turtle hatchlings and delaying offshore migration; depleting or increasing expenditure of the "swim frenzy" energy critical for allowing hatchlings to reach the relative safety of offshore development areas; and possibly entrapping hatchlings within the groin or within eddies or other associated currents.

d. Nest relocation

Besides the potential for missing nests during surveys and a nest relocation program, there is a potential for eggs to be damaged by nest movement or relocation, particularly if eggs are not relocated within 12 hours of deposition (Limpus et al. 1979). Nest relocation can have adverse impacts on incubation temperature (and hence sex ratios), gas exchange parameters, hydric environment of nests, hatching success, and hatchling emergence (Limpus et al. 1979; Ackerman 1980; Parmenter 1980; Spotila et al. 1983; McGehee 1990). Relocating nests into sands deficient in oxygen or moisture can result in mortality, morbidity, and reduced behavioral competence of hatchlings. Water availability is known to influence the incubation environment of the embryos and hatchlings of turtles with flexible-shelled eggs, which has been shown to affect nitrogen excretion (Packard et al. 1984), mobilization of calcium (Packard and Packard 1986), mobilization of yolk nutrients (Packard et al. 1985), hatchling size (Packard et al. 1981; McGehee 1990), energy reserves in the yolk at hatching (Packard et al. 1988), and locomotory ability of hatchlings (Miller et al. 1987).

In a 1994 Florida study comparing loggerhead hatching and emerging success of relocated nests with nests left in their original location, Moody (1998) found that hatching success was lower in relocated nests at nine of 12 beaches evaluated. In addition, emerging success was lower in relocated nests at 10 of 12 beaches surveyed in 1993 and 1994. Many of the direct effects of beach nourishment may persist over time. These direct effects include increased susceptibility of relocated nests to catastrophic events, the consequences of potential increased beachfront development, changes in the physical characteristics of the beach, the formation of escarpments, repair/replacement of groins and jetties, and future sand migration.

Indirect Effects: Many of the direct effects of a groin or beach nourishment may persist over time and become indirect impacts. These indirect effects include increased susceptibility of relocated nests to catastrophic events, the consequences of potential increased beachfront development, changes in the physical characteristics of the beach, the formation of escarpments, and future sand migration.

a. Changes in the physical environment

The presence of the groin may alter the natural coastal processes and result in an unnatural beach profiles resulting from the presence of groin, which could negatively impact sea turtles regardless of the timing of projects. The use of heavy machinery can cause sand compaction (Nelson et al. 1987; Nelson and Dickerson 1988a). Significant reductions in nesting success (i.e., false crawls occurred more frequently) have been documented on severely compacted beaches (Fletemeyer 1980; Raymond 1984; Nelson and Dickerson 1987; Nelson et al. 1987), and increased false crawls may result in increased physiological stress to nesting females.

Beach nourishment may result in changes in sand density (compaction), beach shear resistance (hardness), beach moisture content, beach slope, sand color, sand grain size, sand grain shape, and sand grain mineral content if the placed sand is dissimilar from the original beach sand (Nelson and Dickerson 1988a). These changes could result in adverse impacts on nest site selection, digging behavior, clutch viability, and hatchling emergence (Nelson and Dickerson 1987; Nelson 1988).

Beach nourishment projects create an elevated, wider, and unnatural flat slope berm. Sea turtles nest closer to the water the first few years after nourishment because of the altered profile (and perhaps unnatural sediment grain size distribution) (Ernest and Martin 1999; Trindell 2005).

Beach compaction and unnatural beach profiles resulting from beach nourishment activities could negatively impact sea turtles regardless of the timing of projects. Very fine sand or the use of heavy machinery can cause sand compaction on nourished beaches (Nelson et al. 1987; Nelson and Dickerson 1988a). Significant reductions in nesting success (i.e., false crawls occurred more frequently) have been documented on severely compacted nourished beaches (Fletemeyer 1980; Raymond 1984; Nelson and Dickerson 1987; Nelson et al. 1987), and increased false crawls may result in increased physiological stress to nesting females. Sand compaction may increase the length of time required for female sea turtles to excavate nests and cause increased physiological stress to the animals (Nelson and Dickerson 1988b). Nelson and Dickerson (1988c) concluded that, in general, beaches nourished from offshore borrow sites are harder than natural beaches, and while some may soften over time through erosion and accretion of sand, others may remain hard for 10 years or more.

These impacts can be minimized by using suitable sand and by tilling (minimum depth of 36 inches) compacted sand after project completion. The level of compaction of a beach can be assessed by measuring sand compaction using a cone penetrometer (Nelson 1987). Tilling of a nourished beach with a root rake may reduce the sand compaction to levels comparable to unnourished beaches. However, a pilot study by Nelson and Dickerson (1988c) showed that a tilled nourished beach will remain uncompacted for only up to 1 year. Thus, multi-year beach compaction monitoring and, if necessary, tilling would help to ensure that project impacts on sea turtles are minimized.

A change in sediment color on a beach could change the natural incubation temperatures of nests in an area, which, in turn, could alter natural sex ratios. To provide the most suitable sediment for nesting sea turtles, the color of the nourished sediments should resemble the natural beach sand in the area. Natural reworking of sediments and bleaching from exposure to the sun would help to lighten dark nourishment sediments; however, the timeframe for sediment mixing and bleaching to occur could be critical to a successful sea turtle nesting season.

b. Escarpment formation

On nourished beaches, steep escarpments may develop along their water line interface as they adjust from an unnatural construction profile to a more natural beach profile (Coastal Engineering Research Center 1984; Nelson et al. 1987). Escarpments may also develop on beaches between groins as the beaches equilibrate to their final profiles. Escarpments can hamper or prevent access to nesting sites (Nelson and Blihovde 1998). Researchers have shown that female sea turtles coming ashore to nest can be discouraged by the formation of an escarpment, leading to situations where they choose marginal or unsuitable nesting areas to deposit eggs (e.g., in front of the escarpments, which often results in failure of nests due to prolonged tidal inundation). This impact can be minimized by leveling any escarpments prior to the nesting season.

c. Increased susceptibility to catastrophic events

Nest relocation within a nesting season may concentrate eggs in an area making them more susceptible to catastrophic events. Hatchlings released from concentrated areas also may be subject to greater predation rates from both land and marine predators, because the predators learn where to concentrate their efforts (Glenn 1998; Wyneken et al. 1998).

d. Increased beachfront development

Pilkey and Dixon (1996) stated that beach replenishment frequently leads to more development in greater density within shorefront communities that are then left with a future of further replenishment or more drastic stabilization measures. Dean (1999) also noted that the very existence of a beach nourishment project can encourage more development in coastal areas. Following completion of a beach nourishment project in Miami during 1982, investment in new and updated facilities substantially increased tourism there (National Research Council 1995). Increased building density immediately adjacent to the beach often resulted as much larger buildings that accommodated more beach users replaced older buildings. Overall, shoreline management creates an upward spiral of initial protective measures resulting in more expensive development that leads to the need for more and larger protective measures. Increased shoreline development may adversely affect sea turtle nesting success. Greater development may support larger populations of mammalian predators, such as foxes and raccoons, than undeveloped areas

(National Research Council 1990a), and can also result in greater adverse effects due to artificial lighting, as discussed above.

e. Future sand migration and erosion

Groins and jetties are shore-perpendicular structures that are designed to trap sand that would otherwise be transported by longshore currents. Jetties are defined as structures placed to keep sand from flowing into channels (Kaufman and Pilkey 1979; Komar 1983). In preventing normal sand transport, these structures accrete updrift beaches while causing accelerated beach erosion downdrift of the structures (Komar 1983; Pilkey et al. 1984; National Research Council 1987), a process that results in degradation of sea turtle nesting habitat. As sand fills the area updrift from the groin or jetty, some littoral drift and sand deposition on adjacent downdrift beaches may occur due to spillover. However, these groins and jetties often force the stream of sand into deeper offshore water where it is lost from the system (Kaufman and Pilkey 1979). The greatest changes in beach profile near groins and jetties are observed close to the structures, but effects eventually may extend many miles along the coast (Komar 1983).

Jetties are placed at ocean inlets to keep transported sand from closing the inlet channel. Together, jetties and inlets are known to have profound effects on adjacent beaches (Kaufman and Pilkey 1979). Witherington et al. (2005) found a significant negative relationship between loggerhead nesting density and distance from the nearest of 17 ocean inlets on the Atlantic coast of Florida. The effect of inlets in lowering nesting density was observed both updrift and downdrift of the inlets, leading researchers to propose that beach instability from both erosion and accretion may discourage sea turtle nesting.

Erosion control structures (e.g., terminal groins, T-groins, and breakwaters), in conjunction with beach nourishment, can help stabilize U.S. Gulf and Atlantic coast barrier island beaches (Leonard et al. 1990). However, groins often result in accelerated beach erosion downdrift of the structures (Komar 1983; National Research Council 1987) and corresponding degradation of suitable sea turtle nesting habitat (NMFS and Service 1991; 1992). Initially, the greatest changes are observed close to the structures, but effects may eventually extend significant distances along the coast (Komar 1983).

Groins operate by blocking the natural longshore transport of littoral drift (Kaufman and Pilkey 1979; Komar 1983). Conventional rubble mound groins control erosion by trapping sand and dissipating some wave energy. In general, except for terminal groins at the downdrift limit of a littoral cell, groins are not considered favorable erosion control alternatives because they usually impart stability to the updrift beach and transfer erosion to the downdrift side of the structure. In addition, groins deflect longshore currents offshore, and excess sand builds up on the updrift side of the structure which may be carried offshore by those currents. This aggravates downdrift erosion and erosion escarpments are common on the downdrift side of groins (Humiston and Moore 2001).

Future sand displacement on nesting beaches is a potential effect of the nourishment project. Dredging of sand offshore from an Action Area has the potential to cause erosion of the newly created beach or other areas on the same or adjacent beaches by creating a sand sink. The remainder of the system responds to this sand sink by providing sand from the beach to attempt to reestablish equilibrium (National Research Council 1990b).

f. Erosion control structure breakdown

If erosion control structures fail and break apart, the resulting debris may be spread upon the beach, which may further impede nesting females from accessing suitable nesting sites (resulting in a higher incidence of false crawls) and trap hatchlings and nesting turtles (NMFS and Service 1991; 1992; 1993).

3) Species' response to a proposed action

The Service determined there is a potential for long-term adverse effects on sea turtles, particularly hatchlings, as a result of the presence of the groin. However, the Service acknowledges the potential benefits of the erosion control structure since it may minimize the effects of erosion on sea turtle nesting habitat and extend the sand placement interval. Nonetheless, an increase in sandy beach may not necessarily equate to an increase in suitable sea turtle nesting habitat.

The following summary illustrates sea turtle responses to and recovery from a nourishment project comprehensively studied by Ernest and Martin (1999). A significantly larger proportion of turtles emerging on nourished beaches abandoned their nesting attempts than turtles emerging on natural or pre-nourished beaches. This reduction in nesting success is most pronounced during the first year following project construction and is most likely the result of changes in physical beach characteristics associated with the nourishment project (e.g., beach profile, sediment grain size, beach compaction, frequency and extent of escarpments). During the first post-construction year, the time required for turtles to excavate an egg chamber on untilled, hard-packed sands increases significantly relative to natural conditions. However, tilling (minimum depth of 36 inches) is effective in reducing sediment compaction to levels that did not significantly prolong digging times. As natural processes reduced compaction levels on nourished beaches during the second post-construction year, digging times returned to natural levels (Ernest and Martin 1999).

During the first post-construction year, nests on nourished beaches are deposited significantly seaward of the toe of the dune and significantly landward of the tide line than nests on natural beaches. More nests are washed out on the wide, flat beaches of the nourished treatments than on the narrower steeply sloped natural beaches. This phenomenon may persist through the second post-construction year monitoring and result from the placement of nests near the seaward edge of the beach berm where dramatic profile changes, caused by erosion and scarping, occur as the beach equilibrates to a more natural contour.

The principal effect of beach nourishment on sea turtle reproduction is a reduction in nesting success during the first year following project construction. Although most studies have attributed this phenomenon to an increase in beach compaction and escarpment formation, Ernest and Martin (1999) indicated that changes in beach profile may be more important. Regardless, as a nourished beach is reworked by natural processes in subsequent years and adjusts from an unnatural construction profile to a natural beach profile, beach compaction and the frequency of escarpment formation decline, and nesting and nesting success return to levels found on natural beaches.

D. Cumulative Effects

This project occurs on non-federal lands. Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the Action Area considered in this biological opinion.

It is reasonable to expect continued shoreline stabilization and beach renourishment projects in this area in the future since erosion and sea-level rise increases would impact the existing beachfront development.

III. PIPING PLOVER

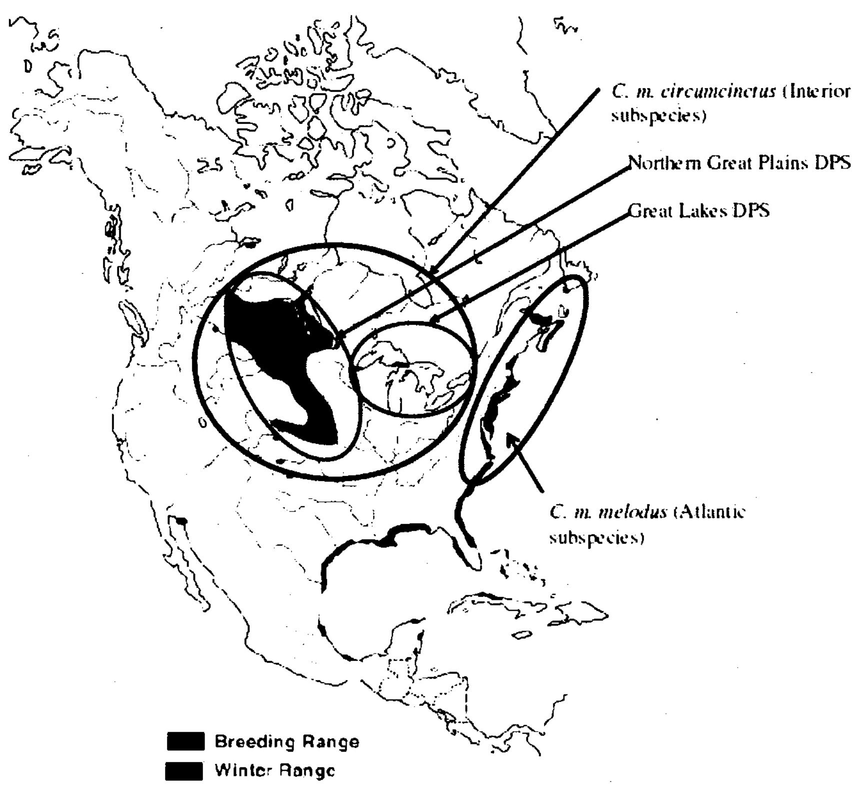
A. Status of the Species/Critical Habitat

1) Species/critical habitat description

Listing: On January 10, 1986, the piping plover was listed as endangered in the Great Lakes watershed and threatened elsewhere within its range, including migratory routes outside of the Great Lakes watershed and wintering grounds (Service 1985). Piping plovers were listed principally because of habitat destruction and degradation, predation, and human disturbance. Protection of the species under the Act reflects the species' precarious status range-wide.

Three separate breeding populations have been identified, each with its own recovery criteria: the northern Great Plains (threatened), the Great Lakes (endangered), and the Atlantic Coast (threatened). Piping plovers that breed on the Atlantic Coast of the U.S. and Canada belong to the subspecies C. m. melodus. The second subspecies, C. m. circumcinctus, is comprised of two Distinct Population Segments (DPSs). One DPS breeds on the Northern Great Plains of the U.S. and Canada, while the other breeds on the Great Lakes. Each of these three entities is demographically independent. The Piping plover winters in coastal areas of the U.S. from North Carolina to Texas, and along the coast of eastern Mexico and on Caribbean islands from Barbados to Cuba and the Bahamas (Haig and Elliott-Smith 2004) (**Figure 2**).

Figure 2. Distribution and range of piping plovers (base map from Elliott-Smith and Haig 2004). Conceptual presentation of subspecies and DPS ranges are not intended to convey precise boundaries.



Piping plovers in the Action Area may include individuals from all three breeding populations. Piping plover subspecies are phenotypically indistinguishable, and most studies in the nonbreeding range report results without regard to breeding origin. Although a recent analysis shows strong patterns in the wintering distribution of piping plovers from different breeding populations, partitioning is not complete and major information gaps persist.

North Carolina is the only state where the piping plover's breeding and wintering ranges overlap and the birds are present year-round. Piping plovers nest above the high tide line on coastal beaches; on sand flats at the ends of sand spits and barrier islands; on gently sloping foredunes; in blowout areas behind primary dunes (overwashes); in sparsely vegetated dunes; and in overwash areas cut into or between dunes. The species requires broad, open, sand flats for feeding, and undisturbed flats with low dunes and sparse dune grasses for nesting. Piping plovers from the federally endangered Great Lakes population as well birds from the threatened populations of the Atlantic Coast and Northern Great Plains overwinter on North Carolina beaches. Piping plovers arrive on their breeding grounds in late March or early April. Following establishment of nesting territories and courtship rituals, the pair forms a depression in the sand, where the female lays her eggs. By early September both adults and young depart for their wintering areas.

Designated habitat: The Service has designated Critical Habitat for the piping plover on three occasions. Two of these designations protected different piping plover breeding populations. Critical Habitat for the Great Lakes breeding population was designated May 7, 2001 (66 Federal Register [FR] 22938; Service 2001a), and Critical Habitat for the northern Great Plains breeding population was designated September 11, 2002 (67 FR 57637; Service 2002). The Service designated Critical Habitat for wintering piping plovers on July 10, 2001 (66 FR 36038; Service 2001b). Wintering piping plovers may include individuals from the Great Lakes and northern Great Plains breeding populations as well as birds that nest along the Atlantic Coast. The three separate designations of piping plover Critical Habitat demonstrate diversity of PCEs between the two breeding populations as well as diversity of PCEs between breeding and wintering populations. There is no designated Critical Habitat in the Action Area.

2) Life history

The piping plover is a small, pale sand-colored shorebird, about seven inches long with a wingspan of about 15 inches (Palmer 1967). Cryptic coloration is a primary defense mechanism for piping plovers where nests, adults, and chicks all blend in with their typical beach surroundings.

Piping plovers live an average of 5 years, although studies have documented birds as old as 11 (Wilcox 1959) and 15 years. Plovers are known to begin breeding as early as one year of age (MacIvor 1990; Haig 1992); however, the percentage of birds that breed in their first adult year is unknown. Piping plover breeding activity begins in mid-March when birds begin returning to their nesting areas (Coutu et al. 1990; Cross 1990; Goldin et al. 1990; MacIvor 1990; Hake 1993). Piping plovers generally fledge only a single brood per season, but may re-nest several times if previous nests are lost. The reduction in suitable nesting habitat due to a number of factors is a major threat to the species, likely limiting reproductive success and future recruitment into the population (Service 2009).

Plovers depart their breeding grounds for their wintering grounds between July and late August, but southward migration extends through November. More information about the three breeding populations of piping plovers can be found in the following documents:

a. Piping Plover, Atlantic Coast Population: 1996 Revised Recovery Plan (USFWS 1996a);
b. 2009 Piping Plover (*Charadrius melodus*) 5-Year Review: Summary and Evaluation (USFWS 2009);
c. 2003 Recovery Plan for the Great Lakes Piping Plover (*Charadrius melodus*) (USFWS 2003a);
d. Questions and Answers about the Northern Great Plains Population of Piping Plover (USFWS 2002).

North Carolina is one of the only states in which piping plovers may be found year-round. Piping plovers migrate through and winter in coastal areas of the U.S. from North Carolina to Texas and in portions of Mexico and the Caribbean. Data based on four rangewide mid-winter (late January to early February) population surveys, conducted at 5-year intervals starting in 1991, show that total numbers have fluctuated over time, with some areas experiencing increases and others decreases. Regional and local fluctuations may reflect the quantity and quality of suitable foraging and roosting habitat, which vary over time in response to natural coastal formation processes as well as anthropogenic habitat changes (e.g., inlet relocation, dredging of shoals and spits). Fluctuations may also represent localized weather conditions (especially wind) during surveys, or unequal survey coverage. Changes in wintering numbers may also be influenced by growth or decline in the particular breeding populations that concentrate their wintering distribution in a given area.

Gratto-Trevor et al. (2009) found strong patterns (but no exclusive partitioning) in winter distribution of uniquely banded piping plovers from four breeding populations. All eastern Canada and 94 percent of Great Lakes birds wintered from North Carolina to southwest Florida.

However, eastern Canada birds were more heavily concentrated in North Carolina, and a larger proportion of Great Lakes piping plovers were found in South Carolina and Georgia. Northern Great Plains populations were primarily seen farther west and south, especially on the Texas Gulf Coast.

Breeding and wintering plovers feed on exposed wet sand in swash zones; intertidal ocean beach; wrack lines; washover passes; mud , sand , and algal flats; and shorelines of streams, ephemeral ponds, lagoons, and salt marshes by probing for invertebrates at or just below the surface (Coutu et al., 1990; USFWS, 1996a). They use beaches adjacent to foraging areas for roosting and preening. Small sand dunes, debris, and sparse vegetation within adjacent beaches provide shelter from wind and extreme temperatures. Behavioral observations of piping plovers on the wintering grounds suggest that they spend the majority of their time foraging (Nicholls and Baldassarre 1990; Drake 1999a; 1999b). Studies have shown that the relative importance of various feeding habitat types may vary by site (Gibbs 1986; Coutu et al. 1990; McConnaughey et al. 1990; Loegering 1992; Goldin 1993; Hoopes 1993). Feeding activities may occur during all hours of the day and night (Staine and Burger 1994; Zonick 1997), and at all stages in the tidal cycle (Goldin 1993; Hoopes 1993). Wintering plovers primarily feed on invertebrates such as polychaete marine worms, various crustaceans, fly larvae, beetles, and occasionally bivalve mollusks found on top of the soil or just beneath the surface (Bent 1929; Cairns 1977; Nicholls 1989; Zonick and Ryan 1996).

Piping plovers exhibit a high degree of intra- and interannual wintering site fidelity (Nicholls and Baldassarre 1990; Drake et al. 2001; Noel and Chandler 2005; Stucker and Cuthbert 2006). However, local movements during winter are more common. In South Carolina, Maddock et al. (2009) documented many cross-inlet movements by wintering banded piping plovers as well as occasional movements of up to 11.2 miles by approximately 10 percent of the banded population. Larger movements within South Carolina were seen during fall and spring migration.

Atlantic Coast plovers nest on coastal beaches, sand flats at the ends of sand spits and barrier islands, gently-sloped foredunes, sparsely-vegetated dunes, and washover areas cut into or between dunes. Plovers arrive on the breeding grounds from mid-March through mid-May and remain for three to four months per year; the Atlantic Coast plover breeding activities begin in March in North Carolina with courtship and territorial establishment (Coutu et al., 1990; McConnaughey et al., 1990). Egg-laying begins around mid-April with nesting and brood rearing activities continuing through July. They lay three to four eggs in shallow scraped depressions lined with light colored pebbles and shell fragments. The eggs are well camouflaged and blend extremely well with their surroundings. Both sexes incubate the eggs which hatch within 30 days, and both sexes feed the young until they can fly. The fledgling period, the time between the hatching of the chicks and the point at which they can fly, generally lasts 25 to 35 days.

Atlantic Coast and Florida studies highlighted the importance of inlets for nonbreeding and breeding piping plovers. Almost 90 percent of roosting piping plovers at ten coastal sites in southwest Florida were on inlet shorelines (Lott et al. 2009b). Piping plovers were among seven shorebird species found more often than expected ($p = 0.0004$; Wilcoxon Test Scores) at inlet locations versus non-inlet locations in an evaluation of 361 International Shorebird Survey sites from North Carolina to Florida (Harrington 2008).

3) Population dynamics

The International Piping Plover Breeding Census is conducted throughout the breeding grounds every 5 years by the Great Lakes/Northern Great Plains Recovery Team of the U.S. Geological Survey (USGS). The census is the largest known, complete avian species census. It is designed to determine species abundance and distribution throughout its annual cycle. The last survey in 2006 documented 3,497 breeding pairs, with a total of 8,065 birds throughout Canada and the U.S. (Elliot-Smith et al. 2009). A more recent 2010 Atlantic Coast breeding piping plover population estimate was 1,782 pairs, which was more than double the 1986 estimate of 790 pairs. This was determined to be a net increase of 86 percent between 1989 and 2010 (Service 2011). The 2006 International Piping Plover Census surveys documented 84 wintering piping plovers at 39 sites along approximately 344 km of North Carolina shoreline, and 87 breeding plovers at 29 sites along 338 km of shoreline (Elliott-Smith et al. 2009). Midwinter surveys may underestimate the abundance of nonbreeding piping plovers using a site or region during other months. In late September 2007, 104 piping plovers were counted at the south end of Ocracoke Island, North Carolina (National Park Service 2007), where none were seen during the 2006 International Piping Plover Winter Census (Elliott-Smith et al. 2009). Local movements of non-breeding piping plovers and number of surveyor visits to the site may also affect abundance estimates (Maddock et al. 2009; Cohen 2009).

The most consistent finding in the various population viability analyses conducted for piping plovers (Ryan et al. 1993; Melvin and Gibbs 1996; Plissner and Haig 2000; Wemmer et al. 2001; Larson et al. 2002; Amirault et al. 2005; Calvert et al. 2006; Brault 2007) indicates even small declines in adult and juvenile survival rates will cause increases in extinction risk. A banding study conducted between 1998 and 2004 in Atlantic Canada concluded lower return rates of juvenile (first year) birds to the breeding grounds than was documented for Massachusetts (Melvin and Gibbs 1996), Maryland (Loegering 1992), and Virginia (Cross 1996) breeding populations in the mid-1980s and very early 1990s. This is consistent with failure of the Atlantic Canada population to increase in abundance despite high productivity (relative to other breeding populations) and extremely low rates of dispersal to the U.S. over the last 15 plus years (Amirault et al. 2005). This suggests maximizing productivity does not ensure population increases. However, other studies suggest that survivability is good at wintering sites (Drake et al. 2001). Please see the Piping Plover 5-Year Review: Summary and Evaluation for additional information on survival rates at wintering habitats (Service 2009).

In 2001, 2,389 piping plovers were located during a winter census, accounting for only 40 percent of the known breeding birds recorded during a breeding census (Ferland and Haig 2002). About 89 percent of birds that are known to winter in the U.S. do so along the Gulf Coast (Texas to Florida), while 8 percent winter along the Atlantic Coast (North Carolina to Florida).
The status of piping plovers on winter and migration grounds is difficult to assess, but threats to piping plover habitat used during winter and migration identified by the Service during its designation of Critical Habitat continue to affect the species. Unregulated motorized and pedestrian recreational use, inlet and shoreline stabilization projects, beach maintenance and nourishment, and pollution affect most winter and migration areas. Conservation efforts at some locations have likely resulted in the enhancement of wintering habitat.

Northern Great Plains Population

The Northern Great Plains plover breeds from Alberta to Manitoba, Canada and south to Nebraska; although some nesting has recently occurred in Oklahoma. Currently the most westerly breeding piping plovers in the United States occur in Montana and Colorado.
The decline of piping plovers on rivers in the Northern Great Plains has been largely attributed to the loss of sandbar island habitat and forage base due to dam construction and operation. Nesting occurs on sand flats or bare shorelines of rivers and lakes, including sandbar islands in the upper Missouri River system, and patches of sand, gravel, or pebbly-mud on the alkali lakes of the northern Great Plains. Plovers do nest on shorelines of reservoirs created by the dams, but reproductive success is often low and reservoir habitat is not available in many years due to high water levels or vegetation. Dams operated with steady constant flows allow vegetation to grow on potential nesting islands, making these sites unsuitable for nesting. Population declines in alkali wetlands are attributed to wetland drainage, contaminants, and predation.

Since the Northern Great Plains population is geographically widespread, with many birds in very remote places, especially in the U.S. and Canadian alkali lakes. Thus, determining the number of birds or even identifying a clear trend in the population is a difficult task. The International Piping Plover Census (IPPC) was designed, in part, to help deal with this problem by instigating a large effort every five years in which an attempt is made to survey every area with known or potential piping plover breeding habitat during a two-week window (i.e., the first two weeks of June). The relatively short window is designed to minimize double counting if birds move from one area to another. The 1988 recovery plan uses the numbers from the IPPC as a major criterion for delisting, as does the 2006 Canadian Recovery Plan (Environment Canada 2006).

Participation in the IPPC has been excellent on the Northern Great Plains, with a tremendous effort put forth to attempt to survey areas during the census window (Elliot-Smith et al. 2009). The large area to be surveyed and sparse human population in the Northern Great Plains make annual surveys of the entire area impractical, so the IPPC provides an appropriate tool for helping to determine the population trend. Many areas are only surveyed during the IPPC years.

Figure 3 shows the number of adult plovers in the Northern Great Plains (U.S. and Canada) for the four International Censuses. The IPPC shows that the U.S. population decreased between 1991 and 1996, then increased in 2001 and 2006. The Canadian population showed the reverse trend for the first three censuses, increasing slightly as the U.S. population decreased, and then decreasing in 2001. Combined, the IPPC numbers suggest that the population declined from 1991 through 2001, then increased almost 58% between 2001 and 2006 (Elliott-Smith et al. 2009).

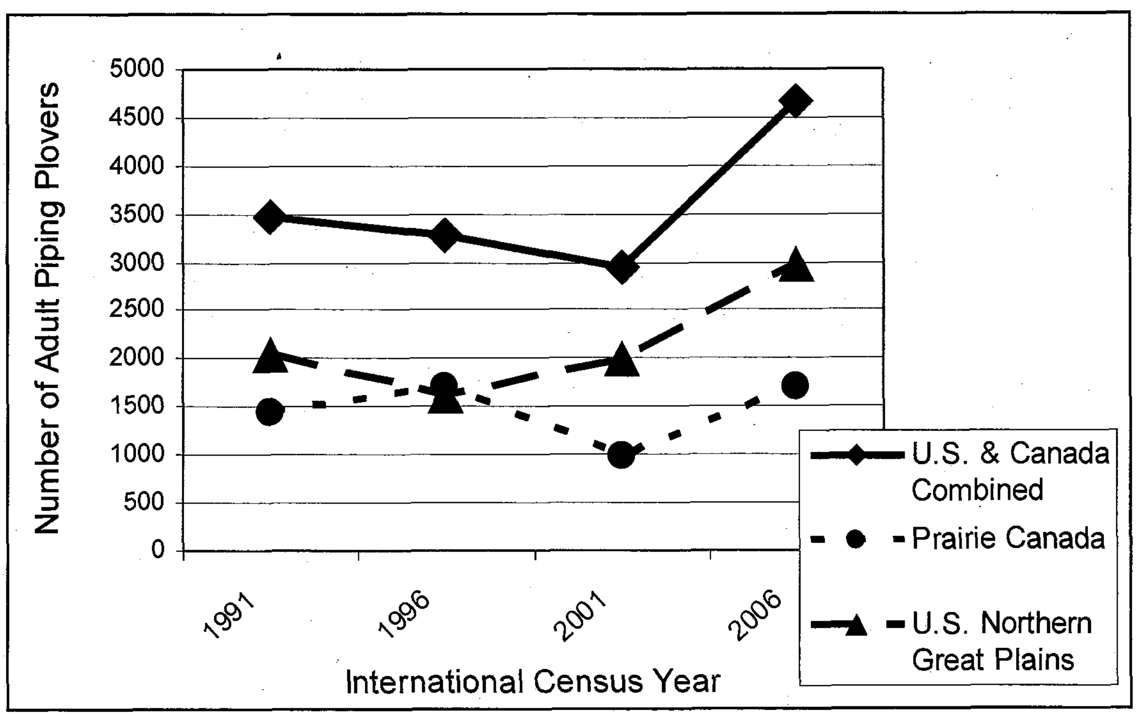


Figure 3. The number of adults reported for the U.S. and Canada Northern Great Plains during the International Censuses compared with the U.S. recovery goal.

The increase in 2006 is likely due in large part to a multi-year drought across the much of the region starting in 2001 that exposed thousands of acres of nesting habitat. The USACE ran low flows on the riverine stretches of the Missouri River for most of the years between censuses, allowing more habitat to be exposed and resulting in relatively high fledge ratios (USACE 2008a). The USACE also began to construct habitat using mechanical means (dredging sand from the riverbed) on the Missouri River in 2004, providing some new nesting and foraging habitat. The drought also caused reservoir levels to drop on many reservoirs throughout the Northern Great Plains (e.g. Missouri River Reservoirs (ND, SD), Lake McConaughey (NE)), providing shoreline habitat. The population increase may also be partially due to more intensive management activities on the alkali lakes, with increased management actions to improve habitat and reduce predation pressures.

While the IPPC provides an index to the piping plover population, the design does not always provide sufficient information to understand the population's dynamics. The five-year time interval between IPPC efforts may be too long to allow managers to get a clear picture of what the short-term population trends are and to respond accordingly if needed. As noted above, the first three IPPCs (1991, 1996, and 2001) showed a declining population, while the fourth (2006) indicated a dramatic population rebound of almost 58% for the combined U.S. and Canada Northern Great Plains population between 2001 and 2006. With only four data points over 15 years, it is impossible to determine if and to what extent the apparent upswing reflects a real population trend versus error(s) in the 2006 census count and/or a previous IPPC. The 2006 IPPC included a detectability component, in which a number of pre-selected sites were visited twice by the same observer(s) during the two-week window to get an estimate of error rate. This study found an approximately 76% detectability rate through the entire breeding area, with a range of between 39% to 78% detectability among habitat types in the Northern Great Plains. Such a large increase in population reported may indeed indicate a positive population trend, but with the limited data available, it is impossible to determine how much. Furthermore, with the next IPPC not scheduled until 2011, there is limited feedback in many areas on whether this increase is being maintained or if the population is declining in the interim. Additionally, the results from the IPPC have been slow to be released, adding to the time lag between data collection and possible management response.

Great Lakes Population

The Great Lakes plovers once nested on Great Lakes beaches in Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, Wisconsin, and Ontario. Great Lakes piping plovers nest on wide, flat, open, sandy or cobble shoreline with very little grass or other vegetation. Reproduction is adversely affected by human disturbance of nesting areas and predation by foxes, gulls, crows and other avian species. Shoreline development, such as the construction of marinas, breakwaters, and other navigation structures, has adversely affected nesting and brood rearing.

The Recovery Plan (Service 2003a) sets a population goal of at least 150 pairs (300 individuals), for at least 5 consecutive years, with at least 100 breeding pairs (200 individuals) in Michigan and 50 breeding pairs (100 individuals) distributed among sites in other Great Lakes states.

The Great Lakes piping plover population, which has been traditionally represented as the number of breeding pairs, has increased since the completion of the recovery plan in 2003 (Cuthbert and Roche 2007; 2006; Westbrock et al. 2005; Stucker and Cuthbert 2004; Stucker et al. 2003). The Great Lakes piping plover recovery plan documents the 2002 population at 51 breeding pairs (USFWS 2003a). The most recent census conducted in 2008 found 63 breeding pairs, an increase of approximately 23%. Of these, 53 pairs were found nesting in Michigan, while 10 were found outside the state, including six pairs in Wisconsin and four in Ontario, Canada. The 53 nesting pairs in Michigan represent approximately 50% of the recovery criterion. The 10 breeding pairs outside Michigan in the Great Lakes basin, represents 20% of the goal, albeit the number of breeding pairs outside Michigan has continued to increase over the past five years. The single breeding pair discovered in 2007 in the Great Lakes region of Canada represented the first confirmed piping plover nest there in over 30 years, and in 2008 the number of nesting pairs further increased to four.

In addition, the number of non-nesting individuals has increased annually since 2003. Between 2003-2008 an annual average of approximately 26 non-nesting piping plovers were observed, based on limited data from 2003, 2006, 2007, and 2008. Although there was some fluctuation in the total population between 2002-2008, the overall increase from 51 to 63 pairs combined with the increased observance of non-breeding individuals indicates the population is increasing. **(Figure 4)**.

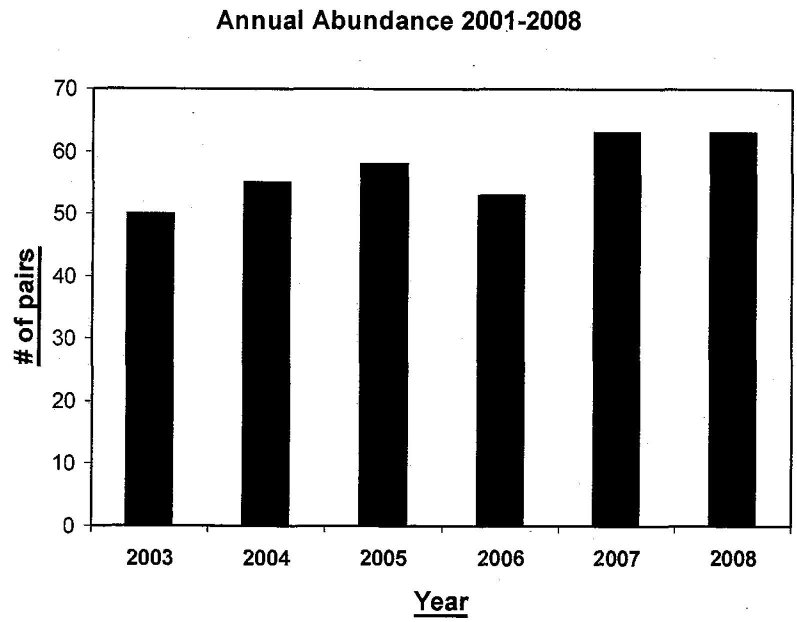


Figure 4. Annual Abundance Estimates for Great Lakes Piping Plovers (2003-2008).

Atlantic Coast Population

The Atlantic Coast piping plover breeds on coastal beaches from Newfoundland and southeastern Quebec to North Carolina. Historical population trends for the Atlantic Coast piping plover have been reconstructed from scattered, largely qualitative records. Nineteenth-century naturalists, such as Audubon and Wilson, described the piping plover as a common summer resident on Atlantic Coast beaches (Haig and Oring 1987). However, by the beginning of the 20th Century, egg collecting and uncontrolled hunting, primarily for the millinery trade, had greatly reduced the population, and in some areas along the Atlantic Coast, the piping plover was close to extirpation. Following passage of the Migratory Bird Treaty Act (40 Stat. 775; 16 U.S.C. 703-712) in 1918, and changes in the fashion industry that no longer exploited wild birds for feathers, piping plover numbers recovered to some extent (Haig and Oring 1985).

Available data suggest that the most recent population decline began in the late 1940s or early 1950s (Haig and Oring 1985). Reports of local or statewide declines between 1950 and 1985 are numerous, and many are summarized by Cairns and McLaren (1980) and Haig and Oring (1985). While Wilcox (1939) estimated more than 500 pairs of piping plovers on Long Island, New York, the 1989 population estimate was 191 pairs (see Table 4, USFWS 1996a). There was little focus on gathering quantitative data on piping plovers in Massachusetts through the late 1960s because the species was commonly observed and presumed to be secure. However, numbers of piping plover breeding pairs declined 50 to 100 percent at seven Massachusetts sites between the early 1970s and 1984 (Griffin and Melvin 1984). Piping plover surveys in the early years of the recovery effort found that counts of these cryptically colored birds sometimes went up with increased census effort, suggesting that some historic counts of piping plovers by one or a few observers may have underestimated the piping plover population. Thus, the magnitude of the species decline may have been more severe than available numbers imply.

Annual estimates of breeding pairs of Atlantic Coast piping plovers are based on multiple surveys at most occupied sites. Sites that cannot be monitored repeatedly in May and June (primarily sites with few pairs or inconsistent occupancy) are surveyed at least once during a standard nine-day count period (Hecht and Melvin 2009).

Since its 1986 listing under the ESA, the Atlantic Coast population estimate has increased 234%, from approximately 790 pairs to an estimated 1,849 pairs in 2008, and the U.S. portion of the population has almost tripled, from approximately 550 pairs to an estimated 1,596 pairs. Even discounting apparent increases in New York, New Jersey, and North Carolina between 1986 and 1989, which likely were due in part to increased census effort (USFWS 1996a), the population nearly doubled between 1989 and 2008. The largest population increase between 1989 and 2008 has occurred in New England (245%), followed by New York-New Jersey (74%). In the Southern (DE-MD-VA-NC) Recovery Unit, overall growth between 1989 and 2008 was 66%, but almost three-quarters of this increase occurred in just two years, 2003-2005. The eastern Canada population fluctuated from year to year, with increases often quickly eroded in subsequent years; net growth between 1989 and 2008 was 9%.

The overall population growth pattern was tempered by periodic rapid declines in the Southern and Eastern Canada Recovery Units. The eastern Canada population decreased 21% in just three years (2002-2005), and the population in the southern half of the Southern Recovery Unit declined 68% in seven years (1995-2001). The recent 64% decline in the Maine population, from 66 pairs in 2002 to 24 pairs in 2008, following only a few years of decreased productivity, provides another example of the continuing risk of rapid and precipitous reversals in population growth.

4) Status and Distribution

Reason for Listing: Hunting during the 19th and early 20th centuries likely led to initial declines in the species; however, shooting piping plovers has been prohibited since 1918 pursuant to the provisions of the Migratory Bird Treaty Act (MBTA). Other human activities, such as habitat loss and degradation, disturbance from recreational pressure, contaminants, and predation are likely responsible for continued declines. These factors include development and shoreline stabilization. The 1985 final rule stated the number of piping plovers on the Gulf of Mexico coastal wintering grounds might be declining as indicated by preliminary analysis of the Christmas Bird Count data. Independent counts of piping plovers on the Alabama coast indicated a decline in numbers between the 1950s and early 1980s. At the time of listing, the Texas Parks and Wildlife Department stated 30 percent of wintering habitat in Texas had been lost over the previous 20 years. The final rule also stated, in addition to extensive breeding area problems, the loss and modification of wintering habitat was a significant threat to the piping plover.

Range-wide Trend: Three range-wide population surveys have been conducted for the piping plover; the 1991 (Haig and Plissner 1992), 1996 (Plissner and Haig 1997), and 2006 ((Elliott-Smith et al. 2009) International Piping Plover Censuses. These surveys were completed to help determine the species distribution and to monitor progress toward recovery.

Recovery Criteria

Delisting of the three piping plover populations may be considered when the following criteria are met:

Northern Great Plains Population (USFWS 1988, 1994)

1. Increase the number of birds in the U.S. northern Great Plains states to 2,300 pairs (Service 1994).
2. Increase the number of birds in the prairie region of Canada to 2,500 adult piping plovers (Service 1988).
3. Secure long term protection of essential breeding and wintering habitat (Service 1994).

Great Lakes Population (USFWS 2003a)

1. At least 150 pairs (300 individuals), for at least 5 consecutive years, with at least 100 breeding pairs (200 individuals) in Michigan and 50 breeding pairs (100 individuals) distributed among sites in other Great Lakes states.
2. Five-year average fecundity within the range of 1.5-2.0 fledglings per pair, per year, across the breeding distribution, and ten-year population projections indicate the population is stable or continuing to grow above the recovery goal.
3. Protection and long-term maintenance of essential breeding and wintering habitat is ensured, sufficient in quantity, quality, and distribution to support the recovery goal of 150 pairs (300 individuals).
4. Genetic diversity within the population is deemed adequate for population

persistence and can be maintained over the long-term.

5. Agreements and funding mechanisms are in place for long-term protection and management activities in essential breeding and wintering habitat.

Atlantic Coast Population (USFWS 1996a)

1. Increase and maintain for 5 years a total of 2,000 breeding pairs, distributed among 4 recovery units.

Recovery Unit	*Minimum Subpopulation*
Atlantic (eastern) Canada	*400 pairs*
New England	*625 pairs*
New York-New Jersey	*575 pairs*
Southern (DE-MD-VA-NC)	*400 pairs*

2. Verify the adequacy of a 2,000 pair population of piping plovers to maintain heterozygosity and allelic diversity over the long term.
3. Achieve a 5-year average productivity of 1.5 fledged chicks per pair in each of the 4 recovery units described in criterion 1, based on data from sites that collectively support at least 90% of the recover unit's population.
4. Institute long-term agreements to assure protection and management sufficient to maintain the population targets and average productivity in each recovery unit.
5. Ensure long-term maintenance of wintering habitat, sufficient in quantity, quality, and distribution to maintain survival rates for a 2,000-pair population.

Breeding Range

Northern Great Plains Population

The IPPC numbers indicate that the Northern Great Plains population (including Canada) declined from 1991 through 2001, and then increased dramatically in 2006. This increase corresponded with a multi-year drought in the Missouri River basin that exposed a great deal of nesting habitat, suggesting that the population can respond fairly rapidly to changes in habitat quantity and quality. Despite this recent improvement, we do not consider the numeric, distributional, or temporal elements of the population recovery criteria achieved.

As the Missouri River basin emerges from drought and breeding habitat is inundated, the population will likely decline. The management activities carried out in many areas during drought conditions have undoubtedly helped to maintain and increase the piping plover population, especially to mitigate for otherwise poor reproductive success during wet years when habitat is limited.

While the population increase seen in recent years demonstrates the possibility that the population can rebound from low population numbers, ongoing efforts are needed to maintain and increase the population. In the U.S., piping plover crews attempt to locate most piping plover nests and take steps to improve their success. This work has suffered from insufficient and unstable funding in most areas.

Emerging threats, such as energy development (particularly wind, oil and gas and associated infrastructure) and climate change are likely to impact piping plovers both on the breeding and wintering grounds. The potential impact of both of these threats is not well understood, and measures to mitigate for them are also uncertain at this time.

In the recently completed status review, the Service concluded that the Northern Great Plains piping plover population remains vulnerable, especially due to management of river systems throughout the breeding range (Service 2009). Many of the threats identified in the 1988 recovery plan, including those affecting Northern Great Plains piping plover population during the two-thirds of its annual cycle spent in the wintering range, remain today or have intensified.

Great Lakes Population

The population has shown significant growth, from approximately 17 pairs at the time of listing in 1986, to 63 pairs in 2008. The total of 63 breeding pairs represents approximately 42% of the current recovery goal of 150 breeding pairs for the Great Lakes population. Productivity goals, as specified in the 2003 recovery plan, have been met over the past 5 years. During this time period the average annual fledging rate has been 1.76, well above the 1.5 fledglings per breeding pair recovery goal. A recent analysis of banded piping plovers in the Great Lakes, however, suggests that after hatch year survival (adult) rates may be declining. Continued population growth will require the long-term maintenance of productivity goals concurrent with measures to sustain or improve important vital rates.

Although initial information considered at the time of the 2003 recovery plan suggested the population may be at risk from a lack of genetic diversity, currently available information suggests that genetic diversity may not pose a high risk to the Great Lakes population. Additional genetic information is needed to assess genetic structure of the population and verify the adequacy of a 150 pair population to maintain long-term heterozygosity and allelic diversity.

Several years of population growth is evidence of the effectiveness of the ongoing Great Lakes piping plover recovery program. Most major threats, however, including habitat degradation, predation, and human disturbance remain persistent and pervasive. Severe threats from human disturbance and predation remain ubiquitous within the Great Lakes. Expensive labor-intensive management to minimize the effects of these continuing threats, as specified in recovery plan tasks, are implemented every year by a network of dedicated governmental and private partners. Because threats to Great Lakes piping plovers persist, reversal of gains in abundance and productivity are expected to quickly follow if current protection efforts are reduced.

Emerging potential threats to piping plovers in the Great Lakes basin include disease, wind turbine generators and, potentially, climate change. A recent out-break of Type E botulism in the Northern Lake Michigan basin resulted in several piping plover mortalities. Future outbreaks in areas that support a concentration of breeding piping plovers could impact survival rates and population abundance. Wind turbine projects, many of which are currently in the planning stages, need further study to determine potential risks to piping plovers and/or their habitat, as well as the need for specific protections to prevent or mitigate impacts. Climate change projections for the Great Lakes include the potential for significant water-level decreases. The degree to which this factor will impact piping plover habitat is unknown, but prolonged water-level decreases are likely to alter habitat condition and distribution.

In the recently completed status review, the Service concluded that the Great Lakes population remains at considerable risk of extinction due to its small size, limited distribution and vulnerability to stochastic events, such as disease outbreak (Service 2009). In addition, the factors that led to the piping plover's 1986 listing remain present.

Atlantic Coast Population

Substantial population growth, from approximately 790 pairs in 1986 to an estimated 1,849 pairs in 2008, has decreased the Atlantic Coast piping plover's vulnerability to extinction since ESA listing. Thus, considerable progress has been made towards the overall goal of 2,000 breeding pairs articulated in recovery criterion 1. As discussed in the 1996 revised recovery plan, however, the overall security of the Atlantic Coast piping plover is fundamentally dependent on even distribution of population growth, as specified in subpopulation targets, to protect a sparsely-distributed species with strict biological requirements from environmental variation (including catastrophes) and increase the likelihood of interchange among subpopulations. Although the New England Recovery Unit has sustained its subpopulation target for the requisite five years, and the New York-New Jersey Recovery Unit reached its target in 2007 (but dipped below again in 2008), considerable additional growth is needed in the Southern and Eastern Canada Recovery Units (recovery criterion 1).

Productivity goals (criterion 3) specified in the 1996 recovery plan must be revised to accommodate new information about latitudinal variation in productivity needed to maintain a stationary population. Population growth, particularly in the three U.S. recovery units, provides indirect evidence that adequate productivity has occurred in at least some years. However, overall security of a 2,000 pair population will require long-term maintenance of these revised recovery-unit-specific productivity goals concurrent with population numbers at or above abundance goals.

Twenty years of relatively steady population growth, driven by productivity gains, also evidences the efficacy of the ongoing Atlantic Coast piping plover recovery program. However, all of the major threats (habitat loss and degradation, predation, human disturbance, and inadequacy of other (non-ESA) regulatory mechanisms) identified in the 1986 ESA listing and 1996 revised recovery plan remain persistent and pervasive. Indeed, recent information heightens the importance of conserving the low, sparsely vegetated beaches juxtaposed with abundant moist foraging substrates preferred by breeding Atlantic Coast piping plovers; development and artificial shoreline stabilization pose continuing widespread threats to this habitat. Severe threats from human disturbance and predation remain ubiquitous along the Atlantic Coast. Expensive labor-intensive management to minimize the effects of these continuing threats, as specified in recovery plan tasks, are implemented every year by a network of dedicated governmental and private cooperators. Because threats to Atlantic Coast piping plovers persist (and in many cases have increased since listing), reversal of gains in abundance and productivity would quickly follow diminishment of current protection efforts.

Finally, two emerging potential threats, wind turbine generators and climate change (especially sea-level rise) are likely to affect Atlantic Coast piping plovers throughout their life cycle. These two threats must be evaluated to ascertain their effects on piping plovers and/or their habitat, as well as the need for specific protections to prevent or mitigate impacts that could otherwise increase overall risks the species.

In the recently completed status review, the Service concluded that the Atlantic Coast piping plover remains vulnerable to low numbers in the Southern and Eastern Canada (and, to a lesser extent, the New York-New Jersey) Recovery Units (Service 2009). Furthermore, the factors that led to the piping plover's 1986 listing remain operative rangewide (including in New England), and many of these threats have increased. Interruption of costly, labor-intensive efforts to manage these threats would quickly lead to steep population declines.

Nonbreeding Range

Piping plovers spend up to 10 months of their life cycle on their migration and winter grounds, generally July 15 through as late as May 15. Piping plover migration routes and habitats overlap breeding and wintering habitats, and, unless banded, migrants passing through a site usually are indistinguishable from breeding or wintering piping plovers. Migration stopovers by banded piping plovers from the Great Lakes have been documented in New Jersey, Maryland, Virginia, and North Carolina (Stucker and Cuthbert 2006). Migrating breeders from eastern Canada have been observed in Massachusetts, New Jersey, New York, and North Carolina (Amirault et al. 2005). As many as 85 staging piping plovers have been tallied at various sites in the Atlantic breeding range (Perkins 2008 pers. communication), but the composition (e.g., adults that nested nearby and their fledged young of the year versus migrants moving to or from sites farther north), stopover duration, and local movements are unknown. In general, distance between stopover locations and duration of stopovers throughout the coastal migration range remains poorly understood.

Review of published records of piping plover sightings throughout North America by Pompei and Cuthbert (2004) found more than 3,400 fall and spring stopover records at 1,196 sites. Published reports indicated that piping plovers do not concentrate in large numbers at inland sites and that they seem to stop opportunistically. In most cases, reports of birds at inland sites were single individuals.

Piping plovers migrate through and winter in coastal areas of the U.S. from North Carolina to Texas and in portions of Mexico and the Caribbean. Gratto-Trevor et al. (2009) reported that six of 259 banded piping plovers observed more than once per winter moved across boundaries of the seven U.S. regions. This species exhibits a high degree of intra- and inter-annual wintering site fidelity (Nicholls and Baldassarre 1990; Drake et al. 2001; Noel et al. 2005; Stucker and Cuthbert 2006). Of 216 birds observed in different years, only eight changed regions between years, and several of these shifts were associated with late summer or early spring migration periods (Gratto-Trevor et al. 2009). Local movements are more common. In South Carolina, Maddock et al. (2009) documented many cross-inlet movements by wintering banded piping plovers as well as occasional movements of up to 18 km by approximately 10% of the banded population; larger movements within South Carolina were seen during fall and spring migration. Similarly, eight banded piping plovers that were observed in two locations during 2006-2007 surveys in Louisiana and Texas were all in close proximity to their original location, such as on the bay and ocean side of the same island or on adjoining islands (Maddock 2008).

Gratto-Trevor et al. (2009) found strong patterns (but no exclusive partitioning) in winter distribution of uniquely banded piping plovers from four breeding populations (**Figure 5**). All eastern Canada and 94% of Great Lakes birds wintered from North Carolina to southwest Florida. However, eastern Canada birds were more heavily concentrated in North Carolina, and a larger proportion of Great Lakes piping plovers were found in South Carolina and Georgia. Northern Great Plains populations were primarily seen farther west and south, especially on the Texas Gulf Coast. Although the great majority of Prairie Canada individuals were observed in Texas, particularly southern Texas, individuals from the U.S. Great Plains were more widely distributed on the Gulf Coast from Florida to Texas.

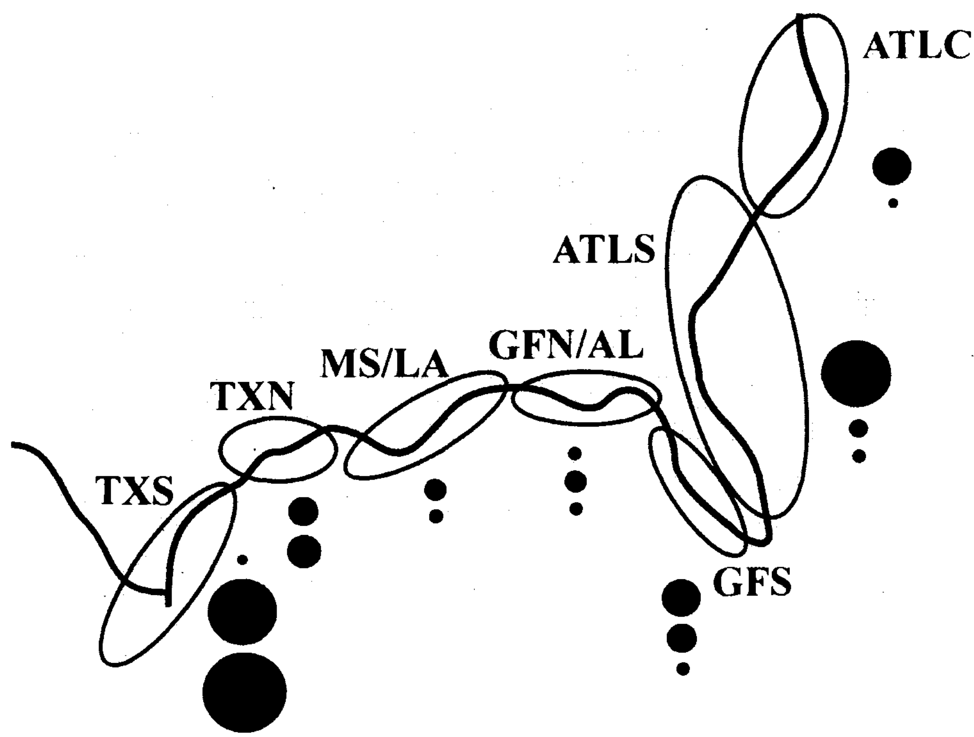


Figure 5. (from Gratto-Trevor et al. 2009, reproduced by permission). Breeding population distribution in the wintering/migration range. Regions: ATLC=Atlantic (eastern) Canada; GFS=Gulf Coast of southern Florida; GFN=Gulf Coast of north Florida; AL=Alabama; MS/LA=Mississippi and Louisiana; TXN=northern Texas; and TXS=southern Texas. For each breeding population, circles represent the percentage of individuals reported wintering along the eastern coast of the U.S. from the central Atlantic to southern Texas/Mexico up to December 2008. Each individual was counted only once. Grey circles represent Eastern Canada birds, Orange U.S. Great Lakes, Green U.S. Great Plains, and Black Prairie Canada. The relative size of the circle represents the percentage from a specific breeding area seen in that winter region. Total number of individuals observed on the wintering grounds was 46 for Eastern Canada, 150 for the U.S. Great Lakes, 169 for the U.S. Great Plains, and 356 for Prairie Canada.

The findings of Gratto-Trevor et al. (2009) provide evidence of differences in the wintering distribution of piping plovers from these four breeding areas. However, the distribution of birds by breeding origin during migration remains largely unknown. Other major information gaps include the wintering locations of the U.S. Atlantic Coast breeding population (banding of U.S. Atlantic Coast piping plovers has been extremely limited) and the breeding origin of piping plovers wintering on Caribbean islands and in much of Mexico. Banded piping plovers from the Great Lakes, Northern Great Plains, and eastern Canada breeding populations showed similar patterns of seasonal abundance at Little St. Simons Island, Georgia (Noel et al. 2007). However, the number of banded plovers originating from the latter two populations was relatively small at that study area.

Four rangewide mid-winter (late January to early February) population surveys, conducted at five-year intervals starting in 1991, are summarized in **Table 6**. Total numbers have fluctuated over time, with some areas experiencing increases and others decreases. Regional and local fluctuations may reflect the quantity and quality of suitable foraging and roosting habitat, which vary over time in response to natural coastal formation processes as well as anthropogenic habitat changes (e.g., inlet relocation, dredging of shoals and spits). Fluctuations may also represent localized weather conditions (especially wind) during surveys, or unequal survey coverage. Changes in wintering numbers may also be influenced by growth or decline in the particular breeding populations that concentrate their wintering distribution in a given area.

Mid-winter surveys may substantially underestimate the abundance of nonbreeding piping plovers using a site or region during other months. In late September 2007, 104 piping plovers were counted at the south end of Ocracoke Island, North Carolina (NPS 2007), where none were seen during the 2006 International Piping Plover Winter Census (Elliott-Smith et al. 2009). Noel et al. (2007) observed up to 100 piping plovers during peak migration at Little St. Simons Island, Georgia, where approximately 40 piping plovers wintered in 2003–2005. Differences among fall, winter, and spring counts in South Carolina were less pronounced, but inter-year fluctuations (e.g., 108 piping plovers in spring 2007 versus 174 piping plovers in spring 2008) at 28 sites were striking (Maddock et al. 2009). Even as far south as the Florida Panhandle, monthly counts at Phipps Preserve in Franklin County ranged from a mid-winter low of four piping plovers in December 2006 to peak counts of 47 in October 2006 and March 2007 (Smith 2007). Pinkston (2004) observed much heavier use of Texas Gulf Coast (ocean-facing) beaches between early September and mid-October (approximately 16 birds per mile) than during December to March (approximately two birds per mile).

Table 6. Results of the 1991, 1996, 2001, and 2006 International Piping Plover Winter Censuses (Haig et al. 2005; Elliott-Smith et al. 2009).

Location	**1991**	**1996**	**2001**	**2006**
Virginia	not surveyed (ns)	ns	ns	1
North Carolina	20	50	87	84
South Carolina	51	78	78	100
Georgia	37	124	111	212
Florida	**551**	**375**	**416**	**454**
-Atlantic	***70***	***31***	***111***	***133***
-Gulf	***481***	***344***	***305***	***321***
Alabama	12	31	30	29
Mississippi	59	27	18	78
Louisiana	750	398	511	226
Location	**1991**	**1996**	**2001**	**2006**
Texas	1,904	1,333	1,042	2,090
Puerto Rico	0	0	6	Ns
U.S. Total	**3,384**	**2,416**	**2,299**	**3,355**
Mexico	27	16	Ns	76
Bahamas	29	17	35	417
Cuba	11	66	55	89
Other Caribbean Islands	0	0	0	28
GRAND TOTAL	**3,451**	**2,515**	**2,389**	**3,884**
Percent of Total International Piping Plover Breeding Census	62.9%	42.4%	40.2%	48.2%

Local movements of nonbreeding piping plovers may also affect abundance estimates. At Deveaux Bank, one of South Carolina's most important piping plover sites, five counts at approximately 10-day intervals between August 27 and October 7, 2006, oscillated from 28 to 14 to 29 to 18 to 26 (Maddock et al. 2009). Noel and Chandler (2008) detected banded Great Lakes piping plovers known to be wintering on their Georgia study site in 73.8 $\pm$ 8.1 % of surveys over three years.

Abundance estimates for nonbreeding piping plovers may also be affected by the number of surveyor visits to the site. Preliminary analysis of detection rates by Maddock et al. (2009) found 87% detection during the mid-winter period on core sites surveyed three times a month during fall and spring and one time per month during winter, compared with 42% detection on sites surveyed three times per year (Cohen 2009 pers. communication).

The 2004 and 2005 hurricane seasons affected a substantial amount of habitat along the Gulf Coast. Habitats such as those along Gulf Islands National Seashore have benefited from increased washover events, which created optimal habitat conditions for piping plovers. Conversely, hard shoreline structures put into place following storms throughout the species range to prevent such shoreline migration prevent habitat creation (see *Factors Affecting Species Environment within the Action Area*). Four hurricanes between 2002 and 2005 are often cited in reference to rapid erosion of the Chandeleur Islands, a chain of low-lying islands in Louisiana where the 1991 International Piping Plover Census tallied more than 350 piping plovers. Comparison of imagery taken three years before and several days after Hurricane Katrina found that the Chandeleur Islands lost 82% of their surface area (Sallenger et al. 2009 in review), and a review of aerial photography prior to the 2006 Census suggested little piping plover habitat remained (Elliott-Smith et al. 2009). However, Sallenger et al. (2009 in review) noted that habitat changes in the Chandeleurs stem not only from the effects of these storms but rather from the combined effects of the storms, long-term (>1,000 years) diminishing sand supply, and sea-level rise relative to the land.

The Service is aware of the following site-specific conditions that benefit several habitats piping plover use while wintering and migrating, including critical habitat units. In Texas, one critical habitat unit was afforded greater protection due to the acquisition of adjacent upland properties by the local Audubon chapter. In another unit in Texas, vehicles were removed from a portion of the beach decreasing the likelihood of automobile disturbance to plovers. Exotic plant removal that threatens to invade suitable piping plover habitat is occurring in a critical habitat unit in South Florida. The Service and other government agencies remain in a contractual agreement with the USDA for predator control within limited coastal areas in the Florida panhandle, including portions of some critical habitat units. Continued removal of potential terrestrial predators is likely to enhance survivorship of wintering and migrating piping plovers. In North Carolina, one critical habitat unit was afforded greater protection when the local Audubon chapter agreed to manage the area specifically for piping plovers and other shorebirds following the relocation of the nearby inlet channel.

The status of piping plovers on winter and migration grounds is difficult to assess, but threats to piping plover habitat used during winter and migration identified by the Service during its designation of critical habitat continue to affect the species. Unregulated motorized and pedestrian recreational use, inlet and shoreline stabilization projects, beach maintenance and nourishment, and pollution affect most winter and migration areas. Conservation efforts at some locations have likely resulted in the enhancement of wintering habitat.

Threats to Piping Plovers

The three recovery plans stated that shoreline development throughout the wintering range poses a threat to all populations of piping plovers. The plans further stated that beach maintenance and nourishment, inlet dredging, and artificial structures, such as jetties and groins, could eliminate wintering areas and alter sedimentation patterns leading to the loss of nearby habitat.

Important components of ecologically sound barrier beach management include perpetuation of natural dynamic coastal formation processes. Structural development along the shoreline or manipulation of natural inlets upsets the dynamic processes and results in habitat loss or degradation (Melvin et al. 1991). Throughout the range of migrating and wintering piping plovers, inlet and shoreline stabilization, inlet dredging, beach maintenance and nourishment activities, and seawall installations continue to constrain natural coastal processes. Dredging of inlets can affect spit formation adjacent to inlets and directly remove or affect ebb and flood tidal shoal formation. Jetties, which stabilize an island, cause island widening and subsequent growth of vegetation on inlet shores. Seawalls restrict natural island movement and exacerbate erosion. As discussed in more detail below, all these efforts result in loss of piping plover habitat. Construction of these projects during months when piping plovers are present also causes disturbance that disrupts the birds' foraging efficiency and hinders their ability to build fat reserves over the winter and in preparation for migration, as well as their recuperation from migratory flights. In addition, up to 24 shorebird species migrate or winter along the Atlantic Coast and almost 40 species of shorebirds are present during migration and wintering periods in the Gulf of Mexico region (Helmers 1992). Continual degradation and loss of habitats used by wintering and migrating shorebirds may cause an increase in intra-specific and inter-specific competition for remaining food supplies and roosting habitats. In Florida, for example, approximately 825 miles of coastline and parallel bayside flats (unspecified amount) were present prior to the advent of high human densities and beach stabilization projects. We estimate that only about 35% of the Florida coastline continues to support natural coastal formation processes, thereby concentrating foraging and roosting opportunities for all shorebird species and forcing some individuals into suboptimal habitats. Thus, intra- and inter-specific competition most likely exacerbates threats from habitat loss and degradation.

Sand placement projects

In the wake of episodic storm events, managers of lands under public, private, and county ownership often protect coastal structures using emergency storm berms; this is frequently followed by beach nourishment or renourishment activities (nourishment projects are considered "soft" stabilization versus "hard" stabilization such as seawalls). Berm placement and beach nourishment deposit substantial amounts of sand along Gulf of Mexico and Atlantic beaches to protect local property in anticipation of preventing erosion and what otherwise will be considered natural processes of overwash and island migration (Schmitt and Haines 2003).

Past and ongoing stabilization projects fundamentally alter the naturally dynamic coastal processes that create and maintain beach strand and bayside habitats, including those habitat components that piping plovers rely upon. Although impacts may vary depending on a range of factors, stabilization projects may directly degrade or destroy piping plover roosting and foraging habitat in several ways. Front beach habitat may be used to construct an artificial berm that is densely planted in grass, which can directly reduce the availability of roosting habitat. Over time, if the beach narrows due to erosion, additional roosting habitat between the berm and the water can be lost. Berms can also prevent or reduce the natural overwash that creates roosting habitats by converting vegetated areas to open sand areas. The vegetation growth caused by impeding natural overwash can also reduce the maintenance and creation of bayside intertidal feeding habitats. In addition, stabilization projects may indirectly encourage further development of coastal areas and increase the threat of disturbance.

At least 668 of 2,340 coastal shoreline miles (29% of beaches throughout the piping plover winter and migration range in the U.S.) are bermed, nourished, or renourished, generally for recreational purposes and to protect commercial and private infrastructure. However, only approximately 54 miles or 2.31% of these impacts have occurred within critical habitat. In Louisiana, sediment placement projects are deemed environmental restoration projects by the USFWS, because without the sediment, many areas would erode below sea level.

Table 7. Summary of the extent of nourished beaches in piping plover wintering and migrating habitat within the conterminous U.S. From USFWS unpublished data (project files, gray literature, and field observations).

State	**Sandy beach shoreline miles available**	**Sandy beach shoreline miles nourished to date (within critical habitat units)**	**Percent of sandy beach shoreline affected (within critical habitat units)**
North Carolina	301[1]	117[5] (unknown)	39 (unknown)
South Carolina	187[1]	56 (0.6)	30 (0.32))
Georgia	100[1]	8 (0.4)	8 (0.40)
Florida	825[2]	404 (6)[6]	49 (0.72)
Alabama	53[1]	12 (2)	23 (3.77)
Mississippi	110[3]	≥6 (0)	5 (0)
Louisiana	397[1]	Unquantified (usually restoration-oriented)	Unknown
Texas	367[4]	65 (45)	18 (12.26)
Overall Total	2,340 (does not include Louisiana)	≥668 does not include Louisiana (54 in CH)	29% (≥2.31% in CH)

Data from [1]www.50states.com; [2] Clark 1993; [3]N.Winstead, Mississippi Museum of Natural Science 2008; [4] www.Surfrider.org; [5] H. Hall, USFWS, pers. comm. 2009; [6] partial data from Lott et al. (2009a).

Inlet stabilization/relocation

Many navigable mainland or barrier island tidal inlets along the Atlantic and Gulf of Mexico coasts are stabilized with jetties, groins, or by seawalls and/or adjacent industrial or residential development. Jetties are structures built perpendicular to the shoreline that extend through the entire nearshore zone and past the breaker zone (Hayes and Michel 2008) to prevent or decrease sand deposition in the channel. Inlet stabilization with rock jetties and associated channel dredging for navigation alter the dynamics of longshore sediment transport and affect the location and movement rate of barrier islands (Camfield and Holmes 1995), typically causing downdrift erosion. Sediment is then dredged and added back to islands which subsequently widen. Once the island becomes stabilized, vegetation encroaches on the bayside habitat, thereby diminishing and eventually destroying its value to piping plovers. Accelerated erosion may compound future habitat loss, depending on the degree of sea-level rise. Unstabilized inlets naturally migrate, re-forming important habitat components, whereas jetties often trap sand and cause significant erosion of the downdrift shoreline. These combined actions affect the availability of piping plover habitat (Cohen et al. 2008).

Using Google Earth© (accessed April 2009), Service's biologists visually estimated the number of navigable mainland or barrier island tidal inlets throughout the wintering range of the piping plover in the conterminous U.S. that have some form of hardened structure. This includes seawalls or adjacent development, which lock the inlets in place (**Table 8**).

Table 8. Number of hardened inlets by state. Asterisk (*) represents an inlet at the state line, in which case half an inlet is counted in each state.

State	**Visually estimated number of navigable mainland and barrier island inlets per state**	**Number of hardened inlets**	**% of inlets affected**
North Carolina	20	2.5*	12.5%
South Carolina	34	3.5*	10.3%
Georgia	26	2	7.7%
Florida	82	41	50%
Alabama	14	6	42.9%
Mississippi	16	7	43.8%
Louisiana	40	9	22.5%
Texas	17	10	58.8%
Overall Total	249	81	32.5%

Tidal inlet relocation can cause loss and/or degradation of piping plover habitat; although less permanent than construction of hard structures, effects can persist for years. Service biologists are aware of at least seven inlet relocation projects (two in North Carolina, three in South Carolina, two in Florida), but this number likely under-represents the extent of this activity.

Sand mining/dredging

Sand mining, the practice of extracting (dredging) sand from sand bars, shoals, and inlets in the nearshore zone, is a less expensive source of sand than obtaining sand from offshore shoals for beach nourishment. Sand bars and shoals are sand sources that move onshore over time and act as natural breakwaters. Inlet dredging reduces the formation of exposed ebb and flood tidal shoals considered to be primary or optimal piping plover roosting and foraging habitat. Removing these sand sources can alter depth contours and change wave refraction as well as cause localized erosion (Hayes and Michel 2008). Exposed shoals and sandbars are also valuable to piping plovers, as they tend to receive less human recreational use (because they are only accessible by boat) and therefore provide relatively less disturbed habitats for birds. We do not have a good estimate of the amount of sand mining that occurs across the piping plover wintering range, nor do we have a good estimate of the number of inlet dredging projects that occur. Most jettied inlets need maintenance dredging, but non-hardened inlets are often dredged as well.

Groins

Groins (structures made of concrete, rip rap, wood, or metal built perpendicular to the beach in order to trap sand) are typically found on developed beaches with severe erosion. Although groins can be individual structures, they are often clustered along the shoreline. Groins can act as barriers to longshore sand transport and cause downdrift erosion (Hayes and Michel 2008), which prevents piping plover habitat creation by limiting sediment deposition and accretion. These structures are found throughout the southeastern Atlantic Coast, and although most were in place prior to the piping plover's 1986 ESA listing, installation of new groins continues to occur.

Seawalls and revetments

Seawalls and revetments are vertical hard structures built parallel to the beach in front of buildings, roads, and other facilities to protect them from erosion. However, these structures often accelerate erosion by causing scouring in front of and downdrift from the structure (Hayes and Michel 2008), which can eliminate intertidal foraging habitat and adjacent roosting habitat. Physical characteristics that determine microhabitats and biological communities can be altered after installation of a seawall or revetment, thereby depleting or changing composition of benthic communities that serve as the prey base for piping plovers. At four California study sites, each comprised of an unarmored segment and a segment seaward of a seawall, Dugan and Hubbard (2006) found that armored segments had narrower intertidal zones, smaller standing crops of macrophyte wrack, and lower shorebird abundance and species richness. Geotubes (long cylindrical bags made of high-strength permeable fabric and filled with sand) are softer alternatives, but act as barriers by preventing overwash. We did not find any sources that summarize the linear extent of seawall, revetment, and geotube installation projects that have occurred across the piping plover's wintering and migration habitat.

Exotic/invasive vegetation

A recently identified threat to piping plover habitat, not described in the listing rule or recovery plans, is the spread of coastal invasive plants into suitable piping plover habitat. Like most invasive species, coastal exotic plants reproduce and spread quickly and exhibit dense growth habits, often outcompeting native plant species. If left uncontrolled, invasive plants cause a habitat shift from open or sparsely vegetated sand to dense vegetation, resulting in the loss or degradation of piping plover roosting habitat, which is especially important during high tides and migration periods.

Beach vitex (*Vitex rotundifolia*) is a woody vine introduced into the southeastern U.S. as a dune stabilization and ornamental plant (Westbrooks and Madsen 2006). It currently occupies a very small percentage of its potential range in the U.S.; however, it is expected to grow well in coastal communities throughout the southeastern U.S. from Virginia to Florida, and west to Texas (Westbrooks and Madsen 2006). In 2003, the plant was documented in New Hanover, Pender, and Onslow counties in North Carolina, and at 125 sites in Horry, Georgetown, and Charleston counties in South Carolina. Beach vitex has been documented from two locations in northwest Florida, but one site disappeared after erosional storm events. The landowner of the other site has indicated an intention to eradicate the plant, but follow through is unknown (Farley 2009 pers. communication). Task forces formed in North and South Carolina in 2004-05 have made great strides to remove this plant from their coasts. To date, about 200 sites in North Carolina have been treated, with 200 additional sites in need of treatment. Similar efforts are underway in South Carolina.

Unquantified amounts of crowfootgrass (*Dactyloctenium aegyptium*) grow invasively along portions of the Florida coastline. It forms thick bunches or mats that may change the vegetative structure of coastal plant communities and alter shorebird habitat.

The Australian pine (*Casuarina equisetifolia*) changes the vegetative structure of the coastal community in south Florida and islands within the Bahamas. Shorebirds prefer foraging in open areas where they are able to see potential predators, and tall trees provide good perches for avian predators. Australian pines potentially impact shorebirds, including the piping plover, by reducing attractiveness of foraging habitat and/or increasing avian predation.

The propensity of these exotic species to spread, and their tenacity once established, make them a persistent threat, partially countered by increasing landowner awareness and willingness to undertake eradication activities.

Wrack removal and beach cleaning

Wrack on beaches and baysides provides important foraging and roosting habitat for piping plovers (Drake 1999a; Smith 2007; Maddock et al. 2009; Lott et al. 2009b; and many other shorebirds on their winter, breeding, and migration grounds. Because shorebird numbers are positively correlated with wrack cover and biomass of their invertebrate prey that feed on wrack (Tarr and Tarr 1987; Hubbard and Dugan 2003; Dugan et al. 2003), grooming will lower bird numbers (Defreo et al. 2009).

There is increasing popularity in the Southeast, especially in Florida, for beach communities to carry out "beach cleaning" and "beach raking" actions. Beach cleaning occurs on private beaches, where piping plover use is not well documented, and on some municipal or county beaches that are used by piping plovers. Most wrack removal on state and federal lands is limited to post-storm cleanup and does not occur regularly.

Man-made beach cleaning and raking machines effectively remove seaweed, fish, glass, syringes, plastic, cans, cigarettes, shells, stone, wood, and virtually any unwanted debris (Barber Beach Cleaning Equipment 2009). These efforts remove accumulated wrack, topographic depressions, and sparse vegetation nodes used by roosting and foraging piping plovers. Removal of wrack also eliminates a beach's natural sand-trapping abilities, further destabilizing the beach. In addition, sand adhering to seaweed and trapped in the cracks and crevices of wrack is removed from the beach. Although the amount of sand lost due to single sweeping actions may be small, it adds up considerably over a period of years (Nordstrom et al. 2006; Neal et al. 2007). Beach cleaning or grooming can result in abnormally broad unvegetated zones that are inhospitable to dune formation or plant colonization, thereby enhancing the likelihood of erosion (Defreo et al. 2009).

Predation

The 1996 Atlantic Coast Recovery Plan summarized evidence that human activities affect types, numbers, and activity patterns of some predators, thereby exacerbating natural predation on breeding piping plovers. The impact of predation on migrating or wintering piping plovers remains largely undocumented.

Recreational disturbance

Intense human disturbance in shorebird winter habitat can be functionally equivalent to habitat loss if the disturbance prevents birds from using an area (Goss-Custard et al. 1996), which can lead to roost abandonment and local population declines (Burton et al. 1996). Pfister et al.

(1992) implicate anthropogenic disturbance as a factor in the long-term decline of migrating shorebirds at staging areas. Disturbance, i.e., human and pet presence that alters bird behavior, disrupts piping plovers as well as other shorebird species. Disturbance can cause shorebirds to spend less time roosting or foraging and more time in alert postures or fleeing from the disturbances (Johnson and Baldassarre 1988; Burger 1991; Burger 1994; Elliott and Teas 1996; Lafferty 2001a, 2001b; Thomas et al. 2002), which limits the local abundance of piping plovers (Zonick and Ryan 1995; Zonick 2000). Shorebirds that are repeatedly flushed in response to disturbance expend energy on costly short flights (Nudds and Bryant 2000).

Shorebirds are more likely to flush from the presence of dogs than people, and birds react to dogs from farther distances than people (Lafferty 2001a; 2001b; Thomas et al. 2002). Dogs off leash are more likely to flush piping plovers from farther distances than are dogs on leash; nonetheless, dogs both on and off leashes disturb piping plovers (Hoopes 1993). Pedestrians walking with dogs often go through flocks of foraging and roosting shorebirds; some even encourage their dogs to chase birds.

Off-road vehicles can significantly degrade piping plover habitat (Wheeler 1979) or disrupt the birds' normal behavior patterns (Zonick 2000). The 1996 Atlantic Coast recovery plan cites tire ruts crushing wrack into the sand, making it unavailable as cover or as foraging substrate (Hoopes 1993; Goldin 1993). The plan also notes that the magnitude of the threat from off-road vehicles is particularly significant, because vehicles extend impacts to remote stretches of beach where human disturbance will otherwise be very slight. Godfrey et al. (1980 as cited *in* Lamont et al. 1997) postulated that vehicular traffic along the beach may compact the substrate and kill marine invertebrates that are food for the piping plover. Zonick (2000) found that the density of off-road vehicles negatively correlated with abundance of roosting piping plovers on the ocean beach. Cohen et al. (2008) found that radio-tagged piping plovers using ocean beach habitat at Oregon Inlet in North Carolina were far less likely to use the north side of the inlet where off-road vehicle use is allowed, and recommended controlled management experiments to determine if recreational disturbance drives roost site selection. Ninety-six percent of piping plover detections were on the south side of the inlet even though it was farther away from foraging sites (1.8 km from the sound side foraging site to the north side of the inlet versus 0.4 km from the sound side foraging site to the north side of the inlet; Cohen et al. 2008).

Based on surveys with land managers and biologists, knowledge of local site conditions, and other information, we have estimated the levels of eight types of disturbance at sites in the U.S. with wintering piping plovers. There are few areas used by wintering piping plovers that are devoid of human presence, and just under half have leashed and unleashed dog presence (Smith 2007; Lott et al. 2009b; Service unpubl. data 2009; Maddock and Bimbi unpubl. data). **Table 9** summarizes the disturbance analysis results. Data are not available on human disturbance at wintering sites in the Bahamas, other Caribbean countries, or Mexico.

Table 9. Percent of known piping plover winter and migration habitat locations, by state, where various types of anthropogenic disturbance have been reported.

	Percent by State							
Disturbance Type	**AL**	**FL**	**GA**	**LA**	**MS**	**NC**	**SC**	**TX**
Pedestrians	67	92	94	25	100	100	88	54
Dogs on leash	67	69	31	25	73	94	25	25
Dogs off leash	67	81	19	25	73	94	66	46
Bikes	0	19	63	25	0	0	28	19
ATVs	0	35	0	25	0	17	25	30
ORVs	0	21	0	25	0	50	31	38
Boats	33	65	100	100	0	78	63	44
Kite surfing	0	10	0	0	0	33	0	0

Although the timing, frequency, and duration of human and dog presence throughout the wintering range are unknown, studies in Alabama and South Carolina suggest that most disturbances to piping plovers occurs during periods of warmer weather, which coincides with piping plover migration (Johnson and Baldassarre 1988; Lott et al. 2009b; Maddock et al. 2009). Smith (2007) documents varying disturbance levels throughout the nonbreeding season at northwest Florida sites.

LeDee (2008) collected survey responses in 2007 from 35 managers (located in seven states) at sites that were designated as critical habitat for wintering piping plovers. Ownership included federal, state, and local governmental agencies and non-governmental organizations managing national wildlife refuges; national, state, county, and municipal parks; state and estuarine research reserves; state preserves; state wildlife management areas; and other types of managed lands. Of 44 reporting sites, 40 allowed public beach access year-round and four sites were closed to the public. Of the 40 sites that allow public access, 62% of site managers reported >10,000 visitors during September-March, and 31% reported >100,000 visitors. Restrictions on visitor activities on the beach included automobiles (at 81% of sites), all-terrain vehicles (89%), and dogs during the winter season (50%). Half of the survey respondents reported funding as a primary limitation in managing piping plovers and other threatened and endangered species at their sites. Other limitations included "human resource capacity" (24%), conflicting management priorities (12%), and lack of research (3%).

Disturbance can be addressed by implementing recreational management techniques such as vehicle and pet restrictions and symbolic fencing (usually sign posts and string) of roosting and feeding habitats. In implementing conservation measures, managers need to consider a range of site-specific factors, including the extent and quality of roosting and feeding habitats and the types and intensity of recreational use patterns. In addition, educational materials such as informational signs or brochures can provide valuable information so that the public understands the need for conservation measures.

In sum, although there is some variability among states, disturbance from human beach recreation and pets poses a moderate to high and escalating threat to migrating and wintering piping plovers. Systematic review of recreation policy and beach management across the nonbreeding range will assist in better understanding cumulative impacts. Site-specific analysis and implementation of conservation measures should be a high priority at piping plover sites that have moderate or high levels of disturbance and the Service and state wildlife agencies should increase technical assistance to land managers to implement management strategies and monitor their effectiveness.

Climate Change (sea-level rise)

Over the past 100 years, the globally-averaged sea level has risen approximately 10-25 centimeters (Rahmstorf et al. 2007), a rate that is an order of magnitude greater than that seen in the past several thousand years (Douglas et al. 2001 as cited in Hopkinson et al. 2008). The IPCC suggests that by 2080 sea-level rise could convert as much as 33% of the world's coastal wetlands to open water (IPCC 2007). Although rapid changes in sea level are predicted, estimated time frames and resulting water levels vary due to the uncertainty about global temperature projections and the rate of ice sheets melting and slipping into the ocean (IPCC 2007; CCSP 2008).

Potential effects of sea-level rise on coastal beaches may vary regionally due to subsidence or uplift as well as the geological character of the coast and nearshore (CCSP 2009; Galbraith et al. 2002). In the last century, for example, sea-level rise along the U.S. Gulf Coast exceeded the global average, and averages as high as 0.32 inches per year, because those areas are subsiding (USEPA 2014). Sediment compaction and oil and gas extraction compound tectonic subsidence (Penland and Ramsey 1990; Morton et al. 2003; Hopkinson et al. 2008). Low elevations and proximity to the coast make all nonbreeding coastal piping plover foraging and roosting habitats vulnerable to the effects of rising sea level. Sea-level rise was cited as a contributing factor in the 68% decline in tidal flats and algal mats in the Corpus Christi area (i.e., Lamar Peninsula to Encinal Peninsula) in Texas between the 1950s and 2004 (Tremblay et al. 2008). Mapping by Titus and Richman (2001) showed that more than 80% of the lowest land along the Atlantic and

Gulf coasts was in Louisiana, Florida, Texas, and North Carolina, where 73.5% of all wintering piping plovers were tallied during the 2006 International Piping Plover Census (Elliott-Smith et al. 2009).

Inundation of piping plover habitat by rising seas could lead to permanent loss of habitat if natural coastal dynamics are impeded by numerous structures or roads, especially if those shorelines are also armored with hardened structures. Without development or armoring, low undeveloped islands can migrate toward the mainland, pushed by the overwashing of sand eroding from the seaward side and being re-deposited in the bay (Scavia et al. 2002). Overwash and sand migration are impeded on developed portions of islands. Instead, as sea-level increases, the ocean-facing beach erodes and the resulting sand is deposited offshore. The buildings and the sand dunes then prevent sand from washing back toward the lagoons, and the lagoon side becomes increasingly submerged during extreme high tides (Scavia et al. 2002), diminishing both barrier beach shorebird habitat and protection for mainland developments.

Modeling for three sea-level rise scenarios (reflecting variable projections of global temperature rise) at five important U.S. shorebird staging and wintering sites predicted loss of 20-70% of current intertidal foraging habitat (Galbraith et al. 2002). These authors estimated probabilistic sea-level changes for specific sites partially based on historical rates of sea-level change (from tide gauges at or near each site); they then superimposed this on projected 50% and 5% probability of global sea-level changes by 2100 of 34 cm and 77 cm, respectively. The 50% and 5% probability sea level change projections were based on assumed global temperature increases of 2° C (50% probability) and 4.7° C (5% probability). The most severe losses were projected at sites where the coastline is unable to move inland due to steep topography or seawalls. The Galbraith et al. (2002) Gulf Coast study site, Bolivar Flats, Texas, is a designated critical habitat unit known to host high numbers of piping plovers during migration and throughout the winter; e.g., 275 individuals were tallied during the 2006 International Piping Plover Census (Elliott-Smith et al. 2009). Under the 50% likelihood scenario for sea-level rise, Galbraith et al. (2002) projected approximately 38% loss of intertidal flats at Bolivar Flats by 2050; however, after initially losing habitat, the area of tidal flat habitat was predicted to slightly increase by the year 2100, because Bolivar Flats lacks armoring, and the coastline at this site can thus migrate inland. Although habitat losses in some areas are likely to be offset by gains in other locations, Galbraith et al. (2002) noted that time lags may exert serious adverse effects on shorebird populations. Furthermore, even if piping plovers are able to move their wintering locations in response to accelerated habitat changes, there could be adverse effects on the birds' survival rates or reproductive fitness.

Table 10 displays the potential for adjacent development and/or hardened shorelines to impede response of habitat to sea-level rise in the eight states supporting wintering piping plovers.

Although complete linear shoreline estimates are not readily obtainable, almost all known piping plover wintering sites in the U.S. were surveyed during the 2006 International Piping Plover Census. To estimate effects at the census sites, as well as additional areas where piping plovers have been found outside of the census period, Service biologists reviewed satellite imagery and spoke with other biologists familiar with the sites. Of 406 sites, 204 (50%) have adjacent structures that may prevent the creation of new habitat if existing habitat were to become inundated. These threats will be perpetuated in places where damaged structures are repaired and replaced, and exacerbated where the height and strength of structures are increased. Data do not exist on the amount or types of hardened structures at wintering sites in the Bahamas, other Caribbean countries, or Mexico.

Table 10. Number of sites surveyed during the 2006 winter International Piping Plover Census with hardened or developed structures adjacent to the shoreline.

State	**Number of sites surveyed during the 2006 winter Census**	**Number of sites with some armoring or development**	**Percent of sites affected**
North Carolina	37 (+2)*	20	51
South Carolina	39	18	46
Georgia	13	2	15
Florida	188	114	61
Alabama	4 (+2)*	3	50
Mississippi	16	7	44
Louisiana	25 (+2)*	9	33
Texas	78	31	40
Overall Total	406	204	50

An asterisk (*) indicates additional piping plovers sites not surveyed in the 2006 Census.

Sea-level rise poses a significant threat to all piping plover populations during the migration and wintering portion of their life cycle. Ongoing coastal stabilization activities may strongly influence the effects of sea-level rise on piping plover habitat. Improved understanding of how sea-level rise will affect the quality and quantity of habitat for migrating and wintering piping plovers is an urgent need.

Storm events

Although coastal piping plover habitats are storm-created and maintained, the 1996 Atlantic Coast Recovery Plan also noted that storms and severe cold weather may take a toll on piping plovers, and the 2003 Great Lakes Recovery Plan postulated that loss of habitats such as overwash passes or wrack, where birds shelter during harsh weather, poses a threat.

Storms are a component of the natural processes that form coastal habitats used by migrating and wintering piping plovers, and positive effects of storm-induced overwash and vegetation removal have been noted in portions of the wintering range. For example, Gulf Islands National Seashore habitats in Florida benefited from increased washover events that created optimal habitat conditions during the 2004 and 2005 hurricane seasons, with biologists reporting piping plover use of these habitats within six months of the storms (Nicholas 2005 pers. communication). Hurricane Katrina (2005) overwashed the mainland beaches of Mississippi, creating many tidal flats where piping plovers were subsequently observed (Winstead 2008). Hurricane Katrina also created a new inlet and improved habitat conditions on some areas of Dauphin Island, Alabama (LeBlanc 2009 pers. communication). Conversely, localized storms, since Katrina, have induced habitat losses on Dauphin Island (LeBlanc 2009 pers. communication).

Noel and Chandler (2005) suspect that changes in habitat caused by multiple hurricanes along the Georgia coastline altered the spatial distribution of piping plovers and may have contributed to winter mortality of three Great Lakes piping plovers. Following Hurricane Ike in 2008, Arvin (2009) reported decreased numbers of piping plovers at some heavily eroded Texas beaches in the center of the storm impact area and increases in plover numbers at sites about 100 miles to the southwest. However, piping plovers were observed later in the season using tidal lagoons and pools that Ike created behind the eroded beaches (Arvin 2009).

The adverse effects on piping plovers attributed to storms are sometimes due to a combination of storms and other environmental changes or human use patterns. For example, four hurricanes between 2002 and 2005 are often cited in reference to rapid erosion of the Chandeleur Islands, a chain of low-lying islands in Louisiana where the 1991 International Piping Plover Census tallied more than 350 piping plovers. Comparison of imagery taken three years before and several days after Hurricane Katrina found that the Chandeleur Islands lost 82% of their surface area (Sallenger et al. 2009 in review), and a review of aerial photography prior to the 2006 Census suggested little piping plover habitat remained (Elliott-Smith et al. 2009). However, Sallenger et al. (2009 in review) noted that habitat changes in the Chandeleurs stem not only from the effects of these storms but rather from the combined effects of the storms, long-term (>1,000 years) diminishing sand supply, and sea-level rise relative to the land.

Other storm-induced adverse effects include post-storm acceleration of human activities such as beach nourishment, sand scraping, and berm and seawall construction. Such stabilization activities can result in the loss and degradation of feeding and resting habitats. Storms also can cause widespread deposition of debris along beaches. Removal of debris often requires large machinery, which can cause extensive disturbance and adversely affect habitat elements such as wrack. Another example of indirect adverse effects linked to a storm event is the increased access to Pelican Island (LeBlanc 2009 pers. communication) due to merging with Dauphin Island following a 2007 storm (Gibson et al. 2009).

Recent climate change studies indicate a trend toward increasing hurricane numbers and intensity (Emanuel 2005; Webster et al. 2005). When combined with predicted effects of sea-level rise, there may be increased cumulative impacts from future storms.

In sum, storms can create or enhance piping plover habitat while causing localized losses elsewhere in the wintering and migration range. Available information suggests that some birds may have resiliency to storms and move to unaffected areas without harm, while other reports suggest birds may perish from storm events. Significant concerns include disturbance to piping plovers and habitats during cleanup of debris, and post-storm acceleration of shoreline stabilization activities, which can cause persistent habitat degradation and loss.

Summary

Habitat loss and degradation on winter and migration grounds from shoreline and inlet stabilization efforts, both within and outside of designated critical habitat, remain a serious threat to all piping plover populations. Modeling strongly suggests that the population is very sensitive to adult and juvenile survival. Therefore, while there is a great deal of effort extended to improve breeding success, to improve and maintain a higher population over time, it is also necessary to ensure that the wintering habitat, where birds spend most of their time, is secure. On the wintering grounds, the shoreline areas used by wintering piping plovers are being developed, stabilized, or otherwise altered, making it unsuitable. Even in areas where habitat conditions are appropriate, human disturbance on beaches may negatively impact piping plovers' energy budget, as they may spend more time being vigilant and less time in foraging and roosting behavior. In many cases, the disturbance is severe enough, that piping plovers appear to avoid some areas altogether. Threats on the wintering grounds may impact piping plovers' breeding success if they start migration or arrive at the breeding grounds with a poor body condition.

5) Analysis of the Species Likely to be Affected

The proposed action has the potential to adversely affect wintering and migrating piping plovers and their habitat from all breeding populations that may use the Action Area. The Atlantic Coast breeding population of piping plover is listed as threatened, while the Great Lakes breeding population is listed as endangered. Potential effects to piping plover include direct loss of foraging and roosting habitat in the Action Area and in the updrift and downdrift portions of South and West Beach, degradation of foraging habitat and destruction of the prey base from sand disposal, and attraction of predators due to food waste from the construction crew. Plovers face predation by avian and mammalian predators that are present year-round on the wintering and nesting grounds.

Although the piping plover is not currently known to nest in the Action Area, the stabilization of the shoreline may also result in less suitable nesting habitat for all shorebirds, including the piping plover.

B. Environmental Baseline

North Carolina barrier beaches are part of a complex and dynamic coastal system that continually respond to inlets, tides, waves, erosion and deposition, longshore sediment transport, and depletion, fluctuations in sea level, and weather events. The location and shape of the coastline perpetually adjusts to these physical forces. Winds move sediment across the dry beach forming dunes and the island interior landscape. The natural communities contain plants and animals that are subject to shoreline erosion and deposition, salt spray, wind, drought conditions, and sandy soils. Vegetative communities include foredunes, primary and secondary dunes, interdunal swales, sand pine scrub, and maritime forests.

During storm events, overwash across the barrier islands is common, depositing sediments on the bayside, clearing vegetation and increasing the amount of open, sandflat habitat ideal for shoreline dependent shorebirds. However, the protection or persistence of these important natural land forms, processes, and wildlife resources is often in conflict with long-term beach stabilization projects and their indirect effects, i.e., increases in residential development, infrastructure, and public recreational uses, and preclusion of overwash which limits the creation of open sand flats preferred by piping plovers.

1) Status of the Species within the Action Area

On Bald Head Island, the 2006 International Piping Plover Census surveys documented 3 wintering piping plovers, and no breeding piping plovers (Elliott-Smith et al. 2009). Data provided by the NCWRC for the Draft EIS indicate as many as 10 piping plovers on Bald Head Island in 1984. See **Table 11**, below.

Table 11. Number of piping plovers observed between 1984 and 2006 on Bald Head Island.

Year	Number of Piping Plovers
1984	10
1985	2
1986	1
1987	2*
1989	4
2000	3*
2001	14*
2002	2*
2006	4

*denotes multiple surveys, so numbers may not represent individual birds

Launched in 2002, by the Cornell Lab of Ornithology and National Audubon Society, eBird provides data concerning bird abundance and distribution at a variety of spatial and temporal scales. eBird is sponsored in part by several Service programs, research groups, non-government offices, and the University of the Virgin Islands. In 2012, a report of 3 piping plovers was documented on Bald Head Island by an eBird member (eBird.org 2014). No breeding piping plovers have been documented in the Action Area.

2) Factors affecting the species environment within the Action Area

Pedestrian Use of the Beach: There are a number of potential sources of pedestrians and pets, including those individuals originating from hotels, beachfront and nearby residences.

Sand nourishment: The beaches of Bald Head Island are regularly nourished with sand from the Corps Wilmington Harbor SMP.

Shoreline stabilization: Sixteen sand-filled groin tubes on South Beach provide stabilization to the shoreline of South Beach.

C. EFFECTS OF THE ACTION

This section is an analysis of the beneficial, direct and indirect effects of the proposed action on migrating and wintering piping plovers within the Action Area. The analysis includes effects interrelated and interdependent of the project activities. An interrelated activity is an activity that is part of a proposed action and depends on the proposed activity. An interdependent activity is an activity that has no independent utility apart from the action.

1) Factors to be considered

The proposed project will occur within habitat used by migrating and wintering piping plovers and construction will occur during a portion of the migration and winter seasons. Long-term and permanent impacts could preclude the creation of new habitat and increase recreational disturbance. Short-term and temporary impacts to piping plovers could result from project work disturbing roosting plovers and degrading currently occupied foraging areas.

Proximity of the action: Construction of the groin and sand placement activities would occur within and adjacent to foraging and roosting habitats for migrating or wintering piping plovers.

Distribution: Project construction activities that may impact migrants and the wintering population of piping plovers on Bald Head Island would occur along the West Beach and South Beach shorelines and on the "Point."

Timing: The timing of project construction could directly and indirectly impact migrating and wintering piping plovers. Piping plovers and red knots may be present year-round in the Action Area, however, the timing of sand placement and groin construction activities will likely occur during the migration and wintering period (July to May).

Nature of the effect: The effects of the project construction include a temporary reduction in foraging habitat, a long-term decreased rate of change that may preclude habitat creation, and increased recreational disturbance. A decrease in the survival of piping plovers on the migration and winter grounds due to the lack of optimal habitat may contribute to decreased survival rates, decreased productivity on the breeding grounds, and increased vulnerability to the three populations.

Although the Service expects direct short-term effects from disturbance during project construction, it is anticipated the action will also result in direct and indirect, long term effects to piping plovers. The Service expects there may be morphological changes to piping plover habitat, including roosting and foraging habitat. Activities that affect or alter the use of optimal habitat or increase disturbance to the species may decrease the survival and recovery potential of the piping plover. Effects to piping plovers and their habitat as a result of groin and jetty repair or replacement will primarily be due to construction ingress and egress when construction is required to be conducted from land. In addition, construction materials and equipment may need to be stockpiled on the beach. Piping plover habitats would remain disturbed until the project is completed and the habitats are restored. The direct effects would be expected to be short-term in duration, until the benthic community reestablishes within the new beach profile. Indirect effects from the activity, including those related to altered sand transport systems, may continue to occur as long as sand remains on the beach.

Duration: Groin installation will be a one-time, phased activity, which will take as long as 7 months to complete. Sand fillet maintenance will be a recurring activity and will take up to four months to complete each time. Thus, the direct effects would be expected to be short-term in duration. Indirect effects from the activity may continue to impact migrating and wintering plovers in subsequent seasons after sand placement. The habitat will be temporarily unavailable to wintering plovers during the construction period, and the quality of the habitat will be reduced for several months following project activities. The mean linear distance moved by wintering plovers from their core area is estimated to be approximately 2.1 miles (Drake et al. 2001), suggesting they could be negatively impacted by temporary disturbances anywhere in their core habitat area.

Disturbance frequency: Disturbance from groin construction activities will be short-term lasting up to two years after the second phase. Recreational disturbance may increase after project completion and have long term-impacts. Disturbance from maintenance of the sand fillet can be anticipated every 3-9 years for the life of the project.

Disturbance intensity and severity: Project construction is anticipated to be conducted during portions of the piping plover migration, winter, and nesting seasons. Conservation measures have been incorporated into the project to minimize impacts. The Action Area encompasses an area in the nesting and wintering range of the piping plover; however, the overall intensity of the disturbance is expected to be minimal. The intensity of the effect on piping plover habitat may vary depending on the frequency of the sand placement activities, the existence of staging areas, and the location of the beach access points. The severity is also likely to be slight, as plovers located within the Action Area are expected to move outside of the construction zone due to disturbance; therefore, no plovers are expected to be directly taken as a result of this action.

2) Analyses for effects of the action

Beneficial effects: For some highly eroded beaches, sand placement will have a beneficial effect on the habitat's ability to support wintering piping plovers. Narrow beaches that do not support a productive wrack line may see an improvement in foraging habitat available to piping plovers following sand placement. The addition of sand to the sediment budget may also increase a sand-starved beach's likelihood of developing habitat features valued by piping plovers, including washover fans and emergent nearshore sand bars.

Direct effects: Direct effects are those direct or immediate effects of a project on the species or its habitat. The construction window (i.e., beach renourishment and groin installation) will extend through one or more piping plover migration and winter seasons. Since piping plovers can be present on these beaches year-round, construction is likely to occur while this species is utilizing these beaches and associated habitats. Heavy machinery and equipment (e.g., trucks and bulldozers operating on Action Area beaches, the placement of the dredge pipeline along the beach, and sand disposal) may adversely affect piping plovers in the Action Area by disturbance and disruption of normal activities such as roosting and foraging, and possibly forcing birds to expend valuable energy reserves to seek available habitat elsewhere.

Burial and suffocation of invertebrate species will occur during each nourishment and renourishment cycle. Impacts from maintenance of the sand fillet will affect at least 2,500 feet of shoreline. Timeframes projected for benthic recruitment and re-establishment following beach nourishment are between 6 months to 2 years.

Maintenance dredging of shallow-draft inlets can occasionally require the removal of emergent shoals that may have formed at the location of the Federally-authorized channel from the migration of the channel over time. In these cases, the dredging activities would result in a complete take of that habitat. However, this take could be either temporary or more permanent in nature depending upon the location of future shoaling within the inlet.

Indirect effects: The proposed project includes beach renourishment and groin installation along 12,600 feet of shoreline as protective elements against shoreline erosion to protect man-made infrastructure. Indirect effects include reducing the potential for the formation of optimal habitats.

The proposed project may limit the creation of optimal foraging and roosting habitat, and may increase the attractiveness of these beaches for recreation increasing recreational pressures within the Action Area. Recreational activities that potentially adversely affect plovers include disturbance by unleashed pets and increased pedestrian use.

3) Species' response to the proposed action

The Service anticipates potential adverse effects throughout the Action Area by limiting proximity to roosting, foraging, and nesting habitat, degrading occupied foraging habitat, and increasing disturbance from increased recreational use.

Elliott and Teas (1996) found a significant difference in actions between piping plovers encountering pedestrians and those not encountering pedestrians. Piping plover encountering pedestrians spend proportionately more time in non-foraging behavior. This study suggests that interactions with pedestrians on beaches cause birds to shift their activities from calorie acquisition to calorie expenditure. In winter and migration sites, human disturbance continues to decrease the amount of undisturbed habitat and appears to limit local piping plover abundance (Zonick and Ryan 1996).

Disturbance also reduces the time migrating shorebirds spend foraging (Burger 1991). Pfister et al. (1992) implicate disturbance as a factor in the long-term decline of migrating shorebirds at staging areas. While piping plover migration patterns and needs remain poorly understood and occupancy of a particular habitat may involve shorter periods relative to wintering, information about the energetics of avian migration indicates that this might be a particularly critical time in the species' life cycle.

D. Cumulative Effects

This project occurs on non-federal lands. Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the Action Area considered in this biological opinion.

It is reasonable to expect continued shoreline stabilization and beach renourishment projects in this area in the future since erosion and sea-level rise increases would impact the existing beachfront development.

IV RED KNOT

A. Status of the Species/Critical Habitat

1) Species/critical habitat description

On September 30, 2013, the Service proposed listing the rufa red knot (*Calidris canutus rufa*) (or red knot) as threatened throughout its range.

The red knot is a medium-sized shorebird about 9 to 11 inches (in) (23 to 28 centimeters (cm)) in length. The red knot migrates annually between its breeding grounds in the Canadian Arctic and several wintering regions, including the Southeast United States (Southeast), the Northeast Gulf of Mexico, northern Brazil, and Tierra del Fuego at the southern tip of South America. During both the northbound (spring) and southbound (fall) migrations, red knots use key staging and stopover areas to rest and feed. Red knots migrate through and overwinter in North Carolina. The term "winter" is used to refer to the nonbreeding period of the red knot life cycle when the birds are not undertaking migratory movements. Red knots are most common in North Carolina during the migration season (mid-April through May and July to Mid-October), and may be present in the state throughout the year (Fussell 1994; Potter et al. 1980). Wintering areas for the red knot include the Atlantic coasts of Argentina and Chile, the north coast of Brazil, the Northwest Gulf of Mexico from the Mexican State of Tamaulipas through Texas to Louisiana, and the Southeast United States from Florida to North Carolina (Newstead et al. 2013; Niles et al. 2008). Smaller numbers of knots winter in the Caribbean, and along the central Gulf coast, the mid-Atlantic, and the Northeast United States. Little information exists on where juvenile red knots spend the winter months (USFWS and Conserve Wildlife Foundation 2012), and there may be at least partial segregation of juvenile and adult red knots on the wintering grounds. There is no designation of critical habitat for red knot.

2) Life history

Each year red knots make one of the longest distance migrations known in the animal kingdom, traveling up to 19,000 miles (mi) (30,000 kilometers (km) annually between breeding grounds in the Arctic Circle and wintering grounds. Red knots undertake long flights that may span thousands of miles without stopping. As they prepare to depart on long migratory flights, they undergo several physiological changes. Before takeoff, the birds accumulate and store large amounts of fat to fuel migration and undergo substantial changes in metabolic rates. In addition, leg muscles, gizzard (a muscular organ used for grinding food), stomach, intestines, and liver all decrease in size, while pectoral (chest) muscles and heart increase in size. Due to these physiological changes, red knots arriving from lengthy migrations are not able to feed maximally until their digestive systems regenerate, a process that may take several days. Because stopovers are time-constrained, red knots require stopovers rich in easily-digested food to achieve adequate weight gain (Niles et al. 2008; van Gils et al. 2005a; van Gils et al. 2005b; Piersma et al. 1999) that fuels the next migratory flight and, upon arrival in the Arctic, fuels a body transformation to breeding condition (Morrison 2006). Red knots from different wintering areas appear to employ different migration strategies, including differences in timing, routes, and stopover areas. However, full segregation of migration strategies, routes, or stopover areas does not occur among red knots from different wintering areas.

Major spring stopover areas along the Mid- and South Atlantic coast include Río Gallegos, Península Valdés, and San Antonio Oeste (Patagonia, Argentina); Lagoa do Peixe (eastern Brazil, State of Rio Grande do Sul); Maranhão (northern Brazil); the Virginia barrier islands (United States); and Delaware Bay (Delaware and New Jersey, United States) (Cohen et al. 2009; Niles et al. 2008; González 2005). Important fall stopover sites include southwest Hudson Bay (including the Nelson River delta), James Bay, the north shore of the St. Lawrence River, the Mingan Archipelago, and the Bay of Fundy in Canada; the coasts of Massachusetts and New Jersey and the mouth of the Altamaha River in Georgia, United States; the Caribbean (especially Puerto Rico and the Lesser Antilles); and the northern coast of South America from Brazil to Guyana (Newstead et al. 2013; Niles 2012; Niles et al. 2010; Schneider and Winn 2010; Niles et al. 2008; Antas and Nascimento 1996; Morrison and Harrington 1992; Spaans 1978). However, large and small groups of red knots, sometimes numbering in the thousands, may occur in suitable habitats all along the Atlantic and Gulf coasts from Argentina to Canada during migration (Niles et al. 2008).

Some red knots wintering in the Southeastern United States and the Caribbean migrate north along the U.S. Atlantic coast before flying overland to central Canada from the mid-Atlantic, while others migrate overland directly to the Arctic from the Southeastern U.S. coast (Niles et al. 2012). These eastern red knots typically make a short stop at James Bay in Canada, but may also stop briefly along the Great Lakes, perhaps in response to weather conditions (Niles et al. 2008; Morrison and Harrington 1992). Red knots are restricted to the ocean coasts during winter, and occur primarily along the coasts during migration. However, small numbers of rufa red knots are reported annually across the interior United States (i.e., greater than 25 miles from the Gulf or Atlantic Coasts) during spring and fall migration—these reported sightings are concentrated along the Great Lakes, but multiple reports have been made from nearly every interior State (eBird.org 2012).

Long-distance migrant shorebirds are highly dependent on the continued existence of quality habitat at a few key staging areas. These areas serve as stepping stones between wintering and breeding areas. Conditions or factors influencing shorebird populations on staging areas control much of the remainder of the annual cycle and survival of the birds (Skagen 2006; International Wader Study Group 2003). At some stages of migration, very high proportions of entire populations may use a single migration staging site to prepare for long flights. Red knots show some fidelity to particular migration staging areas between years (Duerr et al. 2011; Harrington 2001).

Habitats used by red knots in migration and wintering areas are similar in character, generally coastal marine and estuarine (partially enclosed tidal area where fresh and salt water mixes) habitats with large areas of exposed intertidal sediments. In North America, red knots are commonly found along sandy, gravel, or cobble beaches, tidal mudflats, salt marshes, shallow coastal impoundments and lagoons, and peat banks (Cohen et al. 2010; Cohen et al. 2009; Niles et al. 2008; Harrington 2001; Truitt et al. 2001). The supra-tidal (above the high tide) sandy habitats of inlets provide important areas for roosting, especially at higher tides when intertidal habitats are inundated (Harrington 2008).

The red knot is a specialized molluscivore, eating hard-shelled mollusks, sometimes supplemented with easily accessed softer invertebrate prey, such as shrimp- and crab-like organisms, marine worms, and horseshoe crab (*Limulus polyphemus*) eggs (Piersma and van Gils 2011; Harrington 2001). Mollusk prey are swallowed whole and crushed in the gizzard (Piersma and van Gils 2011). Foraging activity is largely dictated by tidal conditions, as red knots rarely wade in water more than 0.8 to 1.2 in (2 to 3 cm) deep (Harrington 2001). Due to bill morphology, the red knot is limited to foraging on only shallow-buried prey, within the top 0.8 to 1.2 in (2 to 3 cm) of sediment (Gerasimov 2009; Zwarts and Blomert 1992).

The primary prey of the rufa red knot in non-breeding habitats include blue mussel (*Mytilus edulis*) spat (juveniles); *Donax* and *Darina* clams; snails (*Littorina spp.*), and other mollusks, with polycheate worms, insect larvae, and crustaceans also eaten in some locations. A prominent departure from typical prey items occurs each spring when red knots feed on the eggs of horseshoe crabs, particularly during the key migration stopover within the Delaware Bay of New Jersey and Delaware. Delaware Bay serves as the principal spring migration staging area for the red knot because of the availability of horseshoe crab eggs (Clark et al. 2009; Harrington 2001; Harrington 1996; Morrison and Harrington 1992), which provide a superabundant source of easily digestible food.

Red knots and other shorebirds that are long-distance migrants must take advantage of seasonally abundant food resources at intermediate stopovers to build up fat reserves for the next non-stop, long-distance flight (Clark et al. 1993). Although foraging red knots can be found widely distributed in small numbers within suitable habitats during the migration period, birds tend to concentrate in those areas where abundant food resources are consistently available from year to year.

3) Population dynamics

In the United States, red knot populations declined sharply in the late 1800s and early 1900s due to excessive sport and market hunting, followed by hunting restrictions and signs of population recovery by the mid-1900s (Urner and Storer 1949; Stone 1937; Bent 1927). However, it is unclear whether the red knot population fully recovered its historical numbers (Harrington 2001) following the period of unregulated hunting. More recently, long-term survey data from two key areas (Tierra del Fuego wintering area and Delaware Bay spring stopover site) both show a roughly 75 percent decline in red knot numbers since the 1980s (Dey et al. 2011; Clark et al. 2009; Morrison et al. 2004; Morrison and Ross 1989; Kochenberger 1983; Dunne et al. 1982; Wander and Dunne, 1982).

For many portions of the knot's range, available survey data are patchy. Prior to the 1980s, numerous natural history accounts are available, but provide mainly qualitative or localized population estimates. No population information exists for the breeding range because, in breeding habitats, red knots are thinly distributed across a huge and remote area of the Arctic. Despite some localized survey efforts, (e.g., Niles et al. 2008), there are no regional or comprehensive estimates of breeding abundance, density, or productivity (Niles et al. 2008).

Counts in wintering areas are useful in estimating red knot populations and trends because the birds generally remain within a given wintering area for a longer period of time compared to the areas used during migration. This eliminates errors associated with turnover or double-counting that can occur during migration counts. Harrington et al. (1988) reported that the mean count of birds wintering in Florida was 6,300 birds (± 3,400, one standard deviation) based on 4 aerial surveys conducted from October to January in 1980 to 1982. Based on these surveys and other work, the Southeast wintering group was estimated at roughly 10,000 birds in the 1970s and 1980s (Harrington 2005a).

Based on resightings of birds banded in South Carolina and Georgia from 1999 to 2002, the Southeast wintering population was estimated at 11,700 ± 1,000 (standard error) red knots. Although there appears to have been a gradual shift by some of the southeastern knots from the Florida Gulf coast to the Atlantic coasts of Georgia and South Carolina, population estimates for the Southeast region in the 2000s were at about the same level as during the 1980s (Harrington 2005a). Based on recent modeling using resightings of marked birds staging in Georgia in fall, as well as other evidence, the Southeast wintering group may number as high as 20,000 (B.

Harrington pers. comm. November 12, 2012), but field survey data are not available to corroborate this estimate.

Beginning in 2006, coordinated red knot surveys have been conducted from Florida to Delaware Bay during 2 consecutive days from May 20 to 24 (**Table 12**). This period is thought to represent the peak of the red knot migration. There has been variability in methods, observers, and areas covered. From 2006 to 2010, there was no change in counts that could not be attributed to varying geographic survey coverage (Dey et al. 2011); thus, we do not consider any apparent trends in these data before 2010.

Table 12. Red knot counts along the Atlantic coast of the United States, May 20 to 24, 2006 to 2012 (A. Dey pers. comm. October 12, 2012; Dey et al. 2011).

<table>
<tr><th>State</th><th>2006</th><th>2007</th><th>2008</th><th>2009</th><th>2010</th><th>2011</th><th>2012</th></tr>
<tr><td>New Jersey</td><td>7,860</td><td>4,445</td><td>10,045</td><td rowspan="2">16,229</td><td>8,945</td><td>7,737</td><td>23,525</td></tr>
<tr><td>Delaware</td><td>820</td><td>2,950</td><td>5,350</td><td>5,530</td><td>5,067</td><td>3,433</td></tr>
<tr><td>Maryland</td><td></td><td></td><td>663</td><td>78</td><td>5</td><td>83</td><td>139</td></tr>
<tr><td>Virginia</td><td>5,783</td><td>5,939</td><td>7,802</td><td>3,261</td><td>8,214</td><td>6,236</td><td>8,482</td></tr>
<tr><td>North Carolina</td><td>235</td><td>304</td><td>1,137</td><td>1,466</td><td>1,113</td><td>1,868</td><td>2,832</td></tr>
<tr><td>South Carolina</td><td></td><td>125</td><td>180</td><td>10</td><td>1,220</td><td>315</td><td>542</td></tr>
<tr><td>Georgia</td><td>796</td><td>2,155</td><td>1,487</td><td></td><td>260</td><td>3,071</td><td>1,466</td></tr>
<tr><td>Florida</td><td></td><td></td><td>868</td><td>800</td><td>41</td><td></td><td>10</td></tr>
<tr><td>Total</td><td>15,494</td><td>15,918</td><td>27,532</td><td>21,844</td><td>25,328</td><td>24,377</td><td>40,429</td></tr>
</table>

Because red knot numbers peak earlier in the Southeast than in the mid-Atlantic (M. Bimbi pers. comm. June 27, 2013), the late-May coast-wide survey data likely reflect the movement of some birds north along the coast, and may miss other birds that depart for Canada from the Southeast along an interior (overland) route prior to the survey window. Thus, greater numbers of red knots may utilize Southeastern stopovers than suggested by the data in **Table 12.** For example, a peak count of over 8,000 red knots was documented in South Carolina during spring 2012 (South Carolina Department of Natural Resources 2012). Dinsmore et al. (1998) found a mean of 1,363 (±725) red knots in North Carolina during spring 1992 and 1993, with a peak count of 2,764 birds.

4) Status and Distribution

Reason for proposed listing: The Service has determined that the rufa red knot is threatened due to loss of both breeding and nonbreeding habitat; potential for disruption of natural predator cycles on the breeding grounds; reduced prey availability throughout the nonbreeding range; and increasing frequency and severity of asynchronies ("mismatches") in the timing of the birds' annual migratory cycle relative to favorable food and weather conditions.

Range-Wide Trends:

Wintering areas for the red knot include the Atlantic coasts of Argentina and Chile, the north coast of Brazil, the Northwest Gulf of Mexico from the Mexican State of Tamaulipas through Texas to Louisiana, and the Southeast United States from Florida to North Carolina (Newstead et al. 2013; L. Patrick pers. comm. August 31, 2012; Niles et al. 2008). Smaller numbers of knots winter in the Caribbean, and along the central Gulf coast (Alabama, Mississippi), the mid-Atlantic, and the Northeast United States. *Calidris canutus* is also known to winter in Central America and northwest South America, but it is not yet clear if all these birds are the *rufa* subspecies.

In some years, more red knots have been counted during a coordinated spring migration survey than can be accounted for at known wintering sites, suggesting there are unknown wintering areas. Indeed, geolocators have started revealing previously little-known wintering areas, particularly in the Caribbean (Niles et al. 2012; L. Niles pers. comm. January 8, 2013).

The core of the Southeast wintering area (i.e., that portion of this large region supporting the majority of birds) is thought to shift from year to year among Florida, Georgia, and South Carolina (Niles et al. 2008). However, the geographic limits of this wintering region are poorly defined. Although only small numbers are known, wintering knots extend along the Atlantic coast as far north as Virginia (L. Patrick pers. comm. August 31, 2012; Niles et al. 2006), Maryland (Burger et al. 2012), and New Jersey (BandedBirds.org 2012; H. Hanlon pers. comm. November 22, 2012; A. Dey pers. comm. November 19, 2012). Still smaller numbers of red knots have been reported between December and February from Long Island, New York, through Massachusetts and as far north as Nova Scotia, Canada (eBird.org 2012).

Recovery Criteria

A Recovery Plan for the red knot has not yet been completed. It will be developed, pursuant to Subsection 4(f) of the ESA, shortly after the species is listed.

Threats to the Red Knot

Within the nonbreeding portion of the range, red knot habitat is primarily threatened by the highly interrelated effects of sea level rise, shoreline stabilization, and coastal development. Lesser threats to nonbreeding habitat include agriculture and aquaculture, invasive vegetation, and beach maintenance activities. Within the breeding portion of the range, the primary threat to red knot habitat is from climate change. With arctic warming, vegetation conditions in the breeding grounds are expected to change, causing the zone of nesting habitat to shift and perhaps contract. Arctic freshwater systems—foraging areas for red knots during the nesting season—are particularly sensitive to climate change. For more information, please see the proposed rule and supplemental documents on the Internet at *http://www.regulations.gov* (Docket Number FWS–R5–ES–2013–0097).

Climate Change & Sea Level Rise

The natural history of Arctic-breeding shorebirds makes this group of species particularly vulnerable to global climate change (Meltofte et al. 2007; Piersma and Lindström 2004; Rehfisch and Crick 2003; Piersma and Baker 2000; Zöckler and Lysenko 2000; Lindström and Agrell 1999). Relatively low genetic diversity, which is thought to be a consequence of survival through past climate-driven population bottlenecks, may put shorebirds at more risk from human-induced climate variation than other avian taxa (Meltofte et al. 2007); low genetic diversity may result in reduced adaptive capacity as well as increased risks when population sizes drop to low levels.

In the short term, red knots may benefit if warmer temperatures result in fewer years of delayed horseshoe crab spawning in Delaware Bay (Smith and Michaels 2006) or fewer occurrences of late snow melt in the breeding grounds (Meltofte et al. 2007). However, there are indications that changes in the abundance and quality of red knot prey are already underway (Escudero et al. 2012; Jones et al. 2010), and prey species face ongoing climate-related threats from warmer temperatures (Jones et al. 2010; Philippart et al. 2003; Rehfisch and Crick 2003), ocean acidification (NRC 2010; Fabry et al. 2008), and possibly increased prevalence of disease and parasites (Ward and Lafferty 2004). In addition, red knots face imminent threats from loss of habitat caused by sea level rise (NRC 2010; Galbraith et al. 2002; Titus 1990), and increasing asynchronies ("mismatches") between the timing of their annual breeding, migration, and wintering cycles and the windows of peak food availability on which the birds depend (Smith et al. 2011; McGowan et al. 2011; Meltofte et al. 2007; van Gils et al. 2005a; Baker et al. 2004).

With arctic warming, vegetation conditions in the red knot's breeding grounds are expected to change, causing the zone of nesting habitat to shift and perhaps contract, but this process may take decades to unfold (Feng et al. 2012; Meltofte et al. 2007; Kaplan et al. 2003). Ecological shifts in the Arctic may appear sooner. High uncertainty exists about when and how changing interactions among vegetation, predators, competitors, prey, parasites, and pathogens may affect the red knot, but the impacts are potentially profound (Fraser et al. 2013; Schmidt et al. 2012; Meltofte et al. 2007; Ims and Fuglei 2005).

For most of the year, red knots live in or immediately adjacent to intertidal areas. These habitats are naturally dynamic, as shorelines are continually reshaped by tides, currents, wind, and storms. Coastal habitats are susceptible to both abrupt (storm-related) and long-term (sea level rise) changes. Outside of the breeding grounds, red knots rely entirely on these coastal areas to fulfill their roosting and foraging needs, making the birds vulnerable to the effects of habitat loss from rising sea levels. Because conditions in coastal habitats are also critical for building up nutrient and energy stores for the long migration to the breeding grounds, sea level rise affecting conditions on staging areas also has the potential to impact the red knot's ability to breed successfully in the Arctic (Meltofte et al. 2007).

According to the NRC (2010), the rate of global sea level rise has increased from about 0.02 in (0.6 mm) per year in the late 19th century to approximately 0.07 in (1.8 mm) per year in the last half of the 20th century. The rate of increase has accelerated, and over the past 15 years has been in excess of 0.12 in (3 mm) per year. In 2007, the IPCC estimated that sea level would "likely" rise by an additional 0.6 to 1.9 feet (ft) (0.18 to 0.59 meters (m)) by 2100 (NRC 2010). This projection was based largely on the observed rates of change in ice sheets and projected future thermal expansion of the oceans but did not include the possibility of changes in ice sheet dynamics (e.g., rates and patterns of ice sheet growth versus loss). Scientists are working to improve how ice dynamics can be resolved in climate models. Recent research suggests that sea levels could potentially rise another 2.5 to 6.5 ft (0.8 to 2 m) by 2100, which is several times larger than the 2007 IPCC estimates (NRC 2010; Pfeffer et al. 2008). However, projected rates of sea level rise estimates remain rather uncertain, due mainly to limits in scientific understanding of glacier and ice sheet dynamics (NRC 2010; Pfeffer et al. 2008). The amount of sea level change varies regionally because of different rates of settling (subsidence) or uplift of the land, and because of differences in ocean circulation (NRC 2010). In the last century, for example, sea level rise along the U.S. mid- Atlantic and Gulf coasts exceeded the global average by 5 to 6 in (13 to 15 cm) because coastal lands in these areas are subsiding (USEPA 2013). Land subsidence also occurs in some areas of the Northeast, at current rates of 0.02 to 0.04 in (0.5 to 1 mm) per year across this region (Ashton et al. 2007), primarily the result of slow, natural geologic processes (NOAA 2013). Due to regional differences, a 2-ft (0.6-m) rise in global sea level by the end of this century would result in a relative sea level rise of 2.3 ft (0.7 m) at New York City, 2.9 ft (0.9 m) at Hampton Roads, Virginia, and 3.5 ft (1.1 m) at Galveston, Texas (U.S. Global Change Research Program (USGCRP) 2009). **Table 13** shows that local rates of sea level rise in the range of the red knot over the second half of the 20th century were generally higher than the global rate of 0.07 in (1.8 mm) per year.

Table 13. Local sea level trends from within the range of the red knot (NOAA 2012)

Station	Mean Local Sea Level Trend (mm per year)	Data Period
Pointe-Au-Père, Canada	-0.36 ± 0.40	1900–1983
Woods Hole, Massachusetts	2.61 ± 0.20	1932–2006
Cape May, New Jersey	4.06 ± 0.74	1965–2006
Lewes, Delaware	3.20 ± 0.28	1919–2006
Chesapeake Bay Bridge Tunnel, Virginia	6.05 ± 1.14	1975–2006
Beaufort, North Carolina	2.57 ± 0.44	1953–2006
Clearwater Beach, Florida	2.43 ± 0.80	1973–2006
Padre Island, Texas	3.48 ± 0.75	1958–2006
Punto Deseado, Argentina	-0.06 ± 1.93	1970–2002

Data from along the U.S. Atlantic coast suggest a relationship between rates of sea level rise and long-term erosion rates; thus, long-term coastal erosion rates may increase as sea level rises (Florida Oceans and Coastal Council 2010). However, even if such a correlation is borne out, predicting the effect of sea level rise on beaches is more complex. Even if wetland or upland coastal lands are lost, sandy or muddy intertidal habitats can often migrate or reform. However, forecasting how such changes may unfold is complex and uncertain. Potential effects of sea level rise on beaches vary regionally due to subsidence or uplift of the land, as well as the geological character of the coast and nearshore (U.S. Climate Change Science Program (CCSP) 2009b; Galbraith et al. 2002). Precisely forecasting the effects of sea level rise on particular coastal habitats will require integration of diverse information on local rates of sea level rise, tidal ranges, subsurface and coastal topography, sediment accretion rates, coastal processes, and other factors that is beyond the capability of current models (CCSP 2009b; Frumhoff et al. 2007; Thieler and Hammar-Klose 2000; Thieler and Hammar-Klose 1999).

Because the majority of the Atlantic and Gulf coasts consist of sandy shores, inundation alone is unlikely to reflect the potential consequences of sea level rise. Instead, long-term shoreline changes will involve contributions from inundation and erosion, as well as changes to other coastal environments such as wetland losses. Most portions of the open coast of the United States will be subject to significant physical changes and erosion over the next century because the majority of coastlines consist of sandy beaches, which are highly mobile and in a state of continual change (CCSP 2009b).

By altering coastal geomorphology, sea level rise will cause significant and often dramatic changes to coastal landforms including barrier islands, beaches, and intertidal flats (CCSP 2009b; Rehfisch and Crick 2003), primary red knot habitats. Due to increasing sea levels, storm-surge-driven floods now qualifying as 100-year events are projected to occur as often as every 10 to 20 years along most of the U.S. Atlantic coast by 2050, with even higher frequencies of such large floods in certain localized areas (Tebaldi et al. 2012). Rising sea level not only increases the likelihood of coastal flooding, but also changes the template for waves and tides to sculpt the coast, which can lead to loss of land orders of magnitude greater than that from direct inundation alone (Ashton et al. 2007).

Red knot migration and wintering habitats in the U.S. generally consist of sandy beaches that are dynamic and subject to seasonal erosion and accretion. Sea level rise and shoreline erosion have reduced availability of intertidal habitat used for red knot foraging, and in some areas, roosting sites have also been affected (Niles et al. 2008). With moderately rising sea levels, red knot habitats in many portions of the United States would be expected to migrate or reform rather than be lost, except where they are constrained by coastal development or shoreline stabilization (Titus et al. 2009). However, if the sea rises more rapidly than the rate with which a particular coastal system can keep pace, it could fundamentally change the state of the coast (CCSP 2009b).

Climate change is also resulting in asynchronies during the annual cycle of the red knot. The successful annual migration and breeding of red knots is highly dependent on the timing of departures and arrivals to coincide with favorable food and weather conditions. The frequency and severity of asynchronies is likely to increase with climate change. In addition, stochastic encounters with unfavorable conditions are more likely to result in population-level effects for red knots now than when population sizes were larger, as reduced numbers may have reduced the resiliency of this subspecies to rebound from impacts.

For unknown reasons, more red knots arrived late in Delaware Bay in the early 2000s, which is generally accepted as a key causative factor (along with reduced supplies of horseshoe crab eggs) behind red knot population declines that were observed over this same timeframe. Thus, the red knot's sensitivity to timing asynchronies has been demonstrated through a population-level response. Both adequate supplies of horseshoe crab eggs and high-quality foraging habitat in Delaware Bay can serve to partially mitigate minor asynchronies at this key stopover site. However, the factors that caused delays in the spring migrations of red knots from Argentina and Chile are still unknown, and we have no information to indicate if this delay will reverse, persist, or intensify. Superimposed on this existing threat of late arrivals in Delaware Bay are new threats of asynchronies emerging due to climate change. Climate change is likely to affect the reproductive timing of horseshoe crabs in Delaware Bay, mollusk prey species at other stopover sites, or both, possibly pushing the peak seasonal availability of food outside of the windows when red knots rely on them. In addition, both field studies and modeling have shown strong links between the red knot's reproductive output and conditions in the Arctic including insect abundance and snow cover. Climate change may also cause shifts in the period of optimal arctic conditions relative to the time period when red knots currently breed.

Shoreline stabilization

Structural development along the shoreline and manipulation of natural inlets upset the naturally dynamic coastal processes and result in loss or degradation of beach habitat (Melvin et al. 1991). As beaches narrow, the reduced habitat can directly lower the diversity and abundance of biota (life forms), especially in the upper intertidal zone. Shorebirds may be impacted both by reduced habitat area for roosting and foraging, and by declining intertidal prey resources, as has been documented in California (Defeo et al. 2009; Dugan and Hubbard 2006). In Delaware Bay, hard structures also cause or accelerate loss of horseshoe crab spawning habitat (CCSP 2009b; Botton et al. in Shuster et al. 2003; Botton et al. 1988), and shorebird habitat has been, and may continue to be, lost where bulkheads have been built (Clark in Farrell and Martin 1997). In addition to directly eliminating red knot habitat, hard structures interfere with the creation of new shorebird habitats by interrupting the natural processes of overwash and inlet formation. Where hard stabilization is installed, the eventual loss of the beach and its associated habitats is virtually assured (Rice 2009), absent beach nourishment, which may also impact red knots. Where they are maintained, hard structures are likely to significantly increase the amount of red knot habitat lost as sea levels continue to rise.

In a few isolated locations, however, hard structures may enhance red knot habitat, or may provide artificial habitat. In Delaware Bay, for example, Botton et al. (1994) found that, in the same manner as natural shoreline discontinuities like creek mouths, jetties and other artificial obstructions can act to concentrate drifting horseshoe crab eggs and thereby attract shorebirds. Another example comes from the Delaware side of the bay, where a seawall and jetty at Mispillion Harbor protect the confluence of the Mispillion River and Cedar Creek. These structures create a low energy environment in the harbor, which seems to provide highly suitable conditions for horseshoe crab spawning over a wider variation of weather and sea conditions than anywhere else in the bay (G. Breese pers. comm. March 25, 2013). Horseshoe crab egg densities at Mispillion Harbor are consistently an order of magnitude higher than at other bay beaches (Dey et al. 2011), and this site consistently supports upwards of 15 to 20 percent of all the knots recorded in Delaware Bay (Lathrop 2005). Notwithstanding localized red knot use of artificial structures, and the isolated case of hard structures improving foraging habitat at

Mispillion Harbor, the nearly universal effect of such structures is the degradation or loss of red knot habitat.

Sand Placement

Where shorebird habitat has been severely reduced or eliminated by hard stabilization structures, beach nourishment may be the only means available to replace any habitat for as long as the hard structures are maintained (Nordstrom and Mauriello 2001), although such habitat will persist only with regular nourishment episodes (typically on the order of every 2 to 6 years). In Delaware Bay, beach nourishment has been recommended to prevent loss of spawning habitat for horseshoe crabs (Kalasz 2008; Carter et al. in Guilfoyle et al. 2007; Atlantic States Marine Fisheries Commission (ASMFC) 1998), and is being pursued as a means of restoring shorebird habitat in Delaware Bay following Hurricane Sandy (Niles et al. 2013; USACE 2012). Beach nourishment was part of a 2009 project to maintain important shorebird foraging habitat at Mispillion Harbor, Delaware (Kalasz pers. comm. March 29, 2013; Siok and Wilson 2011). However, red knots may be directly disturbed if beach nourishment takes place while the birds are present. On New Jersey's Atlantic coast, beach nourishment has typically been scheduled for the fall, when red knots are present, because of various constraints at other times of year. In addition to causing disturbance during construction, beach nourishment often increases recreational use of the widened beaches that, without careful management, can increase disturbance of red knots. Beach nourishment can also temporarily depress, and sometimes permanently alter, the invertebrate prey base on which shorebirds depend. In addition to disturbing the birds and impacting the prey base, beach nourishment can affect the quality and quantity of red knot habitat (M. Bimbi pers. comm. November 1, 2012; Greene 2002). The artificial beach created by nourishment may provide only suboptimal habitat for red knots, as a steeper beach profile is created when sand is stacked on the beach during the nourishment process. In some cases, nourishment is accompanied by the planting of dense beach grasses, which can directly degrade habitat, as red knots require sparse vegetation to avoid predation. By precluding overwash and Aeolian transport, especially where large artificial dunes are constructed, beach nourishment can also lead to further erosion on the bayside and promote bayside vegetation growth, both of which can degrade the red knot's preferred foraging and roosting habitats (sparsely vegetated flats in or adjacent to intertidal areas). Preclusion of overwash also impedes the formation of new red knot habitats. Beach nourishment can also encourage further development, bringing further habitat impacts, reducing future alternative management options such as a retreat from the coast, and perpetuating the developed and stabilized conditions that may ultimately lead to inundation where beaches are prevented from migrating (M. Bimbi pers. comm. November 1, 2012; Greene 2002).

The quantity and quality of red knot prey may also be affected by the placement of sediment for beach nourishment or disposal of dredged material. Invertebrates may be crushed or buried during project construction. Although some benthic species can burrow through a thin layer of additional sediment, thicker layers (over 35 in (90 cm)) smother the benthic fauna (Greene 2002). By means of this vertical burrowing, recolonization from adjacent areas, or both, the benthic faunal communities typically recover. Recovery can take as little as 2 weeks or as long as 2 years, but usually averages 2 to 7 months (Greene 2002; Peterson and Manning 2001). Although many studies have concluded that invertebrate communities recovered following sand placement, study methods have often been insufficient to detect even large changes (e.g., in abundance or species composition), due to high natural variability and small sample sizes (Peterson and Bishop 2005). Therefore, uncertainty remains about the effects of sand placement on invertebrate communities, and how these impacts may affect red knots.

Dredging/sand mining

Many inlets in the U.S. range of the red knot are routinely dredged and sometimes relocated. In addition, nearshore areas are routinely dredged ("mined") to obtain sand for beach nourishment. Regardless of the purpose, inlet and nearshore dredging can affect red knot habitats. Dredging often involves removal of sediment from sand bars, shoals, and inlets in the nearshore zone, directly impacting optimal red knot roosting and foraging habitats (Harrington in Guilfoyle et al. 2007; Winn and Harrington in Guilfoyle et al. 2006). These ephemeral habitats are even more valuable to red knots because they tend to receive less recreational use than the main beach strand. In addition to causing this direct habitat loss, the dredging of sand bars and shoals can preclude the creation and maintenance of red knot habitats by removing sand sources that would otherwise act as natural breakwaters and weld onto the shore over time (Hayes and Michel 2008; Morton 2003). Further, removing these sand features can cause or worsen localized erosion by altering depth contours and changing wave refraction (Hayes and Michel 2008), potentially degrading other nearby red knot habitats indirectly because inlet dynamics exert a strong influence on the adjacent shorelines. Studying barrier islands in Virginia and North Carolina, Fenster and Dolan (1996) found that inlet influences extend 3.4 to 8.1 mi (5.4 to 13.0 km), and that inlets dominate shoreline changes for up to 2.7 mi (4.3 km). Changing the location of dominant channels at inlets can create profound alterations to the adjacent shoreline (Nordstrom 2000).

Reduced food availability

Commercial harvest of horseshoe crabs has been implicated as a causal factor in the decline of the rufa red knot, by decreasing the availability of horseshoe crab eggs in the Delaware Bay stopover (Niles et al. 2008). Notwithstanding the importance of the horseshoe crab and Delaware

Bay, other lines of evidence suggest that the rufa red knot also faces threats to its food resources throughout its range.

During most of the year, bivalves and other mollusks are the primary prey for the red knot. Mollusks in general are at risk from climate change-induced ocean acidification (Fabry et al. 2008). Oceans become more acidic as carbon dioxide emitted into the atmosphere dissolves in the ocean. The pH (percent hydrogen, a measure of acidity or alkalinity) level of the oceans has decreased by approximately 0.1 pH units since preindustrial times, which is equivalent to a 25 percent increase in acidity. By 2100, the pH level of the oceans is projected to decrease by an additional 0.3 to 0.4 units under the highest emissions scenarios (NRC 2010). As ocean acidification increases, the availability of calcium carbonate declines. Calcium carbonate is a key building block for the shells of many marine organisms, including bivalves and other mollusks (USEPA 2012; NRC 2010). Vulnerability to ocean acidification has been shown in bivalve species similar to those favored by red knots, including mussels (Gaylord et al. 2011; Bibby et al. 2008) and clams (Green et al. 2009). Reduced calcification rates and calcium metabolism are also expected to affect several mollusks and crustaceans that inhabit sandy beaches (Defeo et al. 2009), the primary nonbreeding habitat for red knots. Relevant to Tierra del Fuego-wintering knots, bivalves have also shown vulnerability to ocean acidification in Antarctic waters, which are predicted to be affected due to naturally low carbonate saturation levels in cold waters (Cummings et al. 2011).

Blue mussel spat is an important prey item for red knots in Virginia (Karpanty et al. 2012). The southern limit of adult blue mussels has contracted from North Carolina to Delaware since 1960 due to increasing air and water temperatures (Jones et al. 2010). Larvae have continued to recruit to southern locales (including Virginia) via currents, but those recruits die early in the summer due to water and air temperatures in excess of lethal physiological limits. Failure to recolonize southern regions will occur when reproducing populations at higher latitudes are beyond dispersal distance (Jones et al. 2010). Thus, this key prey resource may soon disappear from the red knot's Virginia spring stopover habitats (Karpanty et al. 2012).

Reduced food availability at the Delaware Bay stopover site due to commercial harvest and subsequent population decline of the horseshoe crab is considered a primary causal factor in the decline of the rufa subspecies in the 2000s (Escudero et al. 2012; McGowan et al. 2011; CAFF 2010; Niles et al. 2008; COSEWIC 2007; González et al. 2006; Baker et al. 2004; Morrison et al. 2004), although other possible causes or contributing factors have been postulated (Fraser et al. 2013; Schwarzer et al. 2012; Escudero et al. 2012; Espoz et al. 2008; Niles et al. 2008). Due to harvest restrictions and other conservation actions, horseshoe crab populations showed some signs of recovery in the early 2000s, with apparent signs of red knot stabilization (survey counts, rates of weight gain) occurring a few years later. Since about 2005, however, horseshoe crab population growth has stagnated for unknown reasons. Under the current management framework (known as Adaptive Resource Management, or ARM), the present horseshoe crab harvest is not considered a threat to the red knot because harvest levels are tied to red knot populations via scientific modeling. Most data suggest that the volume of horseshoe crab eggs is currently sufficient to support the Delaware Bay's stopover population of red knots at its present size. However, because of the uncertain trajectory of horseshoe crab population growth, it is not yet known if the egg resource will continue to adequately support red knot populations over the next 5 to 10 years. In addition, implementation of the ARM could be impeded by insufficient funding for the shorebird and horseshoe crab monitoring programs that are necessary for the functioning of the ARM models. Many studies have established that red knots stopping over in Delaware Bay during spring migration achieve remarkable and important weight gains to complete their migrations to the breeding grounds by feeding almost exclusively on a superabundance of horseshoe crab eggs. A temporal correlation occurred between increased horseshoe crab harvests in the 1990s and declining red knot counts in both Delaware Bay and Tierra del Fuego by the 2000s. Other shorebird species that rely on Delaware Bay also declined over this period (Mizrahi and Peters in Tanacredi et al. 2009), although some shorebird declines began before the peak expansion of the horseshoe crab fishery (Botton et al. in Shuster et al. 2003).

Hunting

Legal and illegal sport and market hunting in the mid-Atlantic and Northeast United States substantially reduced red knot populations in the 1800s, and we do not know if the subspecies ever fully recovered its former abundance or distribution. Neither legal nor illegal hunting are currently a threat to red knots in the United States, but both occur in the Caribbean and parts of South America. Hunting pressure on red knots and other shorebirds in the northern Caribbean and on Trinidad is unknown. Hunting pressure on shorebirds in the Lesser Antilles (e.g., Barbados, Guadeloupe) is very high, but only small numbers of red knots have been documented on these islands, so past mortality may not have exceeded tens of birds per year. Red knots are no longer being targeted in Barbados or Guadeloupe, and other measures to regulate shorebird hunting on these islands are being negotiated. Much larger numbers (thousands) of red knots occur in the Guianas, where legal and illegal subsistence shorebird hunting is common. About 20 red knot mortalities have been documented in the Guianas, but total red knot hunting mortality in this region cannot be surmised. Subsistence shorebird hunting was also common in northern Brazil, but has decreased in recent decades. We have no evidence that hunting was a driving factor in red knot population declines in the 2000s, or that hunting pressure is increasing. In addition, catch limits, handling protocols, and studies on the effects of research activities on survival all indicate that overutilization for scientific purposes is not a threat to the red knot.

Threats to the red knot from overutilization for commercial, recreational, scientific, or educational purposes exist in parts of the Caribbean and South America. Specifically, legal and illegal hunting does occur. We expect mortality of individual knots from hunting to continue into the future, but at stable or decreasing levels due to the recent international attention to shorebird hunting.

Predation

In wintering and migration areas, the most common predators of red knots are peregrine falcons (*Falco peregrinus*), harriers (*Circus spp.*), accipiters (Family Accipitridae), merlins (*F. columbarius*), shorteared owls (*Asio flammeus*), and greater black-backed gulls (*Larus marinus*) (Niles et al. 2008). Other large are anecdotally known to prey on shorebirds (Breese 2010). In migration areas like Delaware Bay, terrestrial predators such as red foxes (*Vulpes vulpes*) and feral cats (*Felis catus*) may be a threat to red knots by causing disturbance, but direct mortality from these predators may be low (Niles et al. 2008).

Although little information is available from the breeding grounds, the long-tailed jaeger (*Stercorarius longicaudus*) is prominently mentioned as a predator of red knot chicks in most accounts. Other avian predators include parasitic jaeger (*S. parasiticus*), pomarine jaeger (*S. pomarinus*), herring gull and glaucous gulls, gyrfalcon (*Falcon rusticolus*), peregrine falcon, and snowy owl (*Bubo scandiacus*). Mammalian predators include arctic fox (*Alopex lagopus*) and sometimes arctic wolves (*Canis lupus arctos*) (Niles et al. 2008; COSEWIC 2007). Predation pressure on Arctic-nesting shorebird clutches varies widely regionally, interannually, and even within each nesting season, with nest losses to predators ranging from close to 0 percent to near 100 percent (Meltofte et al. 2007), depending on ecological factors. Abundance of arctic rodents, such as lemmings, is often cyclical, although less so in North America than in Eurasia. In the Arctic, 3- to 4-year lemming cycles give rise to similar cycles in the predation of shorebird nests. When lemmings are abundant, predators concentrate on the lemmings, and shorebirds breed successfully. When lemmings are in short supply, predators switch to shorebird eggs and chicks (Niles et al. 2008; COSEWIC 2007; Meltofte et al. 2007; USFWS 2003b; Blomqvist et al. 2002; Summers and Underhill 1987).

Recreational disturbance

In some wintering and stopover areas, red knots and recreational users (e.g., pedestrians, ORVs, dog walkers, boaters) are concentrated on the same beaches (Niles et al. 2008; Tarr 2008). Recreational activities affect red knots both directly and indirectly. These activities can cause habitat damage (Schlacher and Thompson 2008; Anders and Leatherman 1987), cause shorebirds to abandon otherwise preferred habitats, and negatively affect the birds' energy balances. Effects to red knots from vehicle and pedestrian disturbance can also occur during construction of shoreline stabilization projects including beach nourishment. Red knots can also be disturbed by motorized and nonmotorized boats, fishing, kite surfing, aircraft, and research activities (Niles et al. 2008; Peters and Otis, 2007; Harrington 2005b; Meyer et al. 1999; Burger 1986) and by beach raking or cleaning.

5) Analysis of the Species Likely to be Affected

The proposed action has the potential to adversely affect wintering and migrating red knots and their habitat. Potential effects to red knots include direct loss of foraging and roosting habitat in the Action Area and in the updrift and downdrift portions of South and West Beach, degradation of foraging habitat and destruction of the prey base from sand disposal, and attraction of predators due to food waste from the construction crew. Like the piping plover, red knots face predation by avian and mammalian predators that are present year-round on the migration and wintering grounds.

B. Environmental Baseline

1) Status of the species within the Action Area

Data provided by the NCWRC for the Draft EIS indicate 30 red knots were reported in one survey on East Beach in Bald Head Island in 2006. In May 2009, a report of 2 red knots was documented on Bald Head Island by an eBird member (eBird.org 2014).

2) Factors affecting the species environment within the Action Area

Pedestrian Use of the Beach: There are a number of potential sources of pedestrians and pets, including those individuals originating from hotels, beachfront and nearby residences.

Sand nourishment: The beaches of Bald Head Island are regularly nourished with sand from the Corps Wilmington Harbor SMP.

Shoreline stabilization: Sixteen sand-filled groin tubes on South Beach provide stabilization to the shoreline of South Beach.

C. Effects of the Action

This section is an analysis of the beneficial, direct and indirect effects of the proposed action on migrating and wintering red knots within the Action Area. The analysis includes effects interrelated and interdependent of the project activities. An interrelated activity is an activity that is part of a proposed action and depends on the proposed activity. An interdependent activity is an activity that has no independent utility apart from the action.

1) Factors to be considered

The proposed project will occur within habitat used by migrating and wintering red knots and construction will occur during a portion of the migration and winter seasons. Long-term and permanent impacts could preclude the creation of new habitat and increase recreational disturbance. Short-term and temporary impacts to red knots could result from project work disturbing roosting red knots and degrading currently occupied foraging areas.

Proximity of action: Beach renourishment and groin installation will occur within and adjacent to red knot roosting and foraging habitat.

Distribution: Project construction activities that may impact migrants and the wintering population of red knots on Bald Head Island would occur along the West Beach and South Beach shoreline and the "Point."

Timing: The timing of project construction could directly and indirectly impact migrating and wintering red knots.

Nature of the effect: The effects of the project construction include a temporary reduction in foraging habitat, a long term decreased rate of change that may preclude habitat creation, and increased recreational disturbance. A decrease in the survival of red knots on the migration and winter grounds due to the lack of optimal habitat may contribute to decreased survival rates, decreased productivity on the breeding grounds, and increased vulnerability to the population.

Duration: Groin installation will be a one-time, phased activity, which will take from seven months to two years to complete. Sand fillet maintenance will be a recurring activity and will take up to four months to complete each time. Thus, the direct effects would be expected to be short-term in duration. Indirect effects from the activity may continue to impact migrating and wintering red knots in subsequent seasons after sand placement.

Disturbance frequency: Disturbance from construction activities will be short term, lasting up to two years. Recreational disturbance may increase after project completion and have long-term impacts.

Disturbance intensity and severity: Project construction is anticipated to be conducted during portions of the red knot migration and winter seasons. Conservation measures have been incorporated into the project to minimize impacts.

2) Analyses for effects of the action

Beneficial effects: For some highly eroded beaches, sand placement may have a beneficial effect on the habitat's ability to support wintering or migrating red knots. The addition of sand to the sediment budget may increase a sand-starved beach's likelihood of developing habitat features valued by red knots.

Direct effects: Direct effects are those direct or immediate effects of a project on the species or its habitat. The construction window (i.e., sand placement and groin installation) will extend into one or more red knot migration and winter seasons. Heavy machinery and equipment (e.g., trucks and bulldozers operating on Action Area beaches, the placement of the dredge pipeline along the beach, and sand disposal) may adversely affect migrating and wintering red knots in the Action Area by disturbance and disruption of normal activities such as roosting and foraging, and possibly forcing birds to expend valuable energy reserves to seek available habitat elsewhere.

Burial and suffocation of invertebrate species will occur during each sand fillet maintenance activity. Impacts will affect the 2,500 feet of shoreline. Timeframes projected for benthic recruitment and re-establishment following beach nourishment are between 6 months to 2 years. Depending on actual recovery rates, impacts will occur even if nourishment activities occur outside the red knot migration and wintering seasons.

Indirect effects: The proposed project includes beach renourishment and groin installation along 12,600 feet of shoreline as protective elements against shoreline erosion to protect man-made infrastructure. Indirect effects include reducing the potential for the formation of optimal habitats (coastal marine and estuarine habitats with large areas of exposed intertidal sediments).

The proposed project may limit the creation of optimal foraging and roosting habitat, and may increase the attractiveness of these beaches for recreation increasing recreational pressures within the Action Area. Recreational activities that potentially adversely affect red knots include disturbance by unleashed pets and increased pedestrian use.

3) Species' response to the proposed action

The proposed project will occur within habitat that is used by migrating and wintering red knots. Since red knots can be present on these beaches almost year-round, construction is likely to occur while this species is utilizing these beaches and associated habitats. Short-term and temporary impacts to red knot activities could result from project work occurring on the beach that flushes birds from roosting or foraging habitat. Long-term impacts could include a hindrance in the ability of migrating or wintering red knots to recuperate from their migratory flight from their breeding grounds, survive on their wintering areas, or to build fat reserves in preparation for migration. Long-term impacts may also result from changes in the physical characteristics of the beach from the placement of the sand.

D. Cumulative Effects

This project occurs on non-federal lands. Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the Action Area considered in this biological opinion.

It is reasonable to expect continued shoreline stabilization and beach renourishment projects in this area in the future since erosion and sea-level rise increases would impact the existing beachfront development.

V. SEABEACH AMARANTH

A. Status of the Species/Critical Habitat

1) Species/critical habitat description

Seabeach amaranth (*Amaranthus pumilus*) is an annual plant that grows on Atlantic barrier islands and ocean beaches currently ranging from South Carolina to New York. It was listed as threatened under the Act on April 7, 1993 (58 FR 18035) because of its vulnerability to human and natural impacts and the fact that it had been eliminated from two-thirds of its historic range (USFWS 1996b). Seabeach amaranth stems are fleshy and pink-red or reddish, with small rounded leaves that are 0.5 to 1.0 inches in diameter. The green leaves, with indented veins, are clustered toward the tip of the stems, and have a small notch at the rounded tip. Flowers and fruits are relatively inconspicuous, borne in clusters along the stems. Seabeach amaranth will be considered for delisting when the species exists in at least six states within its historic range and when a minimum of 75 percent of the sites with suitable habitat within each state are occupied by populations for 10 consecutive years (USFWS 1996b). The recovery plan states that mechanisms must be in place to protect the plants from destructive habitat alterations, destruction or decimation by off-road vehicles or other beach uses, and protection of populations from debilitating webworm predation. There is no designation of critical habitat for seabeach amaranth.

2) Life History

Seabeach amaranth is an annual plant. Germination of seabeach amaranth seeds occurs over a relatively long period, generally from April to July. Upon germinating, this plant initially forms a small unbranched sprig, but soon begins to branch profusely into a clump. This clump often reaches one foot in diameter and consists of five to 20 branches. Occasionally, a clump may get as large as three feet or more across, with 100 or more branches. Flowering begins as soon as plants have reached sufficient size, sometimes as early as June, but more typically commencing in July and continuing until the death of the plant in late fall. Seed production begins in July or August and peaks in September during most years, but continues until the death of the plant. Weather events, including rainfall, hurricanes, and temperature extremes, and predation by webworms have strong effects on the length of the reproductive season of seabeach amaranth. Because of one or more of these influences, the flowering and fruiting period can be terminated as early as June or July. Under favorable circumstances, however, the reproductive season may extend until January or sometimes later (Radford et al. 1968; Bucher and Weakley 1990; Weakley and Bucher1992).

3) Population dynamics

Within North Carolina and across its range, seabeach amaranth numbers vary from year to year. Data in North Carolina is available from 1987 to 2013. Recently, the number of plants across the entire state dwindled from a high of 19,978 in 2005 to 165 in 2013. This trend of decreasing numbers is seen throughout its range. 249,261 plants were found throughout the species' range in 2000. By 2013, those numbers had dwindled to 1,320 plants (USFWS, unpublished data).

Seabeach amaranth is dependent on natural coastal processes to create and maintain habitat. However, high tides and storm surges from tropical systems can overwash, bury, or inundate seabeach amaranth plants or seeds, and seed dispersal may be affected by strong storm events. In September of 1989, Hurricane Hugo struck the Atlantic Coast near Charleston, South Carolina, causing extensive flooding and erosion north to the Cape Fear region of North Carolina, with less severe effects extending northward throughout the range of seabeach amaranth. This was followed by several severe storms that, while not as significant as Hurricane Hugo, caused substantial erosion of many barrier islands in the seabeach amaranth's range. Surveys for seabeach amaranth revealed that the effects of these climatic events were substantial

(Weakley and Bucher 1992). In the Carolinas, populations of amaranth were severely reduced. In South Carolina, where the effects of Hurricane Hugo and subsequent dune reconstruction were extensive, amaranth numbers declined from 1,800 in 1988 to I88 in 1990, a reduction of 90 percent. A 74 percent reduction in amaranth numbers occurred in North Carolina, from 41,851 plants in 1988 to 10,898 in 1990. Although population numbers in New York increased in 1990, range-wide totals of seabeach amaranth were reduced 76 percent from 1988 (Weakley and Bucher 1992). The extent stochastic events have on long-term population trends of seabeach amaranth has not been assessed.

4) Status and Distribution

The species historically occurred in nine states from Rhode Island to South Carolina (USFWS 2003c). By the late 1980s, habitat loss and other factors had reduced the range of this species to North and South Carolina. Since 1990, seabeach amaranth has reappeared in several states that had lost their populations in earlier decades. However, threats like habitat loss have not diminished, and populations are declining overall. It is currently found in New York, New Jersey, Delaware, Maryland, Virginia, North Carolina, and South Carolina. The typical habitat where this species is found includes the lower foredunes and upper beach strands on the ocean side of the primary sand dunes and overwash flats at accreting spits or ends of barrier islands.

Seabeach amaranth has been and continues to be threatened by destruction or adverse alteration of its habitat. As a fugitive species dependent on a dynamic landscape and large-scale geophysical processes, it is extremely vulnerable to habitat fragmentation and isolation of small populations. Further, because this species is easily recognizable and accessible, it is vulnerable to taking, vandalism, and the incidental trampling by curiosity seekers. Seabeach amaranth is afforded legal protection in North Carolina by the General Statutes of North Carolina, Sections 106-202.15, 106- 202.19 (N.C. Gen. Stat. section 106 (Supp. 1991)), which provide for protection from intrastate trade (without a permit).

The most serious threats to the continued existence of seabeach amaranth are construction of beach stabilization structures, natural and man-induced beach erosion and tidal inundation, fungi (i.e., white wilt), beach grooming, herbivory by insects and mammals, and off-road vehicles. Herbivory by webworms, deer, feral horses, and rabbits is a major source of mortality and lowered fecundity for seabeach amaranth. However, the extent to which herbivory affects the species as a whole is unknown.

Potential effects to seabeach amaranth from vehicle use on the beaches include vehicles running over, crushing, burying, or breaking plants, burying seeds, degrading habitat through compaction of sand and the formation of seed sinks caused by tire ruts. Seed sinks occur when blowing seeds fall into tire ruts, then a vehicle comes along and buries them further into the sand preventing germination. If seeds are capable of germinating in the tire ruts, the plants are usually destroyed before they can reproduce by other vehicles following the tire ruts. Those seeds and their reproductive potential become lost from the population.

Pedestrians also can negatively affect seabeach amaranth plants. Seabeach amaranth occurs on the upper portion of the beach which is often traversed by pedestrians walking from parking lots, hotels, or vacation property to the ocean. This is also the area where beach chairs and umbrellas are often set up and/or stored. In addition, resorts, hotels, or other vacation rental establishments may set up volleyball courts or other sporting activity areas on the upper beach at the edge of the dunes. All of these activities can result in the trampling and destruction of plants. Pedestrians walking their dogs on the upper part of the beach, or dogs running freely on the upper part of the beach, may result in the trampling and destruction of seabeach amaranth plants.
The extent of the effects that dogs have on seabeach amaranth is not known.

Recovery Criteria

Delisting of seabeach amaranth will be considered when a minimum of 75 percent of the sites with suitable habitat within at least six of the nine historically occupied States are occupied by seabeach amaranth populations for 10 consecutive years.

5) Analysis of the Species Likely to be Affected

The predominant threat to seabeach amaranth is the destruction or alteration of suitable habitat, primarily because of beach stabilization efforts and storm-related erosion (USFWS 1993). Other important threats to the plant include beach grooming and vehicular traffic, which can easily break or crush the fleshy plant and bury seeds below depths from which they can germinate; and predation by webworms (caterpillars of small moths) (USFWS 1993). Webworms feed on the leaves of the plant and can defoliate the plants to the point of either killing them or at least reducing their seed production. Beach vitex (*Vitex rotundifulia*) is another threat to seabeach amaranth, as it is an aggressive, invasive, woody plant that can occupy habitat similar to seabeach amaranth and outcompete it (Invasive Species Specialist Group (ISSG) 2010).

The proposed action has the potential to adversely affect seabeach amaranth within the proposed Action Area. Potential effects include burying, trampling, or injuring plants as a result of construction operations and/or sediment disposal activities; burying seeds to a depth that would prevent future germination as a result of construction operations and/or sediment disposal activities; and, destruction of plants by trampling or breaking as a result of increased recreational activities. The Applicant proposes to place sand between November 15 and March 31 of any given year. However, given favorable weather, seabeach amaranth plants may persist until January. Therefore, there is still the potential for sand placement to adversely impact plants in the Action Area.

B. Environmental Baseline

1) Status of the species within the Action Area

Since 1992, seabeach amaranth surveys have been conducted on Bald Head Island. The numbers of seabeach amaranth vary widely from year to year, from no individuals in 2010 and 2011, to 105 individuals in 1998. See **Table 14** for data from the Corps.

Table 14. Annual seabeach amaranth results on Bald Head Island, NC between 1992 and 2011.

Year	Number of Seabeach Amaranth
1992	1
1993	16
1994	0
1995	0
1996	16
1997	0
1998	105
1999	24
2000	3
2001	1
2002	0
2003	0
2004	0
2005	45
2006	4
2007	0
2008	2
2009	2
2010	0
2011	0

2) Factors affecting the species environment within the Action Area

Pedestrian Use of the Beach: There are a number of potential sources of pedestrians and pets, including those individuals originating from hotels, beachfront and nearby residences.

Sand nourishment: The beaches of Bald Head Island are regularly nourished with sand from the Corps Wilmington Harbor SMP.

Shoreline stabilization: Sixteen sand-filled groin tubes on South Beach provide stabilization to the shoreline of South Beach.

C. EFFECTS OF THE ACTION

1) Factors to be considered

Proximity of action: Beach renourishment and groin installation will occur within and adjacent to seabeach amaranth habitat.

Distribution: Project construction activities that may affect seabeach amaranth plants on Bald Head Island would occur along the shoreline of West Beach and South Beach and the "Point."

Timing: The timing of project construction could directly and indirectly impact seabeach amaranth.

Nature of the effect: The effects of the project construction include burying, trampling, or injuring plants as a result of construction operations and/or sediment disposal activities; burying seeds to a depth that would prevent future germination as a result of construction operations and/or sediment disposal activities; and, destruction of plants by trampling or breaking as a result of increased recreational activities.

Duration: Groin installation will be a one-time, phased activity, which will take from seven months to two years to complete. Sand fillet maintenance will be a recurring activity and will take up to four months to complete each time. Thus, the direct effects would be expected to be short-term in duration. Indirect effects from the activity may continue to impact seabeach amaranth in subsequent seasons after sand placement.

Disturbance frequency: Disturbance from construction activities will be short term, lasting up to two years. Recreational disturbance may increase after project completion and have long-term impacts.

Disturbance intensity and severity: Project construction is anticipated to be conducted during portions of the seabeach amaranth growing and flowering season. Conservation measures have been incorporated into the project to minimize impacts.

2) Analyses for effects of the action

Beneficial Effects: The placement beach-compatible sand may benefit this species by providing additional suitable habitat or by redistributing seed sources buried during past storm events, beach disposal activities, or natural barrier island migration. Disposal of dredged sand may be compatible with seabeach amaranth provided the timing of beach disposal is appropriate, the material placed on the beach is compatible with the natural sand, and special precautions are adopted to protect existing seabeach amaranth plants. Further studies are needed to determine the best methods of beach disposal in seabeach amaranth habitat (Weakley and Bucher 1992).

Direct Effects: Groin construction and sand placement activities may bury or destroy existing plants, resulting in mortality, or bury seeds to a depth that would prevent future germination, resulting in reduced plant populations. Increased traffic from recreationists and their pets can also destroy existing plants by trampling or breaking the plants.

Indirect Effects: Future tilling of the beach may be necessary if beach compaction hinders sea turtle nesting activities. Thus, the placement of heavy machinery or associated tilling equipment on the beach may destroy or bury existing plants.

3) Species' response to the proposed action

The construction of the groin and placement of sand in the Action Area could bury existing plants if work is conducted during the growing season. Sand placement at any time of year could also bury seeds to a depth that would prevent germination.

Sand placement beaches could also have positive impacts on seabeach amaranth by creating additional habitat for the species. Although more study is needed before the long-term impacts can be accurately assessed, several populations are shown to have established themselves on beaches receiving dredged sediments, and have thrived through subsequent applications of dredged material (Weakley and Bucher 1992).

D. CUMULATIVE EFFECTS

This project occurs on non-federal lands. Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the Action Area considered in this biological opinion.

It is reasonable to expect continued shoreline stabilization and beach renourishment projects in this area in the future since erosion and sea-level rise increases would impact the existing beachfront development.

VI. CONCLUSION

Sea Turtles

After reviewing the current status of the nesting loggerhead sea turtle, green sea turtle, and leatherback sea turtle, the environmental baseline for the Action Area, the effects of the proposed sand placement and groin construction, the proposed Conservation Measures, and the cumulative effects, it is the Service's biological and conference opinion that the placement of sand and construction and presence of the groin as proposed, is not likely to jeopardize the continued existence of the loggerhead sea turtle, green sea turtle, leatherback sea turtle, piping plover, red knot, and seabeach amaranth. The Service has determined that the project is not likely to destroy or adversely modify proposed critical habitat for nesting loggerhead sea turtles.

The conservation of the five loggerhead recovery units in the Northwest Atlantic is essential to the recovery of the loggerhead sea turtle. Each individual recovery unit is necessary to conserve genetic and demographic robustness, or other features necessary for long-term sustainability of the entire population. Thus, maintenance of viable nesting in each recovery unit contributes to the overall population. The NRU, one of the five loggerhead recovery units in the Northwest Atlantic occurs within the Action Area. The NRU averages 5,215 nests per year (based on 1989-2008 nesting data). Of the available nesting habitat within the NRU, construction will occur and/or will likely have an effect on 12,600 lf of nesting shoreline.

Generally, green and leatherback sea turtle nesting overlaps with or occurs within the beaches where loggerhead sea turtles nest on both the Atlantic and Gulf of Mexico beaches. Thus, for green and leatherback sea turtles, sand placement activities will affect 12, 600 lf of shoreline.

Long-term adverse effects to adult and hatchling sea turtles are anticipated as a result of the presence of the groin. The permanent placement of the groin is expected to affect nesting, hatching, and hatchling emerging success within that area for the life of the structure. Although a variety of factors, including some that cannot be controlled, can influence how an erosion control structure construction project will perform from an engineering perspective, measures can be implemented to minimize adverse impacts to sea turtles. Take of sea turtles will be minimized by implementation of the Reasonable and Prudent Measures, and Terms and Conditions outline below. These measures have been shown to help minimize adverse impacts to sea turtles.

Research has shown that the principal effect of sand placement on sea turtle reproduction is a reduction in nesting success, and this reduction is most often limited to the first year or two following project construction. Research has also shown that the impacts of a nourishment project on sea turtle nesting habitat are typically short-term because a nourished beach will be reworked by natural processes in subsequent years, and beach compaction and the frequency of escarpment formation will decline. Although a variety of factors, including some that cannot be controlled, can influence how a nourishment project will perform from an engineering perspective, measures can be implemented to minimize impacts to sea turtles.

Piping Plovers

After reviewing the current status of the northern Great Plains, Great Lakes, and Atlantic Coast wintering piping plover populations, the environmental baseline for the Action Area, the effects of the proposed activities, the proposed Conservation Measures, and the cumulative effects, it is the Service's biological opinion that implementation of these actions, as proposed, is not likely to jeopardize the continued existence of the piping plover.

Red Knot

After reviewing the current status of the migrating and wintering red knot populations, the environmental baseline for the Action Area, the effects of the proposed activities, the proposed Conservation Measures, and the cumulative effects, it is the Service's conference opinion that implementation of these actions, as proposed, is not likely to jeopardize the continued existence of the red knot.

Seabeach Amaranth

After reviewing the current status of the seabeach amaranth population, the environmental baseline for the Action Area, the effects of the proposed activities, the proposed Conservation Measures, and the cumulative effects, it is the Service's biological opinion that implementation of these actions, as proposed, is not likely to jeopardize the continued existence of the seabeach amaranth.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered or threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, carrying out an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited under the Act provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The measures described below in Sections VII and VIII are non-discretionary, and must be implemented by the Corps so that they become binding conditions of any grant or permit issued to the Applicant, as appropriate, for the exemption in section 7(o)(2) to apply. The Corps has a continuing duty to regulate the activity covered by this incidental take statement. If the Corps (1) fails to assume and implement the terms and conditions or (2) fails to require the Applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Corps must report the progress of the action and its impacts on the species to the Service as specified in the incidental take statement [50 CFR §402.14(i)(3)].

For red knots, the prohibitions against taking the species found in section 9 of the Act do not apply until the species is listed. However, the Service advises the Corps to consider implementing the following reasonable and prudent measures. If this conference opinion is adopted as a biological opinion following a listing or designation, these measures, with their implementing terms and conditions, will be nondiscretionary, and must be undertaken by the Corps so that they become binding conditions of any grant or permit issued to the Applicant, as appropriate for the exemption in section 7(o)(2) to apply. The Corps has a continuing duty to regulate the activity covered by this incidental take statement, as discussed in the previous paragraph.

Sections 7(b)(4) and 7(o)(2) of the Act generally do not apply to listed plant species. However, limited protection of listed plants from take is provided to the extent that the Act prohibits the removal and reduction to possession of Federally listed endangered plants or the malicious damage of such plants on areas under Federal jurisdiction, or the destruction of endangered plants on non-Federal areas in violation of state law or regulation, or in the course of any violation of a State criminal trespass law.

AMOUNT OR EXTENT OF TAKE

Amount of Extent of Take – Loggerhead, Green, and Leatherback Sea Turtles

The Service anticipates 12,600 lf of nesting beach habitat could be taken as a result of this proposed action.

Take is expected to be in the form of: (1) destruction of all nests that may be constructed and eggs that may be deposited and missed by a nest survey, nest mark and avoidance program, or egg relocation program within the boundaries of the proposed project; (2) destruction of all nests deposited during the period when a nest survey, nest mark and avoidance, or egg relocation program is not required to be in place within the boundaries of the proposed project; (3) reduced hatching success due to egg mortality during relocation and adverse conditions at the relocation site; (4) harassment in the form of disturbing or interfering with female turtles attempting to nest within the construction area or on adjacent beaches as a result of construction activities; (5) misdirection of nesting and hatchling turtles on beaches adjacent to the sand placement or construction area as a result of project lighting, including the ambient lighting from dredges; (6) behavior modification of nesting females due to escarpment formation within the Action Area during the nesting season, resulting in false crawls or situations where they choose marginal or unsuitable nesting areas to deposit eggs; (7) Destruction of nests from escarpment leveling within a nesting season when such leveling has been approved by the Service; (8) behavior modification of nesting females or hatchlings due to the presence of the groin which may act as barriers to movement or cause disorientation of turtles while on the nesting beach; (9) physical entrapment of hatchling sea turtles on the nesting beach due to the presence of the groin; behavior modification of nesting females if they dig above a buried portion of the structure, resulting in false crawls or situations where they choose marginal or unsuitable nesting areas; and (10) obstruction or entrapment of an unknown number of adult and hatchling sea turtles during ingress or egress at nesting sites.

Incidental take is anticipated for the 12,600 lf of beach that has been identified. The Service anticipates incidental take of sea turtles will be difficult to detect for the following reasons: (1) the turtles nest primarily at night and all nests are not found because [a] natural factors, such as rainfall, wind, and tides may obscure crawls and [b] human-caused factors, such as pedestrian and vehicular traffic, may obscure crawls, and result in nests being destroyed because they were missed during a nesting survey, nest mark and avoidance, or egg relocation program (2) the total number of hatchlings per undiscovered nest is unknown; (3) the reduction in percent hatching and emerging success per relocated nest over the natural nest site is unknown; (4) an unknown number of females may avoid the project beach and be forced to nest in a less than optimal area; (5) lights may misdirect an unknown number of hatchlings and cause death; (6) an unknown number of adult and hatchling sea turtles may be obstructed or entrapped during ingress or egress at nesting sites; and (7) escarpments may form and prevent an unknown number of females from accessing a suitable nesting site.

However, the level of take of these species can be anticipated by the sand placement activities and construction and presence of the groin on suitable turtle nesting beach habitat because: (1) turtles nest within the Action Area; (2) construction will likely occur during a portion of the nesting season; (3) the groin construction project will modify beach profile and width and increase the presence of escarpments; (4) the renourishment project will modify the incubation substrate, beach slope, and sand compaction; and (5) artificial lighting will deter and/or misdirect nesting hatchling turtles.

Amount or Extent of Take – Piping Plover and Red Knot

It is difficult for the Service to estimate the exact number of piping plovers and red knots that could be migrating through or wintering within the Action Area at any one point in time and place during project construction. Disturbance to suitable habitat resulting from both construction and sand placement activities within the Action Area would affect the ability of an undetermined number of piping plovers and red knots to find suitable foraging and roosting habitat during any given year.

The Service anticipates that directly and indirectly an unspecified amount of piping plovers and red knots along 12,600 feet of shoreline, all at some point, potentially usable by piping plovers and red knots, could be taken in the form of harm and harassment as a result of this proposed action; however, incidental take of piping plovers and red knots will be difficult to detect for the following reasons:

(1) harassment to the level of harm may only be apparent on the breeding grounds the following year; and
(2) dead plovers and red knots may be carried away by waves or predators.

The level of take of this species can be anticipated by the proposed activities because:

(1) piping plovers and red knots migrate through and winter in the Action Area;

(2) the placement of the constructed beach is expected to affect the coastal morphology and prevent early successional stages, thereby precluding the maintenance and creation of additional recovery habitat;
(3) increased levels of pedestrian disturbance may be expected; and
(4) a temporary reduction of food base will occur.

The Service has reviewed the biological information and other information relevant to this action. The take is expected in the form of harm and harassment because of: (1) decreased fitness and survivorship of plovers and red knots due to loss and degradation of foraging and roosting habitat; (2) decreased fitness and survivorship of plovers and red knots attempting to migrate to breeding grounds due to loss and degradation of foraging and roosting habitat.

EFFECT OF THE TAKE

Sea Turtles

In the accompanying biological and conference opinions, the Service determined that this level of anticipated take is not likely to result in jeopardy to the loggerhead sea turtle, green sea turtle, and leatherback sea turtle species. The Service has determined that the proposed project will not result in destruction or adverse modification of proposed critical habitat for the loggerhead sea turtle.

Incidental take of nesting and hatchling sea turtles is anticipated to occur during project construction and during the life of the project. Take will occur on nesting habitat on 12,600 feet of shoreline.

Piping Plovers

In the accompanying biological opinion, the Service determined that this level of anticipated take is not likely to result in jeopardy to the piping plover species. Incidental take of piping plovers is anticipated to occur along 12,600 feet of shoreline.

Red Knot

In the accompanying biological and conference opinions, the Service determined that this level of anticipated take is not likely to result in jeopardy to the red knot species. Incidental take of red knots is anticipated to occur along 12,600 feet of shoreline.

VII. REASONABLE AND PRUDENT MEASURES

The Service believes the following reasonable and prudent measures (RPMs) are necessary and appropriate to minimize take of loggerhead sea turtles, green sea turtles, leatherback sea turtles, piping plovers, red knots, and seabeach amaranth. Unless specifically addressed below, these RPMs are applicable for the construction of both phases of the terminal groin and for any maintenance activities for the life of the permit. If the Applicant is unable to comply with the RPMs and Terms and Conditions, the Corps as the regulatory authority may inform the Service why the RPM or Term and Condition is not reasonable and prudent for the specific project or activity and request exception under the biological and conference opinions.

RPMs – All Species

1. All derelict material or other debris must be removed from the beach prior to any construction.

2. Conservation Measures included in the permit application/project plans must be implemented in the proposed project. If a RPM and Term and Condition address the same requirement, the requirements of the RPM and Term and Condition take precedent over the Conservation Measure.

3. Predator-proof trash receptacles must be installed and maintained at all beach access points used for the initial project construction and all maintenance events, to minimize the potential for attracting predators of sea turtles, piping plovers, and red knots.

4. A meeting between representatives of the Applicant's or Corps' contractor, Service, NCWRC, the permitted sea turtle surveyor, bird and other species surveyors, as appropriate, must be held prior to the commencement of construction of the terminal groin.

5. In the event the terminal groin structure begins to disintegrate, all debris and structural material must be removed.

6. The Applicant or Corps must submit all reports produced pursuant to the Inlet Management Plan (Appendix B of the EIS, and referenced in the revisions to North Carolina General Statute 113A-115.1(e)(5)) to the Service's Raleigh Field Office, within 30 days of completion of each report.

7. The groin must be removed or modified if it is determined to not be effective as determined pursuant to the Inlet Management Plan listed above, or if it is determined to be causing a significant adverse impact to the beach and dune system.

8. After initial construction of the terminal groin, and for the life of the permit, all sand placement activities to maintain the sand fillet must be conducted within the winter work window (November 16 to March 30), unless necessitated by an emergency condition and allowed after consultation with the Service.

RPMs – Loggerhead, Green, and Leatherback Sea Turtle

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize take of loggerhead, green, and leatherback sea turtles:

1. Beach quality sand suitable for sea turtle nesting, successful incubation, and hatchling emergence must be used on the project site for initial construction and all maintenance events.

2. During the nesting season and hatching season from May 1 through November 15, no construction shall be conducted at night.

3. During the nesting season and hatching season from May 1 through November 15, to the maximum extent practicable, all excavations and temporary alteration of beach topography will be filled or leveled to the natural beach profile prior to 9:00 p.m. each day.

4. If any nesting turtles are sighted on the beach during daylight hours, construction activities must cease immediately until the turtle has returned to the water.

5. If a dredge is to be used during the sea turtle nesting season (May 1 through November 15), prior to the beginning of the project, the Corps shall submit a lighting plan for the dredge that will be used in the project.

6. If the sand placement activities or construction of the groin project will be conducted during the period from May 1 through November 15, daily early morning surveys for nesting sea turtles must be conducted. If nests are constructed in the area of construction, the nests must be marked and avoided, or the eggs relocated.

7. During nesting season, construction equipment and materials must be stored in a manner that will minimize impacts to sea turtles to the maximum extent practicable.

8. No permanent exterior lighting will be installed in association with this construction project, unless required by the U.S. Coast Guard. During the nesting season, no temporary lighting of the construction area is authorized at any time during the sea turtle nesting season from May 1 through November 15.

9. During the nesting season and hatching season May 1 through November 15, a barrier shall be installed around the perimeter of the groin or jetty construction work area above MHW, sufficient to prevent adult or hatchling sea turtles from accessing the project site.

10. If the vehicle access corridor is located between a marked turtle nest and the ocean, starting no more than 50 days after the nest is laid, any tire ruts or other depressions that are present in the corridor shall be leveled by the end of the work day. Leveling the ruts and depressions will minimize impacts to emerging hatchlings.

11. Visual surveys for escarpments along the Action Area must be made following initial completion of the terminal groin and any sand maintenance events, and also prior to May 1 for three subsequent years (after sand is placed on the beach). Escarpment formation must be monitored and leveling must be conducted if needed to reduce the likelihood of impacting nesting and hatchling sea turtles.

12. Sand compaction must be monitored in the area of sand placement immediately after completion of the project, after any future sand maintenance events, and also prior to May 1 for three subsequent years after sand is placed on the beach.

13. Daily sea turtle nesting surveys must be conducted by the Applicant or Corps for three nesting seasons following construction of the groin or sand maintenance events, if the groin remains on the beach. All nests 2,500 feet on either side of the groin must be marked for three (3) years post-construction. These nests must be monitored daily until the end of incubation to determine whether those nests are eroded and whether the groin is a potential barrier to hatchlings moving off the beach and through the surf zone. If the groin is found to be an obstruction, Corps will notify NCWRC and the Service immediately for remedial action.

14. A report describing the fate of the nests and hatchlings and any actions taken, must be submitted to the Service following completion of the proposed work for each year when an activity has occurred (such as sand placement).

15. The sand-filled geotubes within the Action Area shall be monitored annually to determine the depth at which each geotube lies beneath the sand, and the potential impacts to nesting sea turtles.

RPMs – Piping Plover and Red Knot

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize take of piping plovers and red knots:

1. All personnel involved in the construction or sand placement process along the beach shall be trained to recognize the presence of piping plovers and red knots prior to initiation of work on the beach. Before start of work each morning, a visual survey must be conducted in the area of work for that day, to determine if piping plovers or red knots are present.

2. A bird monitoring plan must be developed to monitor piping plover, red knot, waterbirds, colonial waterbirds and other shorebirds during and after construction. Monitoring must be conducted for a minimum of three (3) full years past the completion of both phases of groin construction, or until the end of the shorebird nesting season (August 31) of the third year, whichever is later.

3. A meeting must be held within 13 months of completion of the final phase of construction of the terminal groin (Phase I or Phase II, as appropriate), for the Applicant, Corps, Service, and NCWRC to discuss the potential need for habitat management within the sand fillet.

RPM – Seabeach Amaranth

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize take of seabeach amaranth:

1. Seabeach amaranth surveys must be conducted in the Action Area for a minimum of three years after completion of construction.

VIII. TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the Act, the Corps must comply with the following terms and conditions, which implement the RPMs described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary. Unless addressed specifically below, the terms and conditions are applicable for the construction of both phases of the terminal groin and for any maintenance activities for the life of the permit.

Terms and Conditions – All Species

1. All derelict coastal armoring geotextile material and other debris must be removed from the beach prior to any sand placement or construction to the maximum extent possible. If debris removal activities take place during the sea turtle nesting season, the work must be conducted during daylight hours only and must not commence until completion of the sea turtle nesting survey each day.

2. Conservation Measures included in the permit application/project plans must be implemented in the proposed project. If a RPM and Term and Condition address the same requirement, the requirements of the RPM and Term and Condition take precedent over the Conservation Measure.

3. Predator-proof trash receptacles must be installed and maintained during construction at all beach access points used for the project construction and sand maintenance events, to minimize the potential for attracting predators of sea turtles, piping plovers, and red knots. All contractors conducting the work must provide predator-proof trash receptacles for the construction workers. All contractors and their employees must be briefed on the importance of not littering and keeping the Action Area free of trash and debris. See Appendix A for examples of suitable receptacles.

4. A meeting between representatives of the contractor, the Service, NCWRC, the permitted sea turtle surveyor, bird and other species surveyors, as appropriate, must be held prior to the commencement of construction of the terminal groin. At least 10 business days advance notice must be provided prior to conducting this meeting. The meeting will provide an opportunity for explanation and/or clarification of the required measures in the BO, as well as additional guidelines when construction occurs during the sea turtle nesting season, such as storing equipment, minimizing driving, and reporting within the work area, as well as follow-up meetings during construction.

5. In the event the structure begins to disintegrate, all debris and structural material must be removed from the nesting beach area and deposited off site immediately upon coordination with the Service. If removal of the structure is required during the period from May 1 to November 15, no work will be initiated without prior coordination with the Corps and the Service.

6. The Applicant or Corps must submit all reports produced pursuant to the Inlet Management Plan (Appendix B of the EIS, and referenced in the revisions to North Carolina General Statute 113A-115.1(e)(5)) to the Service's Raleigh Field Office, within 30 days of completion of each report.

7. The groin must be removed or modified if it is determined to not be effective as determined by the Inlet Management Plan referred to above, or if it is determined to be causing a significant adverse impact to the beach and dune system.

8. After initial construction of the terminal groin, and for the life of the permit, all sand placement activities to maintain the sand fillet must be conducted within the winter work window (November 16 to March 30), unless necessitated by an emergency condition and allowed after consultation with the Service.

Terms and Conditions – Loggerhead, Green, and Leatherback Sea Turtle

1. Beach compatible fill must be placed on the beach or in any associated dune system. Beach compatible fill must be sand that is similar to a native beach in the vicinity of the site that has not been affected by prior sand placement activity. Beach compatible fill must be sand solely of natural sediment and shell material, containing no construction debris, toxic material or other foreign matter. The beach compatible fill must be similar in both color and grain size distribution (sand grain frequency, mean and median grain size and sorting coefficient) to the native material in the Action Area. Beach compatible fill is material that maintains the general character and functionality of the material occurring on the beach and in the adjacent dune and coastal system. In general, fill material that meets the requirements of the North Carolina Technical Standards for Beach Fill (15A NCAC 07H .0312) is considered compatible.

2. During the nesting season and hatching season from May 1 through November 15, no construction shall occur on the beach at night. Construction activities must be conducted during daylight hours only to avoid encountering nesting females and emerging hatchling sea turtles. Construction activities must not occur in any location prior to completion of the necessary sea turtle protection measures outlined in number 6, below.

3. From May 1 through November 15, to the maximum extent practicable, excavations and temporary alteration of beach topography will be filled or leveled to the natural beach profile prior to 9:00 p.m. each day.

4. If any nesting turtles are sighted on the beach during daylight hours, construction activities must cease immediately until the turtle has returned to the water, and the sea turtle permit holder responsible for nest monitoring has marked for avoidance or relocated any nest(s) that may have been laid.

5. If the dredge is to be used during the sea turtle nesting season (May 1 through November 15), prior to the beginning of the project, the Applicant shall submit a lighting plan for the dredge that will be used in the project. The plan shall include a description of each light source that will be visible from the beach and the measures implemented to minimize this lighting.

6. Daily early morning (between sunrise and 9 a.m.) surveys for sea turtle nests will be required if any portion of the sand placement or groin construction project occurs during the period from May 1 through November 15. No construction or sand placement activity may commence until completion of the sea turtle nesting survey each day. If nests are constructed in the area of construction during the nesting season, the nests must be marked and either avoided until completion of the project or relocated.
    a. Nesting surveys must be initiated 90 days prior to sand placement or groin construction activities or by May 1, whichever is later. Nesting surveys must continue through the end of the project or through November 15, whichever is earlier. If nests are constructed in areas where they may be affected by construction activities, the eggs must be relocated to minimize sea turtle nest burial, crushing of eggs, or nest excavation.
    b. Nesting surveys and nest marking will only be conducted by personnel with prior experience and training in these activities, and who are duly authorized to conduct such activities through a valid permit issued by the Service or the NCWRC.
    c. Only those nests that may be affected by construction or sand placement activities will be relocated. Nest relocation must not occur upon completion of the project. Nests requiring relocation must be moved no later than 9 a.m. the morning following deposition to a nearby self-release beach site in a secure setting where artificial lighting will not interfere with hatchling orientation. Relocated nests must not be placed in organized groupings. Relocated nests must be randomly staggered along the length and width of the beach in settings that are not expected to experience daily inundation by high tides or known to routinely experience

severe erosion and egg loss, predation, or subject to artificial lighting. Nest relocations in association with construction activities must cease when construction activities no longer threaten nests.

d. Nests deposited within areas where construction activities have ceased or will not occur for 90 days or nests laid in the nourished berm prior to tilling must be marked for avoidance and left in situ unless other factors threaten the success of the nest. Nests must be marked with four stakes at a 10-foot distance around the perimeter of the nest for the buffer zone. The turtle permit holder must install an on-beach marker at the nest site and a secondary marker at a point as far landward as possible to assure that future location of the nest will be possible should the on-beach marker be lost. No activities that could result in impacts to the nest will occur within the marked area. Nest sites must be inspected daily to assure nest markers remain in place and the nest has not been disturbed by the project activity.

7. From May 1 through November 15, construction equipment must not be stored on South Beach. Construction equipment placed on the beach must be located as far landward as possible without compromising the integrity of the dune system. Pipes placed parallel to the dune must be 5 to 10 feet away from the toe of the dune if the width of the beach allows. If pipes are stored on the beach, they must be placed in a manner that will minimize the impact to nesting habitat and must not compromise the integrity of the dune systems.

8. No permanent exterior lighting will be installed in association with this construction project, unless required by the U.S. Coast Guard. During the nesting season, no temporary lighting of the construction area is authorized at any time during the sea turtle nesting season from May 1 through November 15.

9. During the nesting season and hatching season from May 1 through November 15, a barrier (e.g., hay bales, silt screens) sufficient to prevent adult and hatchling sea turtles from accessing the project site shall be installed above MHW in a 100-foot buffer around the perimeter of the project site. The barrier shall be placed parallel to shore, above MHW, as close to the groin or jetty as feasible during the period from sunset to sunrise. The barrier will be inspected as part of the daily early morning inspections (outlined in term and condition #6), to ensure no animals are entrapped in the work area.

10. If the vehicle access corridor is located between a marked turtle nest and the ocean, starting no more than 50 days after the nest is laid, any tire ruts or other depressions that are present in the corridor shall be leveled by the end of the work day. Leveling the ruts and depressions will minimize impacts to emerging hatchlings.

11. Visual surveys for escarpments along the Action Area must be made immediately after completion of construction, after sand maintenance events, and within 30 days prior to May 1 for three subsequent years after any construction or sand placement event. Escarpments that interfere with sea turtle nesting or that exceed 18 inches in height for a distance of 100 feet must be leveled and the beach profile must be reconfigured to minimize scarp formation by the dates listed above. Any escarpment removal must be reported by location. If the sand placement activities or groin construction are completed during the early part of the sea turtle nesting and hatching season (May 1 through May 30), escarpments may be required to be leveled immediately, while protecting nests that have been relocated or left in place. The Service must be contacted immediately if subsequent reformation of escarpments that interfere with sea turtle nesting or that exceed 18 inches in height for a distance of 100 feet occurs during the nesting and hatching season to determine the appropriate action to be taken. If it is determined that escarpment leveling is required during the nesting or hatching season, the Service or NCWRC will provide a brief written authorization within 30 days that describes methods to be used to reduce the likelihood of impacting existing nests. An annual summary of escarpment surveys and actions taken must be submitted to the Service's Raleigh Field Office.

12. Sand compaction must be monitored in the area of sand placement immediately after completion of the construction, after any sand maintenance event, and also prior to May 1 for three subsequent years after any construction or sand placement event. Out-year compaction monitoring and remediation are not required if the placed material no longer remains on the dry beach.
    a. Within 7 days of completion of sand placement and prior to any tilling, a field meeting shall be held with the Service, NCWRC, and the Corps to inspect the Action Area for compaction, and determine whether tilling is needed.
    b. If tilling is needed, the area must be tilled to a depth of 36 inches.
    c. All tilling activity shall be completed prior to May 1.
    d. Tilling must occur landward of the wrack line and avoid all vegetated areas that are 3 sf or greater, with a 3 sf buffer around the vegetated areas.
    e. If tilling occurs during shorebird nesting season (after April 1), shorebird surveys are required prior to tilling per the Migratory Bird Treaty Act.
    f. A report on the results of compaction monitoring will be submitted to the Raleigh Field Office and NCWRC prior to any tilling actions being taken. An annual

summary of compaction assessments and the actions taken will be submitted to the Service, as required in REPORTING REQUIREMENTS, below.

g. This condition will be evaluated annually and may be modified if necessary to address sand compaction problems identified during the previous year.

13. Daily sea turtle nesting surveys must be conducted by the Applicant or Corps for three (3) full nesting seasons following construction (Phases I and II) if the groin structure remains in place. All nests 2,500 feet on either side of the groin must be marked for 3 years post-construction. The survey area must be divided into three segments: Updrift Zone, Project Zone, and Downdrift Zone. The parameters listed in Appendix B shall be recorded for each crawl encountered on a daily survey. In addition, any obstructions (natural or man-made) encountered by the turtle and the turtle's response to that obstruction must be reported. These nests must be monitored daily till the end of hatching to determine whether those nests are eroded and whether the groin is a potential barrier to hatchlings moving off the beach and through the surf zone. This information will be provided to the Raleigh Field Office pursuant to the REPORTING REQUIREMENTS section, below, and will be used to periodically assess the cumulative effects of these projects on sea turtle nesting and hatchling production and monitor suitability for nesting. The Corps will notify the NCWRC and the Service immediately for remedial action.

14. A report describing the fate of sea turtle nests and hatchlings and any actions taken, must be submitted to the Raleigh Field Office following completion of the proposed work for each year when an activity has occurred (e.g. sand placement or groin construction). Please see REPORTING REQUIREMENTS below, for more information.

15. The sand-filled geotubes within the Action Area shall be monitored to determine the depth at which each geotube lies beneath the sand, and the potential impacts to nesting sea turtles. Prior to May 1 each year, the Applicant must monitor the location and depth of each sand-filled geotube located within 2,500 lf of either side of the groin field. The depth from the top of the sand vertically to the top of the sand-geotube shall be measured at two locations for each geotube: the landward end and near the center (125-175 feet from the landward end, depending on the length of the geotube). Sand-filled geotubes should remain at least four (4) feet below the surface of the sand in order to avoid potential impacts to turtles attempting to dig a nest. A figure indicating the latitude/longitude of each geotube and the depths measured shall be submitted to the Raleigh Field Office pursuant to the REPORTING REQUIREMENTS section.

Terms and Conditions – Piping Plover and Red Knot

1. All personnel involved in the construction or sand placement process along the beach shall be trained to recognize the presence of piping plovers and red knots prior to initiation of work on the beach. Before start of work each morning, a visual survey must be conducted in the area of work for that day, to determine if piping plovers or red knots are present. If plovers or red knots are present in the work area, careful movement of equipment in the early morning hours should allow those individuals to move out of the area. If piping plovers or red knots are observed, the observer shall make a note on the Quality Assurance form for that day, and submit the information to the Corps and the Service's Raleigh Field Office the following day.

2. A bird monitoring plan must be developed to monitor piping plover, red knot, waterbirds, colonial waterbirds and other shorebirds during and after construction. Monitoring must be conducted for a minimum of three (3) full years past the completion of both phases of groin construction, or until the end of the shorebird nesting season (August 31) of the third year after construction, whichever is later. Post-construction monitoring may only be ceased after the review of at least three years' worth of data and approval by the USACE, USFWS, NCDCM, and NCWRC.
    a. The bird monitoring plan must be submitted for review and approval to the USACE, USFWS, NCDCM, and NCWRC, at least 60 days prior to the anticipated start of construction for Phase I.
    b. During construction of both phases, bird monitoring must be conducted weekly. Between construction phases and for at least three years after construction is completed, bimonthly (twice-monthly) bird surveys shall be conducted in all intertidal and shoreline areas along South Beach and West Beach. Field observations must be conducted during daylight hours, and primarily during high tide.
    c. Shorebird identification, especially when in non-breeding plumage, can be difficult. The person(s) conducting the survey must demonstrate the qualifications and ability to identify shorebird species and be able to provide the information listed below. The bird monitoring plan should include the collection and reporting of the following:
        i. Date, location, time of day, weather, and tide cycle when survey was conducted;
        ii. Latitude and longitude of observed piping plover and red knot locations (decimal degrees preferred);
        iii. Any color bands observed on piping plovers or red knots or other birds;
        iv. Behavior (e.g., foraging, roosting, preening, bathing, flying, aggression,

walking, courtship, copulation);

v. Landscape features(s) where birds are located (e.g., inlet spit, tidal creeks, shoals, lagoon shoreline);

vi. Habitat features(s) used by birds when observed (e.g., intertidal, fresh wrack, old wrack, dune, mid-beach, vegetation);

vii. Substrata used by birds (e.g., sand, mud/sand, mud, algal mat); and

viii. The amount and type of recreational use (e.g., people, dogs on or off leash, vehicles, kite-boarders).

d. All monitoring information shall be provided in standardized form on an Excel spreadsheet. Monitoring results shall be submitted (datasheets, maps, database) on standard electronic media (e.g., CD, DVD) to the Raleigh Field Office. Please see REPORTING REQUIREMENTS below, for more information.

3. A meeting must be held within 13 months of completion of the final phase of construction of the terminal groin (Phase I or Phase II, as appropriate), for the Applicant, Corps, Service, and NCWRC to discuss the potential need for habitat management within the sand fillet.

Terms and Conditions – Seabeach Amaranth

1. Seabeach amaranth surveys must be conducted in the Action Area, including at least 2,500 lf on each side of the groin along South Beach and West Beach, for a minimum of three years after completion of groin construction. Surveys should be conducted in August of each year. Habitat known to support this species, including the upper edges of the beach, lower foredunes, and overwash flats must be visually surveyed for the plant. Annual reports should include numbers of plants, latitude/longitude, and habitat type. Please see REPORTING REQUIREMENTS, below, for more information.

IX. REPORTING REQUIREMENTS

An annual report detailing the monitoring and survey data collected during the preceding year (required in the above Terms and Conditions) and summarizing all piping plover, red knot, shorebird, seabeach amaranth, and sea turtle data must be provided to the Raleigh Field Office by January 31 of each year for review and comment. In addition, any information or data related to a conservation measure or recommendation that is implemented should be included in the annual report. The contact for these reporting requirements is:

Pete Benjamin, Supervisor
Raleigh Field Office
U.S. Fish and Wildlife Service
Post Office Box 33726
Raleigh, North Carolina 27636-3726
(919) 856-4520

Upon locating a dead, injured, or sick individual of an endangered or threatened species, initial notification must be made to the USFWS Law Enforcement Office below. Additional notification must be made to the USFWS Ecological Services Field Office identified above and to the NCWRC at (252) 241-7367. Care should be taken in handling sick or injured individuals and in the preservation of specimens in the best possible state for later analysis of cause of death or injury.

Tom Chisdock
U.S. Fish and Wildlife Service
160 Zillicoa St.
Asheville, NC 28801
828-258-2084

X. COORDINATION OF INCIDENTAL TAKE STATEMENT WITH OTHER LAWS, REGULATIONS, AND POLICIES

The USFWS will not refer the incidental take of any migratory bird for prosecution under the Migratory Bird Treaty Act of 1918, as amended (16 USC S 703-712), if such take is in compliance with the terms and conditions specified herein. Take resulting from activities that are not in conformance with the Corps permit or these biological or conference opinions (e.g. deliberate harassment of wildlife, etc.) are not considered part of the proposed action and are not covered by this incidental take statement and may be subject to enforcement action against the individual responsible for the act.

XI. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

For the benefit of loggerhead, green, and leatherback sea turtles, the Service recommends the following conservation recommendations:

1. Construction activities for this project and similar future projects should be planned to take place outside the main part of the sea turtle nesting and hatching season, as much as possible.

2. Appropriate native salt-resistant dune vegetation should be established on the restored dunes.

3. Educational signs should be placed where appropriate at beach access points explaining the importance of the area to sea turtles and/or the life history of sea turtle species that nest in the area.

For the benefit of the piping plover, the Service recommends the following conservation recommendations:

1. The Corps' Applicant should maintain suitable piping plover migrating and wintering habitat. Natural accretion at inlets should be allowed to remain. Accreting sand spits on barrier islands provide excellent foraging habitat for migrating and wintering plovers.

2. A conservation/education display sign would be helpful in educating local beach users about the coastal beach ecosystem and associated rare species. The sign could highlight the piping plovers life history and basic biology and ways recreationists can assist in species protection efforts (e.g., keeping pets on a leash, removing trash to sealed refuge containers, etc.). The Service would be willing to assist the Applicant in the development of such a sign, in cooperation with NCWRC, interested non-governmental stakeholders (i.e., National Audubon Society), the Corps, and the other interested stakeholders (i.e., property owners, etc.).

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

XII. REINITIATION NOTICE – CLOSING STATEMENT

This concludes formal consultation on the action outlined in the request. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion or the project has not been completed within five years of the issuance of these biological and conference opinions; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action.

In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

For red knot and nesting loggerhead critical habitat, you may ask the Service to confirm the conference opinion as a biological opinion issued through formal consultation if the red knot is listed and/or nesting loggerhead sea turtle critical habitat is designated. The request must be in writing. If the Service reviews the proposed action and finds that there have been no significant changes in the action as planned or in the information used during the conference, the Service will confirm the conference opinion as the biological opinion and no further section 7 consultation will be necessary.

After listing of the red knot as endangered or threatened and after designation of critical habitat for nesting loggerhead sea turtles, and any subsequent adoption of this conference opinion, the Federal agency will request reinitiation if:

(1) the amount or extent of incidental take is exceeded;
(2) new information reveals effects of the agency action that may affect the species or critical habitat in a manner or to an extent no considered in this conference opinion;
(3) the agency action is subsequently modified in a manner that causes an effect to the species or critical habitat that was not considered in this conference opinion;
or
(4) a new species is listed or critical habitat designated that may be affected by the action.

For red knot and nesting loggerhead critical habitat, the incidental take statement provided in this conference opinion does not become effective until the species is listed and the conference opinion is adopted as the biological opinion issued through formal consultation. At that time, the project will be reviewed to determine whether any take of the red knot or nesting loggerhead critical habitat has occurred. Modifications of the opinion and incidental take statement may be appropriate to reflect that take. No take of the red knot or nesting loggerhead critical habitat may occur between the listing of the red knot or designation of nesting loggerhead critical habitat, and the adoption of the conference opinion through formal consultation, or the completion of a subsequent formal consultation.

For this biological opinion, the incidental take will be exceeded when the renourishment of 12,600 feet of beach extends beyond the project's authorized boundaries. Incidental take of an undetermined number of young or eggs of sea turtles, piping plovers, red knots, and seabeach amaranth plants has been exempted from the prohibitions of section 9 by this opinion. The Service appreciates the cooperation of the Corps during this consultation. We would like to continue working with you and your staff regarding this project. For further coordination please contact Kathy Matthews at (919) 856-4520, ext. 27. In future correspondence concerning the project, please reference FWS Log No. 2014-F-0204.

Sincerely,

John Ann Shearer

for Pete Benjamin
Field Supervisor

cc: USFWS, Jacksonville, FL (Ann Marie Lauritsen) (via email)
USFWS, Hadley, MA (Anne Hecht) (via email)
USFWS, Pleasantville, NJ (Wendy Walsh) (via email)
NMFS, Pivers Island (via email)
NMFS, St. Peterburg, FL
NCDCM, Morehead City, NC
NCWRC, Washington, NC
Village of Bald Head Island, NC

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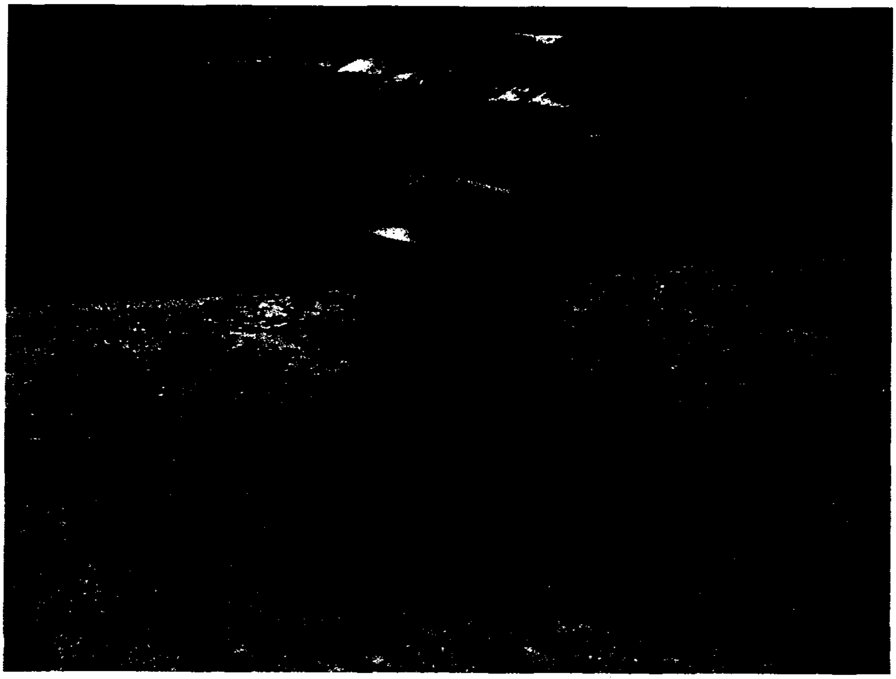
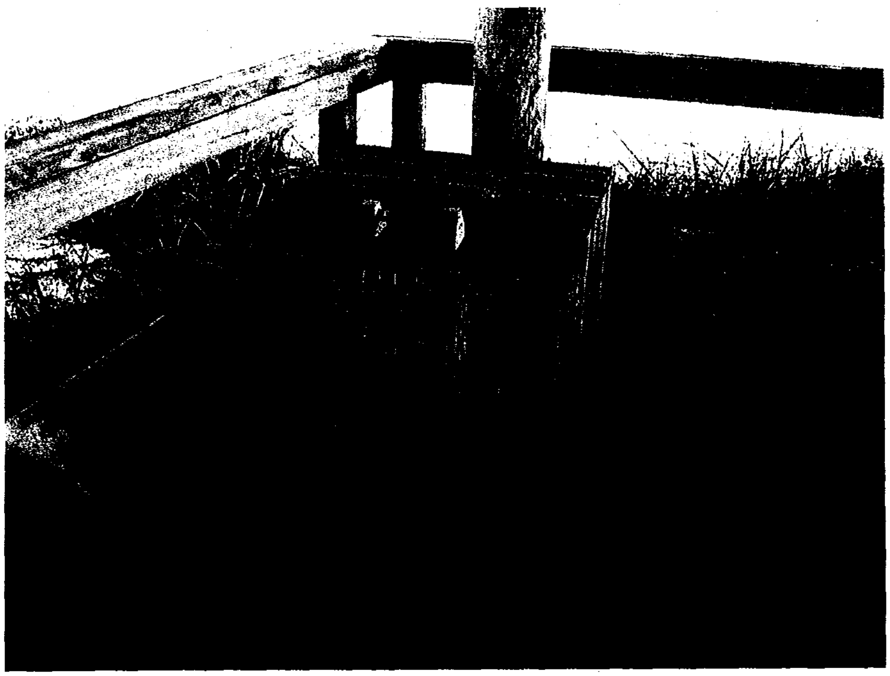
Appendix A

EXAMPLES OF PREDATOR PROOF TRASH RECEPTACLES



Example of predator proof trash receptacle at Gulf Islands National Seashore. Lid must be tight fitting and made of material heavy enough to stop animals such as raccoons.

Example of trash receptacle anchored into the ground so it is not easily turned over.



Example of predator proof trash receptacle at Perdido Key State Park. Metal trash can is stored inside. Cover must be tight fitting and made of material heavy enough to stop animals such as raccoons.

Example of trash receptacle must be secured or heavy enough so it is not easily turned over.

Appendix B
Parameters to be recorded for turtle crawls

CHARACTERISTIC	PARAMETER	MEASUREMENT	VARIABLE
Nesting Success	False crawls - number	Visual assessment of all false crawls	Number and location of false crawls in nourished areas and non-nourished areas: any interaction of turtles with obstructions, such as groins, seawalls, or scarps, should be noted.
	False crawl - type	Categorization of the stage at which nesting was abandoned	Number in each of the following categories: emergence-no digging, preliminary body pit, abandoned egg chamber.
	Nests	Number	The number of sea turtle nests in nourished and non-nourished areas should be noted. If possible, the location of all sea turtle nests must be marked on a project map, and approximate distance to seawalls or scarps measured in meters. Any abnormal cavity morphologies should be reported as well as whether turtle touched groins, seawalls, or scarps during nest excavation.
	Nests	Lost nests	The number of nests lost to inundation or erosion or the number with lost markers.
	Nests	Relocated nests	The number of nests relocated and a map of the relocation area(s). The number of successfully hatched eggs per relocated nest.
	Lighting impacts	Disoriented sea turtles	The number of disoriented hatchlings and adults.

APPENDIX T

SEA TURTLE NESTING LOCATIONS (2007-2011)

Coordinate locations of turtle nests provided by others, and are not intended to be survey grade.
Aerial photograph is dated 2012.
Data for turtle nest locations continues along East Beach north of Middle Island (not shown).

Legend
2007 Loggerhead Nest Locations

LMG LAND MANAGEMENT GROUP INC.
Environmental Consultants
Post Office Box 2522
Wilmington, North Carolina 28402
Telephone: 910-452-0001

Project: Village of Bald Head Island Shoreline Protection Project Draft Environmental Impact Statement	Date: 10/13/2013
	Revision Date: NA
	Scale: 1"=1500'
	Job Number: 40-11-238
Title: **Turtle Nests 2007** ***Bald Head Island Conservancy Data***	Drawn By:
	Sheet Number: **Appendix T Sheet 1**

0 750 1500 3000

Coordinate locations of turtle nests provided by others, and are not intended to be survey grade.
Aerial photograph is dated 2012.
Data for turtle nest locations continues along East Beach north of Middle Island (not shown).

Legend

2008 Loggerhead Nest Locations

LMG LAND MANAGEMENT GROUP INC.
Environmental Consultants
Post Office Box 2522
Wilmington, North Carolina 28402
Telephone: 910-452-0001

Project: Village of Bald Head Island Shoreline Protection Project Draft Environmental Impact Statement	Date: 10/13/2013	Revision Date: NA
	Scale: 1"=1500'	Job Number: 40-11-238
Title: ***Turtle Nests 2008*** ***Bald Head Island Conservancy Data***	Drawn By:	Sheet Number: **Appendix T Sheet 2**

Coordinate locations of turtle nests provided by others, and are not intended to be survey grade.
Aerial photograph is dated 2012.
Data for turtle nest locations continues along East Beach north of Middle Island (not shown).

Legend
2009 Loggerhead Nest Locations
2009 Green Sea Nest Locations

LMG LAND MANAGEMENT GROUP INC. Environmental Consultants
Post Office Box 2522
Wilmington, North Carolina 28402
Telephone: 910-452-0001

Project: Village of Bald Head Island Shoreline Protection Project Draft Environmental Impact Statement

Title: **Turtle Nests 2009** *Bald Head Island Conservancy Data*

Date: 10/13/2013
Revision Date: NA
Scale: 1"=1500'
Job Number: 40-11-238
Drawn By:
Sheet Number: Appendix T Sheet 3

Coordinate locations of turtle nests provided by others, and are not intended to be survey grade.
Aerial photograph is dated 2012.
Data for turtle nest locations continues along East Beach north of Middle Island (not shown).

Legend

- 2010 Loggerhead Nest Locations
- 2010 Green Sea Nest Locations

LMG LAND MANAGEMENT GROUP INC.
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Post Office Box 2522
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Project: Village of Bald Head Island Shoreline Protection Project Draft Environmental Impact Statement	Date: 10/13/2013	Revision Date: NA
	Scale: 1"=1500'	Job Number: 40-11-238
Title: **Turtle Nests 2010** ***Bald Head Island Conservancy Data***	Drawn By:	Sheet Number: **Appendix T Sheet 4**

Coordinate locations of turtle nests provided by others, and are not intended to be survey grade.
Aerial photograph is dated 2012.
Data for turtle nest locations continues along East Beach north of Middle Island (not shown).

Legend
2011 Loggerhead Nest Locations
2011 Green Sea Nest Locations

LMG LAND MANAGEMENT GROUP INC.
Environmental Consultants
Post Office Box 2522
Wilmington, North Carolina 28402
Telephone: 910-452-0001

Project: Village of Bald Head Island Shoreline Protection Project Draft Environmental Impact Statement	Date: 10/13/2013	Revision Date: NA	
	Scale: 1"=1500'	Job Number: 40-11-238	
Title: **Turtle Nests 2011** *Bald Head Island Conservancy Data*	Drawn By:	Sheet Number: **Appendix T Sheet 5**	

APPENDIX U

UNDERSTANDING THE COSTS AND BENEFITS OF SHORELINE CHANGE

(Prepared by Dr. Peter Schuhmann,
Professor of Economics, University of North Carolina at Wilmington)

Appendix U: Understanding the Costs and Benefits of Shoreline Change

Prepared By: Dr. Peter Schuhmann, Professor of Economics
Department of Economics and Finance
University of North Carolina at Wilmington

1.0 Introduction

Actions associated with mitigating the effects of shoreline change are expected to create an array of costs and benefits. These include market costs, such as any physical or engineering costs associated with active mitigation, as well as non-market costs and benefits, such as those associated with changes in the quality of recreational experiences and effects on the natural environment. Shoreline nourishment, armoring via hardened structures, or retreat each entail costs and benefits that accrue to different groups of stakeholders and over different time periods. As noted in Landry (2011), nourishing shorelines by adding sand may protect coastal habitats and real estate as well as the possibilities for recreation, but without maintenance, the duration of such benefits can be expected to be temporary. Armoring the shoreline may likewise protect coastal property, but may have adverse impacts on habitats and proximate shorelines. Shoreline retreat will involve relocation or demolition of existing buildings and infrastructure and can be expected to impose substantial costs and burdens on coastal property owners. Local governments may also be opposed to shoreline retreat for reasons related to the potential infrastructure losses, diminished property tax revenues, and impacts on coastal tourism, or real estate sales (Landry, 2011).

As a result of these disparate costs and benefits, alternative efforts to mitigate shoreline erosion can be expected to be valued differently by different groups of people. Direct and indirect economic impacts from alternative shoreline management strategies will vary across a given population, as will preferences for maintaining, preserving or allowing natural change (Judge, Osborne and Smith, 1995). As noted in Judge, Osborne and Smith (1995), some individuals will have preference for non-interventionist approaches that allow natural erosion to take place. These individuals may derive real economic value from the existence of unfettered coastal ecosystems. While such “retreat” options will likely have an adverse impact on the value of beaches and beach front property at eroding sites, they may also induce positive or negative value changes at proximate sites via changes in crowding or changes in aesthetic appeal. For example, as noted in Parsons and Powell (2001), the amenity value of beachfront properties lost to erosion may not be lost in the aggregate, but rather transferred to properties further inland. Further, in the absence of land use controls active mitigation efforts such as beach armoring or renourishment may serve to encourage additional use and/or development, which may in turn compromise the integrity and value of the beach that such efforts were designed to protect or create a situation where continued mitigation is necessary to protect value. With regard to this latter point, Gopalakrishnan et al. (2011) find that beach replenishment activities are likely to occur more frequently in communities where baseline property values are higher.

Finally, certain groups of stakeholders may have different and contrasting values related to natural or anthropogenic changes to the shoreline. For example, as noted in Landry, Keeler and Kriesel (2003), property owners may desire shoreline proximity for recreational and aesthetic reasons and also value shoreline distance for protection from erosion. Huang et al. (2007) also note that anthropogenic modifications to beaches involve multiple positive and negative impacts on individual stakeholders. They find that erosion control measures are less valued when there are adverse impacts on wildlife, water quality and erosion at neighboring beaches.

In light of diverse impacts and preferences, economic analysis of the potential gains and losses from proposed shoreline management actions can be a useful input for policy makers who are confronted with the need to balance conflicting objectives while conforming to budgetary limitations. However, as alluded to above, understanding the economic values associated with shoreline management alternatives is a complex and multifaceted undertaking. Determining which strategy makes the most economic sense for a given coastal community is an empirical question, requiring detailed consideration of an array of natural, physical and socioeconomic characteristics (Parsons and Powell, 2001) and forecasting potential impacts into the future. Coupling these complexities with the inherently dynamic nature of marine coastlines suggests that the effects of shoreline management alternatives will vary according to myriad factors such as preferences for recreation, the degree of shoreline development, the characteristics of proximate and substitute sites and the bio-physical character of affected coastal ecosystems. As such, quantitative forecasting of the economic impacts of shoreline management alternatives is fraught with difficulty. Such analysis is beyond the scope of this report.

2.0 Limitations

The purpose of this report is to review the extant literature regarding economic considerations that are pertinent to the proposed management alternatives for the Bald Head Island Shoreline Stabilization Project and to summarize available evidence in the literature so as to frame and characterize the potential scope of economic costs and benefits associated with the proposed alternatives. This report does not provide an itemization or explicit estimation of economic values associated with the management alternatives, nor does this report provide a ranking of alternatives based on relative economic values or any other criteria. This report should not be considered a substitute for a monetary cost-benefit analysis, but rather should be taken as a framework for understanding the potential scope of economic impacts associated with the range of project alternatives evaluated in the Environmental Impact Statement (EIS).

3.0 Economic Value and Valuation

Economists define the value of a particular good or service as what it is *worth* to people, in terms of the contribution of the good or service to well-being (Bockstael et al., 2000). Value is best measured by what people are *willing and able to pay* (WTP) for a good or service. Value should not be confused with the *cost* or expenditure required to obtain a good or service, because cost may differ greatly from what something is worth. For example, a beach renourishment project may involve $5 million in physical and engineering costs, but may generate considerably more (or less) in actual economic value.

It should also be recognized that economic value extends to goods and services that are not explicitly traded in markets such as clean beaches and healthy habitats, and may include benefits not directly associated with use, such as benefits resulting from the knowledge that particular species or ecosystems exist ("existence values"), are available for potential future use (“option values”), or are available for future generations (“bequest values”). The measurement of non-market values is detailed in later sections of this report. Evidence in support of “non-use values” includes the willingness of people to give up time and other resources (including money) for goods and services that they never interact with in any tangible fashion. While relatively unknown outside of the economics profession, the consideration of non-market and non-use values is germane to any analysis of beach management alternatives due to their explicit mention in the Water Resource Council Principles and Guidelines (P&G) for federal projects (USACE, 2000 as noted in Landry, 2011). A deep body of literature examines these values in a wide range of contexts and for numerous species and ecosystems. We highlight some of those that pertain to shoreline stabilization projects later in this appendix.

More generally, it is clear that coastal ecosystems provide a variety of goods and services that create economic value via contributions to human well-being. These include services that affect the value of goods that are traded in markets such as the protection of coastal real estate and tourism as well as services that impact non-market goods and services such as aesthetics, habitat provision and opportunities for recreation. Quantifying the associated benefits to people from these goods and services is the domain of economic valuation. Valuation simply means empirical estimation of what something is worth, typically in monetary terms.

3.1 Valuation Methods

Because humans interact with the environment in many ways, approaches to valuation take a variety of forms. The choice of method is most often a function of what is being valued and the intended use or policy purpose of the values. A common point of demarcation for valuation methods pertains to whether the economic values in question are market-based or “non-market” values. Market values are often readily observed using applicable prices and quantities. Measuring and monetizing the costs and benefits associated with changes that are not revealed in market transactions requires the application of empirical techniques that fall under the category of non-market valuation. Examples of non-market values include changes in human wellbeing associated with aesthetics, opportunities for recreation and changes to the natural environment. Non-market valuation techniques are well-established in the academic and practitioner literature.

Examples of market-based valuation methods include the market price method, the replacement cost method and the damage avoidance method. Non-market valuation methods include the travel cost method, hedonic pricing and the contingent valuation method. A variety of sources are available for detailed reviews of these methods (e.g. Smith, 1996; Bockstael, et al., 2000; Schuhmann, 2012). For the purposes of this report, we only review those methods that are pertinent to the valuation of changes to coastal systems. Much of the review below is based upon Schuhmann (2012).

3.1.1 The Replacement Cost Approach

Some goods and services provided by the natural environment can be replaced by manmade goods and services. This basic idea is the foundation of the *replacement cost approach* (RC) to valuation, which uses the *costs* associated with providing replacement services as the value of the associated natural services. As such, this approach fits into the category of market-based valuation methods. As an example, artificial breakwaters may provide some of the shoreline protection services afforded by barrier islands or reefs. The costs of constructing breakwaters may therefore be used as an estimate of the economic value that stands to be lost if the natural service was to be degraded. The replacement cost approach is appealing in its ease of calculation and interpretation – the method typically relies on readily available market data and represents the opportunity costs associated with the degradation of natural assets in terms of costs that would have to be incurred in the absence of protection.

The replacement cost approach should be used with caution, however, as it does not deliver a true measure of the value of natural goods and services in the sense of net gains to society. In short, the replacement cost method provides a measurement of *costs*, which may not reflect the benefits gained from natural resources. For example, the cost of widening a beach via sand management may be entirely unrelated to the benefits derived from naturally wide beaches. Moreover, this method should only be applied when certain conditions are met (Bockstael et al., 2000; EPA, 2009; WRI, 2009). First, the manmade alternatives must provide an effective replacement for natural services. While it is unlikely that manmade alternatives can provide the full range of benefits provided by natural assets, there must be at least some service flows that can be attained via substitution of manmade alternatives. Further, the costs of that substitute must be known or estimable and must represent the least-cost means of providing the service in question. Finally, society must be willing and able to incur the costs associated with the replacement. These latter two points may require extensive research to confirm, as the scope of economic costs associated with habitat modification likely extends beyond monetary or market-based expenses. Only when these non-market costs are understood, measured and conveyed to the public can society's willingness to accept them be established.

3.1.2 The Cost (Damage) Avoidance Approach

Related to the replacement cost approach, the *cost (damage) avoidance approach* (CA) is based on the idea that manmade services may be able to offset or prevent harm caused by natural or anthropogenic change. The cost avoidance approach relies on market-based estimates of the costs associated with potential damage to manmade assets as an estimate of the value of the natural services that prevent those damages from occurring. For example, the cost of replacing coastal property may be used as an estimate of the benefits derived from beach nourishment activities that mitigate damage from storms. As noted in Landry (2011), this is the approach employed by the US Army Corps of Engineers when defining benefits in P&G. As is the case with the replacement cost approach, this method ascribes estimates of *costs* to notions of *value*, which may be an inherently flawed means of understanding the *benefits* derived from changes in natural resources. Using the value of coastal real estate as an estimate for the value of beach width may lead to the conclusion that highly developed beaches are worth more than undeveloped beaches. While this may seem logical from a private landowner's perspective, the opposite may be true from the perspective of society. That is, undeveloped beaches may confer larger economic gains to society than developed ones. Landry (2011) provides additional discussion of this important issue.

3.1.3 Revealed Preference Methods

In terms of understanding the economic value of beach width and shoreline amenities, the most commonly employed non-market valuation methods are the revealed preference approaches of *hedonic pricing* method and the *travel cost method*. These approaches are based on establishing empirical links between changes in natural resources and market behaviors. For example, beach width may affect sales prices of coastal real estate or influence the number of tourists that visit a particular destination. By collecting data on real estate sales or travel to the coast, the associated value of beach width can be estimated. Specifically, the hedonic pricing method uses data on house characteristics (size, age, neighborhood characteristics, etc.), associated environmental amenities (e.g. proximity to the coast or beach width near the house) and selling prices. To estimate the contribution of those environmental amenities to the market value of the house, regression analysis is used where price serves as the dependent variable and independent variables are house characteristics, including environmental amenities. The estimated regression coefficient on the environmental characteristic represents the marginal change in average selling price for a change in that characteristic, and can be interpreted as the implicit price of the characteristic. Because this method relies on actual transactions, value results are difficult to critique, provided that proper methodology was employed and that the environmental characteristics of interest were accurately quantified and have not undergone meaningful change since the time of the real estate transactions. The literature contains several applications of the hedonic pricing method to value coastal attributes, many of which are reviewed herein.

The travel cost method is another revealed preference approach that is commonly employed to value natural resources associated with recreation. Site visitation data, including travel costs and the number of trips taken to a particular destination are collected and used to estimate a trip demand curve, where explicit and implicit travel expenses serve as a proxy for price. The net benefits of a particular site or the value of the resources within each site can then be estimated by integrating under the estimated demand curve at a particular price point (e.g. mean or median price). Numerous examples of recreation demand models applied to value beach visitation appear in the published literature. Pertinent applications are reviewed later in this report.

3.1.4 Stated Preference Methods

The above methods are useful for understanding the economic value associated with property and recreation aspects of coastal quality and amenities, but they are not amenable to the valuation of benefits that are not associated with direct use. When people derive values from simply knowing that natural resources are preserved or maintained in a particular state, s*tated preference methods* such as the Contingent Valuation Method (CVM) and Choice Modeling (CM) must be employed. These methods, which rely on surveys to elicit values, are well-accepted approaches for valuing non-market goods and services. CVM has been adopted by the U.S. Department of Interior to measure non-market values associated with damages under CERCLA 1980 (US DOI 1986), while NOAA has endorsed the use of this method for damage assessment under the Oil Pollution Act of 1990 (Arrow et al. 1993). The CM approach appears to be gaining favor in the economics literature as it avoids many of the difficulties associated with CVM and allows multidimensional attribute changes to be valued simultaneously (Huybers, 2004). As is the case with all valuation approaches, estimates of value are subject to an array of biases and caveats, hence care must be taken with regard to proper methodology and interpretation.

3.1.4 Economic Impact Analysis

In addition to estimating changes in economic value to users, property owners and other direct stakeholders, analysts may be interested in understanding the effects of changes in natural resource quantity or quality on the broader economy. Such impacts might include additional revenues, incomes and employment realized by local, regional and national economies. *Economic impact analysis* is the process concerned with such estimation, and recognizes that a portion of each dollar spent by a consumer or producer represents revenue earned by someone else in the economy. As the new revenue earner spends that income, each transaction creates additional income that ripples through businesses and households creating “economic multiplier effects”. These impacts are estimable, and are typically categorized into *direct* effects, *indirect* effects and *induced* effects. *Direct effects* are market contributions to the economy, and are typically measured by gross total revenues, total employment or gross incomes. *Indirect effects* are impacts on the incomes and wages of the suppliers of inputs used in the industry in question when those earnings are subsequently spent on other goods and services. *Induced effects* are the economic impacts of spending of generated income by households who are either directly or indirectly employed in the industry. Indirect and induced effects taken together are often referred to as *value added effects* (Fedler, 2010).

Economic impact analysis relies on the use of input-output models which delineate forward and backward linkages in earnings and spending between economic sectors of interest and the rest of the economy. An empirical understanding of these linkages allows for the estimation of *multipliers* which quantify the extent to which a given economic activity (direct effect) generates other economic activity. Value added multipliers convert direct expenditures into total economic impact (Fedler, 2010). For example, if the estimated value added multiplier for tourism spending is 1.5, then each $1 of direct spending by tourists results in an additional $1.50 of indirect and induced effects, for a total economic impact of $2.50.   Because economic impact analysis does not calculate net economic gains to market participants and does not account for non-market values, economic impact analysis and the use of input-output models should be considered a complement rather than a substitute for the calculation of economic value using other methods described above (Hoagland, et al, 2005).

4.0 Beach Nourishment as a Dynamic Optimization Problem

A recent branch of economics research has examined beach management decisions as a dynamic optimization problem where the timing and rate of renourishment that maximizes the discounted present value of net gains (benefits less costs) is derived (Landry, 2011). Required inputs for such modeling efforts include a rate of natural erosion or decay, the economic costs of beach nourishment, a parameter that converts sand volume to beach width, and a function representing aggregate benefits from beach width. The principle outputs are an optimal schedule of renourishment, the optimal quantity of sand that should be applied during each operation, and a measurement of how these values are affected by changes in the inputs (Landry, 2011). An obvious benefit of this approach is the ability to determine, *a priori*, the potential economic value of beach management actions under a range of hypothetical conditions. A downside is the time, effort and expertise required to conduct the modeling. While it is beyond the scope of this report to apply dynamic optimization models for coastlines in North Carolina, some notable results can be gleaned from prior work in the literature.

5.0 Categories of Potential Impacts from Coastal Management Alternatives

The economic costs and benefits associated with shoreline management projects will include changes in market values and non-market values. Affected market values may include with the physical costs of active mitigation efforts (e.g. construction and maintenance costs associated with hardened structures, acquisition of beach nourishment material, destruction and/or relocation of coastal real estate), and the change in economic value to coastal property and public infrastructure. Non-market values include those associated with changes to the size and integrity of beaches and dunes, inlets and their associated functions, including provision of public recreational opportunities, aesthetics and wildlife habitat. Effects on coastal property values will materialize in market values, and likely entail elements of both market and non-market values. These include changes in the storm protection benefits from beaches and dunes as well as values associated with recreation and aesthetics.

When comparing management alternatives, it is important to note that in many cases the benefits of active mitigation efforts can be considered costs of inaction. For example, the benefits of shoreline stabilization via nourishment or hardened structures include maintaining the integrity of the shoreline and the associated real estate. These economic values are likely to be partially or wholly sacrificed in the absence of active mitigation. Hence, an analysis of the costs of inaction (e.g. retreat) would include lost shoreline integrity and declinations in the economic value of associated real estate. Likewise, the benefits of inaction may include the value associated with maintaining natural environmental conditions in a state unaltered by active mitigation.

A deep body of literature exists examining the nature, scope and measurement of these economic values. Below, we provide a brief overview of this literature so as to provide a context for the potential scope of changes in economic value that might be associated with alternative shoreline management projects under consideration in North Carolina.

5.1 Values Associated with Coastal Property and Physical Capital

Natural and anthropogenic changes to shorelines can be expected to affect the value of coastal real estate. The value of at-risk property can be viewed as a potential economic cost associated with inaction (e.g. retreat) or an economic benefit of protection via active management (e.g. nourishment, armoring). Hence, an appraisal of coastal property values and/or derivation of the effect of beach characteristics on property values via the hedonic pricing method can serve as a valuable input in terms of understanding the costs and benefits of management alternatives.

However, caution must be exercised when conducting such appraisals for a number of reasons. First, property values can fluctuate with local and national economic conditions. Available sales, tax assessment or appraisal data may be reflective of market that may no longer be applicable to contemporaneous or future valuations. Further, natural characteristics of coastlines the associated economic benefits are inherently dynamic, which may create empirical difficulties when attempting to quantify the association between those characteristics and property values. For example, even with periodic renourishment, sand volume and beach width can be expected to vary over time. As such, explorations of the relationship between beach characteristics and property values that rely on measurements of those characteristics at a particular point in time may not properly account for anticipated future change or the flow of benefits from average quality metrics (Gopalakrishnan et al., 2011). Indeed, market participants' understanding of shoreline dynamics and expectations regarding shoreline management interventions will likely be capitalized into market values (Landry and Hindsley, 2011; Landry, 2011). For example, if a strategy of retreat is reasonably anticipated, the value of threatened properties could be driven toward zero (Landry, 2011). Likewise, uncertainty regarding legislative or budgetary conditions may confer a perception of investment risk, which can also be expected to be capitalized into market values. To the extent that shoreline characteristics at the time and location of data collection do not reflect those expectations, value estimates will be compromised.

An additional complication arises from the potential endogeneity between property values and shoreline characteristics. While it is clear that property values will depend on the characteristics of proximate shorelines (additional discussion below), shoreline characteristics may also depend on property values. As noted in Gopalakrishnan et al. (2011), shoreline management decisions may depend on the benefits from changing the natural character of the shoreline. For example, beach nourishment might occur on a larger scale or more frequent interval where beaches protect valuable real estate. This bi-directional causality may confound empirical estimation of the effect of beach width on property values.

To summarize, the value of at-risk property and assets that stand to be lost or protected can and should be considered when appraising the costs and benefits associated with alternative actions for shoreline management. The hedonic pricing method is the most commonly employed approach to understanding the relationship between shoreline characteristics and the market value of such assets, but such analysis should be exercised with careful consideration of the above cautions and caveats.

5.1.1 Categories of Value

Parsons and Powell (2001) categorize the costs of shoreline retreat as land loss, capital (structure) loss, proximity loss, and transition loss. The economic value of land loss is the difference between the value of affected land in the absence of beach erosion and the value of the same land with beach erosion. Because there will always be a given area of land that is beach front, value lost to erosion is associated with diminished land availability inshore rather than the loss of beachfront land. Capital loss is the difference between the asset value of housing, commercial buildings, and public infrastructure in the absence of beach erosion and the value of those same assets with beach erosion, including any loss of use and additional maintenance costs associated with retreat.

Proximity loss is the decrease in human welfare associated with adjusting the pattern of coastal development in response to an unstable shoreline. For example, Parsons and Powell (2001) note that in the face of an unstable shoreline, permanent structures may be rebuilt further from the shore or temporary structures may be built close to the shore. Either case confers less economic welfare associated with proximity than permanent structures built close to the shore, which is the presumed pattern of coastal development when shorelines are stable. Finally, transition loss is the economic costs associated with removal of housing, commercial buildings, and public infrastructure and includes costs of labor, capital and materials. It is important to note that the costs associated with replacing coastal real estate may not be an appropriate proxy for the benefits of avoiding replacement, as the latter entails the value associated with occupying a property, which may or may not be related to construction costs (Landry, 2011).

5.1.2 Examples from the literature

A deep body of literature examines the relationship between the value of coastal real estate and environmental amenities such as views, distance to shorelines, beach width and water quality. Each of these amenities is found to enhance property values as reflected in market prices. The contribution of amenities such as views and beach width is found to diminish with distance from the ocean.

With regard to ocean views, Benson et al. (1997) and Benson et al. (1998) use the Hedonic Pricing approach to estimate the value of scenic views to single family homes in Washington. Both studies find that homes with ocean views are associated with statistically significant price premiums. The 1997 study suggests that ocean frontage adds up to 147 percent to the market price of a home. Views of the ocean add between 10 and 32 percent to market prices, with lower values corresponding to partial views. The richer dataset used in the 1998 study allows for detailed characterization of view quality and distance from the water, and suggests that prices of homes with high quality (unobstructed) views of the ocean are 59 percent higher than prices of otherwise comparable homes on average. Lower quality ocean views convey lower price premiums, ranging between 8 and 31 percent. Not unexpectedly, while controlling for the quality of view, the value of ocean views is found to be inversely related to distance from the water. Prices of homes that are a very short distance from the water with unobstructed views may be more than 68 percent higher than otherwise similar homes.

Pompe and Rinehart (1999) also find that property buyers value ocean views. These authors apply the hedonic pricing approach to home sales in South Carolina and find that views of the ocean add approximately 45 percent to the value of developed lots and 83 percent to the value of vacant (undeveloped) lots.

Numerous studies explore the economic value of beach width to property owners. Pompe and Rinehart (1995) and Pompe and Rinehart (1999) find that property buyers value wider beaches. These two studies - applications of the Hedonic Pricing approach to data from coastal property sales in South Carolina – show that the marginal value of beach width varies with distance from the beach and differs for developed and undeveloped lots. Specifically, Pompe and Rinehart (1995) find that an additional foot of beach width is estimated to increase the value of developed and undeveloped oceanfront lots by $554 and $754 respectively. At a distance of one-half mile from the beach, the price premium for an additional foot of width is found to be considerably lower, roughly $254 and $165 for developed and undeveloped lots respectively. In Pompe and Rinehart (1999), an additional foot of beach width is found to add $194.09 and $310.84 to the market value of developed and undeveloped oceanfront lots, respectively. The authors caution that these latter estimates are based on a relatively small number of oceanfront parcels. Smaller price premiums are found for properties that are not oceanfront with ocean views, and even smaller (but still statistically significant) premiums are found for properties near the beach, but without ocean views.

With regard to loss of beach width to erosion, Parsons and Powell (2001) use a hedonic price regression to estimate the costs of shoreline retreat in Delaware. Specifically, using a range of estimates for average erosion rates at seven different beach communities along the Delaware coast, they approximate the expected location of the shoreline in the absence of active management actions and predict which specific houses would be lost as the shoreline migrates. For each structure that is predicted to be lost, value is predicted using a hedonic price regression based on market data. It is important to note the reason why the hedonic approach is employed rather than simply relying on market values of at-risk real estate: The hedonic approach allows the estimation of the coastal amenity value associated with each structure. This coastal amenity value is subtracted from this anticipated loss under the assumption that such value is simply transferred to other structures that are now closer to the shoreline. The costs associated with removal of the structure (i.e. the transition loss) are assumed to be $25,000 per structure and are added to create an estimate of the total loss associated with losing that property to retreat. Commercial structure losses are approximated using Marshall and Swift's property appraisal method. It is important to note that the authors assume that the majority of the value associated with infrastructure is capitalized into the value of residential structures, and as such the associated losses are captured in the hedonic estimation. To the extent that such infrastructure conveys economic benefits to the public at large (e.g. tourists, or nearby residents), this assumption results in an underestimate of the true costs of retreat. Further, while the authors mention the costs of infrastructure removal and/or relocation, it is not clear that these costs are explicitly accounted for. The authors also do not attempt to estimate proximity losses, which are assumed to be small. Finally, the authors do not account for unstable beach conditions and the effect of such future risk on values of homes that are now closer to the shoreline.

Their results suggest that over a 50-year period, the costs of active beach renourishment are expected to be substantially less than the lost value associated with retreat. The authors suggest that the costs of renourishment would have to increase by a factor of four for retreat to be an economically preferable alternative, though they caution that cost estimates may vary greatly with assumed rates of erosion. Because of the characteristics of the study area, the majority of losses from retreat are those associated with residential real estate. Transition losses and losses associated with commercial structures are found to account for about 15% of total losses. Importantly, the coastal amenity value is found to be a statistically significant component of the economic value of at-risk property. For example, for an ocean-front house valued at $300,000, the ocean-front amenity is found to account for nearly $132,000 of the value. A bay-front house of similar value would owe $24,000 to its proximity to water and canal frontage appears to be worth $63,000. The authors also suggest that for houses less than a half-mile from the beach, each 25 feet of distance from the coast is worth about $1200 for a representative $300,000 house. Because these amenity values can be assumed to transfer to properties further inland as a result of retreat, these results suggest that a simple subtraction of the current market value of at-risk real estate will grossly overestimate the costs of retreat and unimpeded shoreline recession. That is, while retreat can be expected to diminish or eliminate the market value of beachfront properties, the beachfront itself will always exist. Hence, properties that were once “one row back” will now be beachfront, and can be expected to increase in value. Nonetheless, given the current costs and technology associated with shoreline renourishment, retreat appears to be an unfavorable option from a market costs perspective.

Landry, Keeler and Kriesel (2003) explore the desirability of shoreline management alternatives by quantifying the economic impacts on coastal property owners who face risk of economic loss from erosion, the change in value of recreational uses of coastal areas that may be impacted by shoreline management and the costs of management. Effects on the natural environment (e.g. habitat loss or change) are not considered. Specifically, the incremental value of improved beach widths for coastal residents is estimated using hedonic analysis applied to a sample of 318 property sales on Tybee Island, GA. Including among the set of sales price determinants in the hedonic regression are beach width, distance from the beach, erosion risk, and the presence of erosion control structures. The measure of erosion risk was an indicator variable for property proximity to known high risk areas on the island. Beach width is found to be a statistically significant determinant of property value, with each one-meter increase adding $233 to property value. Ocean-front and inlet-front amenity values are estimated to be of $34,068 and $87,620 respectively. Property values in high risk areas were estimated to be reduced by $9,269.

Landry and Hindsley (2011) also apply the hedonic pricing method to real estate transactions for single-family residences in Tybee Island, GA, and measure the value of high- and low-tide beach and dune widths at nearby beaches, adjusted for changes in beach width due to sand replenishment activities. They find that beach and dune width have a statistically significant influence property value for properties located within 300 meters from the shore, but find no relationship for properties located further from the shore. Specifically, Landry and Hindsley estimate marginal willingness-to-pay for beach width for houses within 300 meters from the beach ranges from $421 to $487 for an additional meter of high-tide beach, or $272 to $465 for an additional meter of low-tide beach. The incremental value of dune width ranges from $212 to $383 per meter for houses within the 300 meter distance. When the estimation is extended to properties beyond the 300 meter distance, marginal values decrease. These authors also find that the value of ocean frontage is estimated to be between $39,000 and $75,000 and between $121,000 and $128,000 inlet frontage.

Gopalakrishnan et al. (2011) estimate the value of beach width to coastal property in ten coastal towns in North Carolina[1] using hedonic pricing models. When beach width is treated as an exogenous characteristic, the average increase in oceanfront property value is approximately $1,440 per additional foot of beach width. This value approaches zero for properties that are located more than 330 feet from the beach. When beach width is treated as endogenously determined[2] (i.e. property values are function of beach width and beach width, via nourishment activity, is a function of property value), the authors find that beach width likely accounts for a larger portion of coastal property value. Specifically, the coefficient on the (fitted) beach width variable is five times larger than in the exogenous specification, suggesting that the average increase in oceanfront property value is approximately $8,800 per additional foot of beach width, or a roughly 0.5 percent increase in value per 1 percent increase in beach width. The authors suggest that their results indicate that property values will be more sensitive to beach width when there is severe erosion and beach replenishment is used to stabilize the shoreline. Notably, unlike Landry and Hindsley (2011), Gopalakrishnan et al. (2011) find that the presence of dunes does not impact property values.

[1] The sample of towns includes Carolina Beach, Kure Beach and Wrightsville Beach in New Hanover County. All other towns in the sample are in Carteret County or Dare County.

[2] This model is estimated via two-stage least squares, where geomorphological variables are used to instrument for beach width in the first stage, and fitted values of beach width are used in the price hedonic in the second stage.

5.1.3 Summary

There is a preponderance of evidence that property owners place considerable economic value on beach width. This value declines with distance from the shore. While some literature suggests that the existence of dunes has a positive impact on property values, the evidence to date is not clear. It is important to note, as articulated by Landry and Hindsley (2011), interpretation of specific value estimates such as those detailed above depends on individual perceptions of future resource quality. If conditions are expected to improve over time, value estimates should be interpreted as lower bounds on true value. If instead, conditions are expected to degrade, value estimates should be interpreted as upper bounds on true value.

5.2 Coastal Infrastructure

In addition to privately owned residential properties, coastal areas also contain physical capital in the form of public infrastructure (e.g. roads, water, electric, sewer). As with privately held capital, this public capital conveys economic benefits to society. Again, the value of these benefits to society can be considered a benefit of erosion control measures, or a cost associated with the failure to control erosion. It is important to note, as expressed in Parsons and Powell (2001), that some of the benefits associated with public capital accrue directly to property owners and will be capitalized into market values for associated real estate (e.g. water and sewer services), and thus included as part of damage avoidance estimates if the value of privately held coastal property is assessed. Yet, other aspects of value for these public assets are not amenable to market valuation, because the benefits derived from their use are not for sale (e.g. the value of public roads adjacent to public beaches). The only readily available market measure of value is that pertaining to new construction costs. That is, while there is no observable market value of what infrastructure is worth in terms of benefits conveyed to the public, we can observe or estimate the cost associated with its construction. As a case in point, in order to measure the potential value of terminal groins in terms of protecting public assets, the cost of constructing public infrastructure was used in NCCRC (2010).

While the procedural endorsement of the RC and CA approaches is understandable in light of the lack of an alternative proxy for value, as noted in the discussion above, the monetary estimates derived from these approaches should not be used without careful consideration. In particular, infrastructure replacement costs seem a tenuous measure of the value of protecting in-situ infrastructure in situations where a lack of protection induces sufficient erosion to eliminate any possibility of replacing that infrastructure. In circumstances where inundation (conversion of land habitat to water) removes the possibility of replacement, the cost of constructing infrastructure might best be considered an unrecoverable sunk cost. Costs that are germane to these situations would include expenses associated with physical removal of the infrastructure. However, when inundation necessitates replacement of lost infrastructure at an alternative location services in order to maintain service flows to properties that remain unaffected by erosion, replacement costs may be an appropriate estimate of at-risk value provided that they account for costs associated with right-of-way acquisition, engineering, permitting, and construction costs (in addition to removal of infrastructure).

5.3 Values Associated with Recreation and Tourism

5.3.1 Categories of value

Alternative actions for mitigating the effects of shoreline change are expected to impact the quantity and quality of recreation and tourism opportunities at the site of interest. Management action or inaction may also create effects on proximate sites or sites that are considered substitutes. These effects may include changes in beach area, the quality of sand, ease of access, the quality of the marine environment, the quality of scenery and the quantity or quality of habitats and species. Changes in economic values will be manifested in changes in the quantity or quality of extractive direct uses (e.g. catch-and-keep fishing), non-extractive direct uses (e.g. sunbathing, bird watching, walking/running, surfing, catch-and-release fishing), and passive uses (e.g. enjoying the aesthetics of a coastal area). In the case of beach nourishment and/or armoring, perhaps the most obvious of these changes is that associated with the amount of physical space available for recreation. Landry (2011) categorizes the economic value of changes in beach area as associated with improvements in scenery and aesthetics, allowing space for more users and decreasing congestion for existing users.

These categories of value are not mutually exclusive. Indeed, a single user can derive economic value from all of the above activities. Further, due to the non-rival and non-excludable characteristics of many of these uses, value derived by one individual does not preclude others from enjoying benefits as well. The most widely applied methodology for estimation of the economic value of changes in coastal quality as it pertains to recreation is the travel cost method, or its close cousin, random utility modeling. Applications of these revealed preference approaches are detailed in an extensive body of literature, some of which is reviewed below. Stated preference approaches such as the contingent valuation method and choice modeling may be appropriate in cases where benefits extend to aspects of value associated with more passive uses.

In addition to value accruing to direct users, additional economic impacts from changes in coastal quality may be realized by local businesses via changes in tourism demand and by governments via changes in tax revenues. Estimation of such economic impacts requires the use of economic impact analysis (input-output models) described earlier in this report. While the estimation of tourism multipliers and the economic impacts of discrete tourism-related events have received attention in the literature (e.g Dwyer et al., 2004; Frechtling and Horvath, 1999; Hodur and Leistritz, 2007), a recent review of the economics of coastal erosion by Landry (2011) finds a dearth of research regarding the economic benefits accruing to local businesses from beach management.

Finally, it is important to note that management alternatives involving shoreline retreat may not create losses in terms of foregone recreation and tourism opportunities. As discussed in Parsons and Powell (2001), if the shoreline is simply relocated further inland, with no changes to other beach characteristics, the welfare derived from recreationists can be assumed to be unchanged. More generally, to the extent that shoreline change does have an adverse effect on the quantity or quality of recreational opportunities, the degree of economic loss to users and associated businesses will depend upon the availability of substitute locations for such activities (Landry, 2011). If alternative sites are available, proximate and of similar quality, the economic losses associated with diminished quality at one site may be mitigated via substitution.

Clearly, the economic value from coastal recreation and tourism is multi-faceted and involves numerous user groups. A comprehensive empirical estimation of quality-induced changes in values associated with recreation is not straightforward, and should be site-specific entailing multiple valuation approaches.

5.3.2 Examples from the literature

The literature pertaining to the economic value of coastal recreation is vast. This literature includes estimates of the value of access, typically addressed via revealed preference methods, as well as the value associated with changes in site quality, which is more commonly assessed via stated preference techniques. We do not attempt to provide a comprehensive review of this literature, but rather try to highlight particular studies that may be germane to the issues at hand.

Bin et al. (2005) apply the travel cost method to estimate the economic value of beach recreation in North Carolina. Data were collected at seven beach sites in the state, including Topsail Island and Wrightsville Beach. Value estimates range from $11 to $80 for day trips and between $11 and $41 for overnight trips. There is notable variation in value estimates across sites, with higher values found for beaches that are inaccessible by automobile or are not as well-known as other beaches in the sample. The authors speculate that the perception of exclusivity may influence the recreational value of beaches and suggest that unique site characteristics and user preferences for different types of experiences are important determinants of value.

In a contingent valuation analysis of beach renourishment in the Cape Hatteras National Seashore, N.C., Judge, Osborne and Smith (1995) find that average willingness to pay for beach renourishment is approximately $178 per person per year. This value was a positive function of anticipated future visitation and is inversely related to prior experience at the site. Willingness to pay also decreases with distance from the site for those users with no prior experience visiting Cape Hatteras and is a positive function of education level and the attitude that beach towns suffering from storm erosion should receive additional federal assistance.

Whitehead et al. (2008) use the travel cost method and a combination of revealed preference and stated preference data to estimate changes in recreation demand at 17 beaches in southeastern North Carolina that would occur with improved parking and beach nourishment. The study area included numerous beaches in Carteret, Pender, Onslow, New Hanover and Brunswick Counties. Regarding beach nourishment, respondents were informed that beach nourishment projects would be performed at least once every 3 to 5 years for a 50-year term for the purpose of shore protection and enhanced recreation opportunities, and average beach width would increase by 100 feet. A majority of respondents (58%) expressed support for the beach nourishment policy, and most respondents (85%) felt that the stated beach nourishment policy would be effective in maintaining beach width. Yet, some respondents (21%) were satisfied with current beach widths and some (18%) felt that beach width should not be altered by people. Enhanced beach width was found to increase total net gains to beach visitors by approximately $7 per person per trip and roughly $68 per person per year.

5.4 Values Associated with Coastal Species and Habitats

As is the case with empirical explorations regarding the economic value associated with coastal recreation, the literature on the economic value of species and habitats is extensive. Howarth and Farber (2002) provide important background reading regarding the economic valuation of ecosystem services, and note the importance of constructing monetary measures of economic wellbeing that account for non-market values held by people. These non-market values include existence values pertaining to species and ecosystems. The authors also highlight the importance of accounting for values held by a range of stakeholder groups rather than value held by a “representative” individual. A review of the literature provided by Spurgeon (1999) suggests that use and non-use benefits derived from coastal ecosystems are substantial. These ecosystems provide an array of valuable services that result in economic benefits to the public at large. Barbier et al. (2008) note the importance of considering nonlinearities when accounting for changes in coastal ecosystem service flows. Specifically, they note that changes in coastal ecosystem services do not necessarily respond linearly to changes in habitat size. This implies that valuation of coastal ecosystem services should not be based on simple linear extrapolations of lost habitat to point estimates of monetary value.

In the case of wetlands, ecosystem services include filtration, storage, and detoxification of residential and agricultural wastes and mitigation of pollution and nutrient-laden runoff into receiving water bodies (Stedman and Dahl, 2008). Wetland preservation can be viewed as a cost-saving measure for communities as these water-quality services can involve considerably lower costs than community or municipal water treatment alternatives (US EPA, 2006). By absorbing and storing flood waters, wetlands can also serve as a natural buffer protecting adjacent real estate from the effects of rising surface waters during storms. Similarly, dune habitats provide important storm-protection services for coastal land and property. Wetlands and dunes also provide important transitional habitat between aquatic and terrestrial environments for resident and migratory wildlife. Wetlands serve as critical nursing areas for marine organisms, including the majority of fish and shellfish species harvested in the U.S. (US EPA, 2006). The quality and abundance of coastal ecosystems are therefore directly related to the health of fish and wildlife stocks (Stedman and Dahl, 2008).

The existence of dunes and wetlands in a community may enhance property values for storm protection benefits, aesthetics and through improved opportunities for recreation activities such as hiking, bird watching, and photography. Wetlands may be considered a disamenity if they are associated with odors, insects or undesirable wildlife interactions.

Several studies have attempted to estimate the economic impact of proximate wetlands on land values using the hedonic pricing method. Generally, these studies suggest that the effect of wetlands on property values depends on the type and character of the wetland. For example, in an examination of property values in rural Florida, Reynolds and Regalado (1998) find that proximity to scrub-shrub and shallow pond wetlands has a positive impact on property values, while proximity to emergent palustrine wetlands may have an adverse effect. In mainland North Carolina, Bin and Polasky (2003) find that the open and sparsely vegetated nature of coastal wetlands provide a value-enhancing amenity while more densely forested inland wetlands do not, and may in fact decrease property values.

Numerous studies employing stated preference methods find substantial economic value associated with recreation, wildlife habitat, flood control, and improved water quality from wetland services (McConnell and Walls, 2005). Woodward and Wui (2001) review the results from 39 empirical studies, and find that type of wetland and method of analysis has substantial effect on estimated wetland values, noting that only imprecise estimates of wetland values can be garnered from the literature. Hence, it is reasonable to conclude that wetlands are an important source of economic value to surrounding areas, but without case-specific empirical analysis, a reasonable approximate of the magnitude or distribution of that value is not feasible.

Spurgeon (1999) provides an overview of the economics associated with coastal habitat rehabilitation and creation, including a review of the relevant literature. The author notes that the costs associated with habitat rehabilitation or creation costs vary widely between and within ecosystems. The two studies that pertain to dune habitats suggest that rehabilitation costs may range from approximately $19,000 to $25,000 per hectare.[3]

Numerous studies are available that pertain to the economic value of species and species protection. Shogren et al. (1999) provide useful background reading. Loomis and White (1996) provide results from a meta-analysis of the economic benefits of rare and endangered species. Whitehead (1993) estimates willingness to pay for preservation of coastal non-game habitat and loggerhead sea turtle nesting habitat in North Carolina using the contingent valuation method and a sample of 600 North Carolina residents. Average annual willingness to pay is approximately $11 for the loggerhead sea turtle program and $15 for the coastal nongame wildlife program. In addition to generating estimates of the economic value of coastal habitat associated with species protection, this work highlights the importance of accounting for uncertainty when estimating the economic value associated with threatened or

[3] The latter value pertains to a 2.5 ha dune rehabilitation project in Scotland and includes costs associated with replanting dune grass, providing fencing for trapping sand and installing gabion revetments. Additional maintenance costs for the project are noted as less than $1,000 per year. The former value pertains to a 17.8 ha dune rehabilitation project in Monterey, CA.

endangered wildlife populations. The author notes that failure to account for uncertainty with regard to the continued existence of the resource as well as uncertainty pertaining to demand and preferences may result in inappropriate benefits estimates.

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APPENDIX V

STORM RESPONSE SIMULATION

Delft3D Storm Response Simulations
With and Without a Terminal Groin

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November 12, 2012

Introduction

A calibrated, depth-averaged Delft3D model was utilized to predict the physical performance of the terminal groin following passage of a low-frequency tropical storm event. The model was run for both with- and without-terminal groin conditions in order to draw relative conclusions on storm response. Both scenarios include the placement of approximately 1.2 Mcy of beach nourishment and simulate beach conditions following or concurrent with project construction. Spatial distribution of the beach fill varied between scenarios according to specific project needs. Both models consider the existing sand-filled geotextile tube groins. The storm-response results suggest that the terminal groin improves the performance of the placed beach nourishment sand without causing significant negative impacts to the downdrift shoreline.

The terminal groin is modeled as "leaky" using porous plates which are by definition infinitely high, semi-permeable numerical structures. The permeability of porous plates is numerically controlled by a friction term which was set to 4.5 for these simulations, roughly representing a level of permeability between about 10 and 30 percent. The existing tube groins are described as thin dams in the model, which act as impermeable, infinitely high barriers to sediment transport.

Storm conditions simulated in the model are similar to those identified during the June 10-14, 1996 passage of Hurricane Bertha. The model does not seek to expressly model Hurricane Bertha, and damages caused by local high winds and inland flooding are not described in the model. Rather, the tropical event simulated herein is akin to a Bertha-like event. Hurricane Bertha was, at its peak intensity, a Category 3 storm which made landfall as a Category 2 storm in the immediate vicinity of Bald Head Island. Hurricane Bertha's track is mapped in **Figure 1**.

Waves, Water Levels, and Bathymetry

The storm model was run in real time, for the 4 day period June 10 - 14, 1996. A time series detailing significant wave height, wave period, wave direction, and wind velocity for this time period were obtained from data published by the U.S. Army Corps of Engineers Wave

Information Studies (WIS). Specifically, data from offshore WIS station 63320 were used. The location of this station is shown in **Figure 1**. WIS station 63320 is very near both the seaward row of the numerical wave grid and the NOAA buoy used to generate input conditions for the calibrated long-term morphological model. As such, the WIS time series data were input directly into the model as-is. The offshore wave time series is plotted in **Figure 2**. Hurricane Bertha represents the third largest wave heights in the 20-year WIS record covering the period 1980-1999.

A time series of measured water levels for this period was specified using tide data collected at Oak Island, NC. Hourly tide measurements were obtained from NOAA's National Ocean Service station 8659182, which is located in the Atlantic Ocean off Oak Island, NC. The hourly water level time series used for model input is plotted in **Figure 3**.

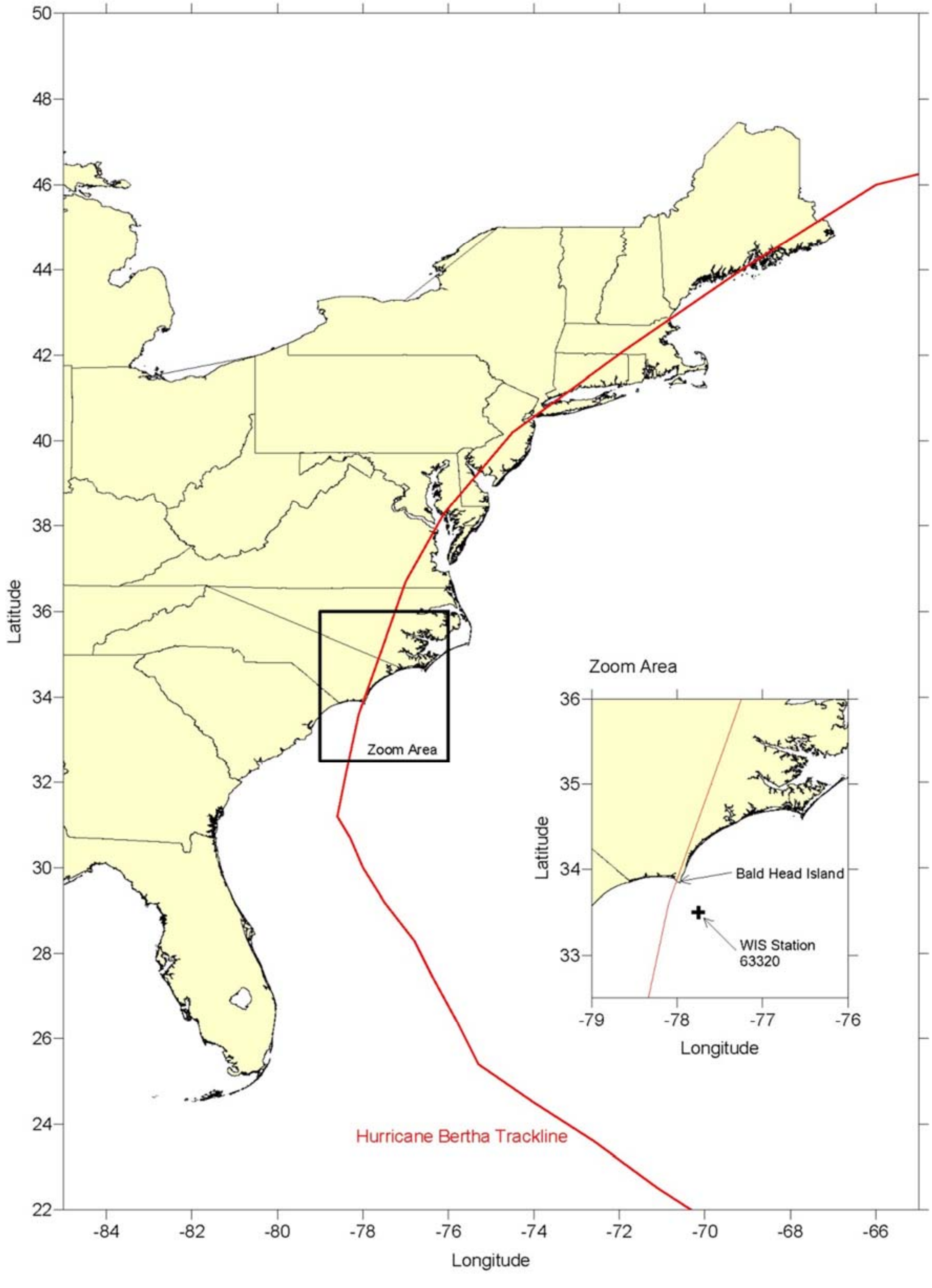

Figure 1: Track of Hurricane Bertha (1996).

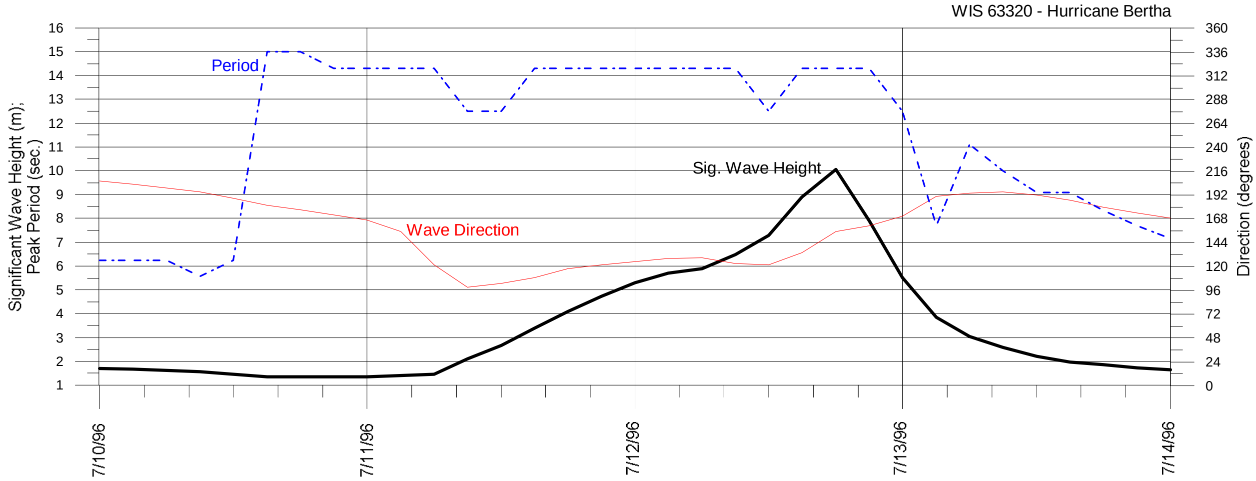

Figure 2: Input offshore wave time series obtained from WIS Station 63320.

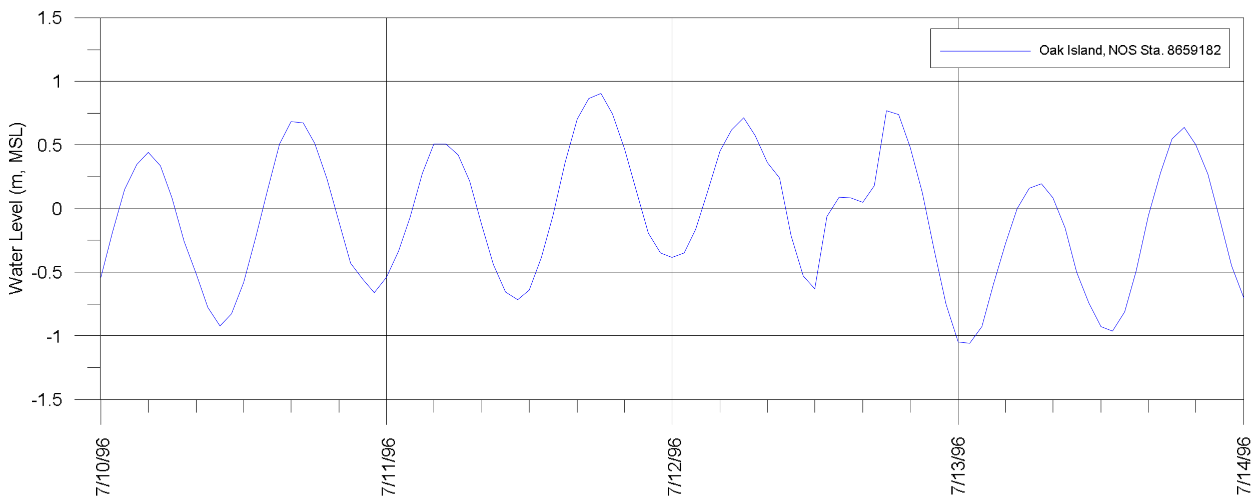

Figure 3: Input water level time series obtained from NOS Station 8659182, Oak Island, NC.

Figure 4 depicts the input bathymetry for the beach fill only condition (without terminal groin). This modeled scenario represents a typical sand placement (disposal) project along Bald Head Island. The project includes placement of about 1.2Mcy of sand extending from the Point eastward to about Station 166+00. A typical nourishment event of this volume will bury, and deactivate, the existing tube groins. The beach fill only scenario was run as a baseline condition in order to form the basis for relative comparison to the terminal groin (with fill) simulation.

Figure 5 plots the input bathymetry for the semi-permeable terminal groin scenario. The modeled bathymetry includes placement of a similarly sized beach fill placement project. The 1.2Mcy nourishment is distributed from the terminal groin to about Station 130+00 where it begins to taper into the existing profile. The distribution of the fill increases in sectional density towards the west in order to pre-fill the fillet along the updrift side of the terminal groin.

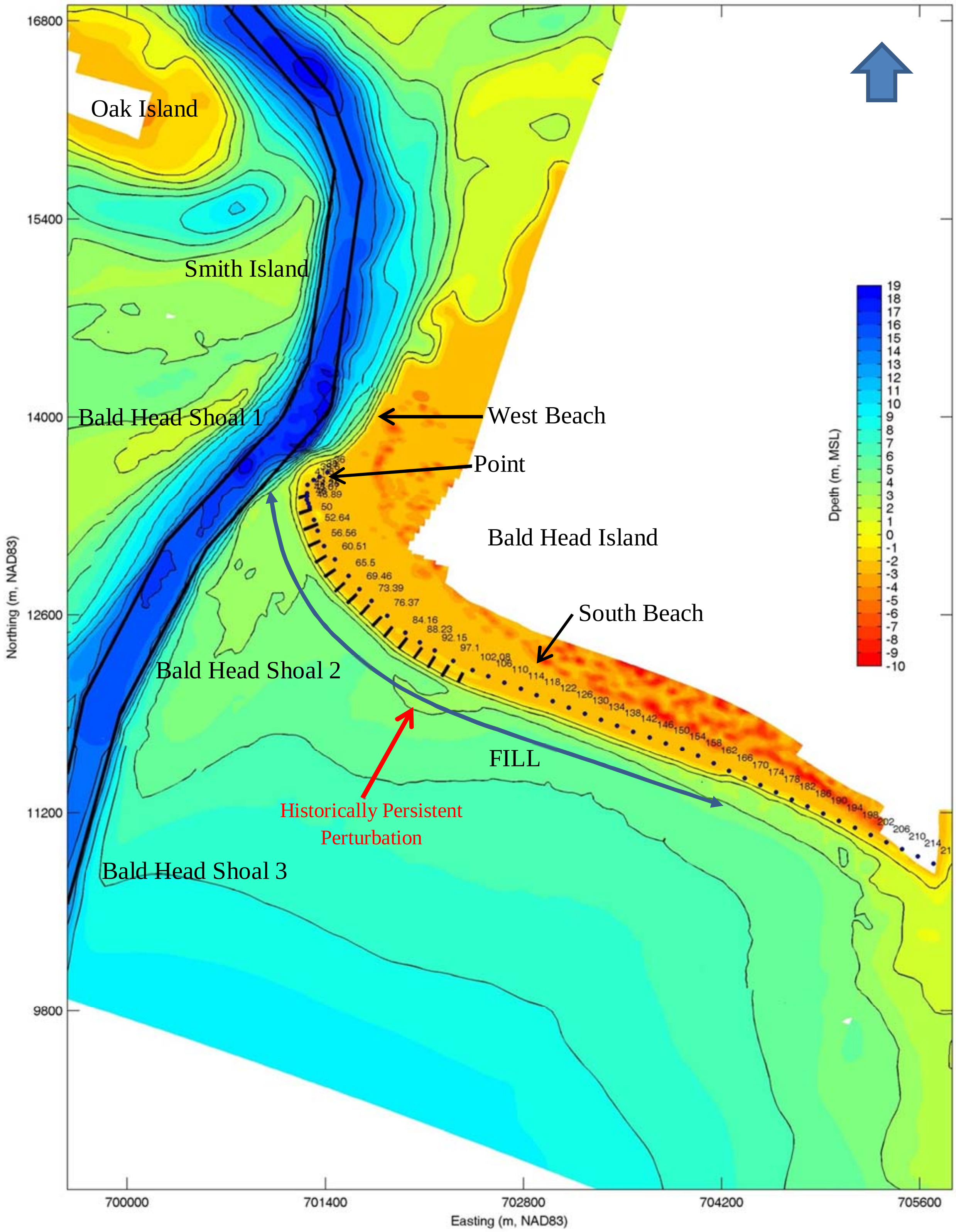

Figure 4: Nearshore bathymetry used for model input in the beach fill only simulation.

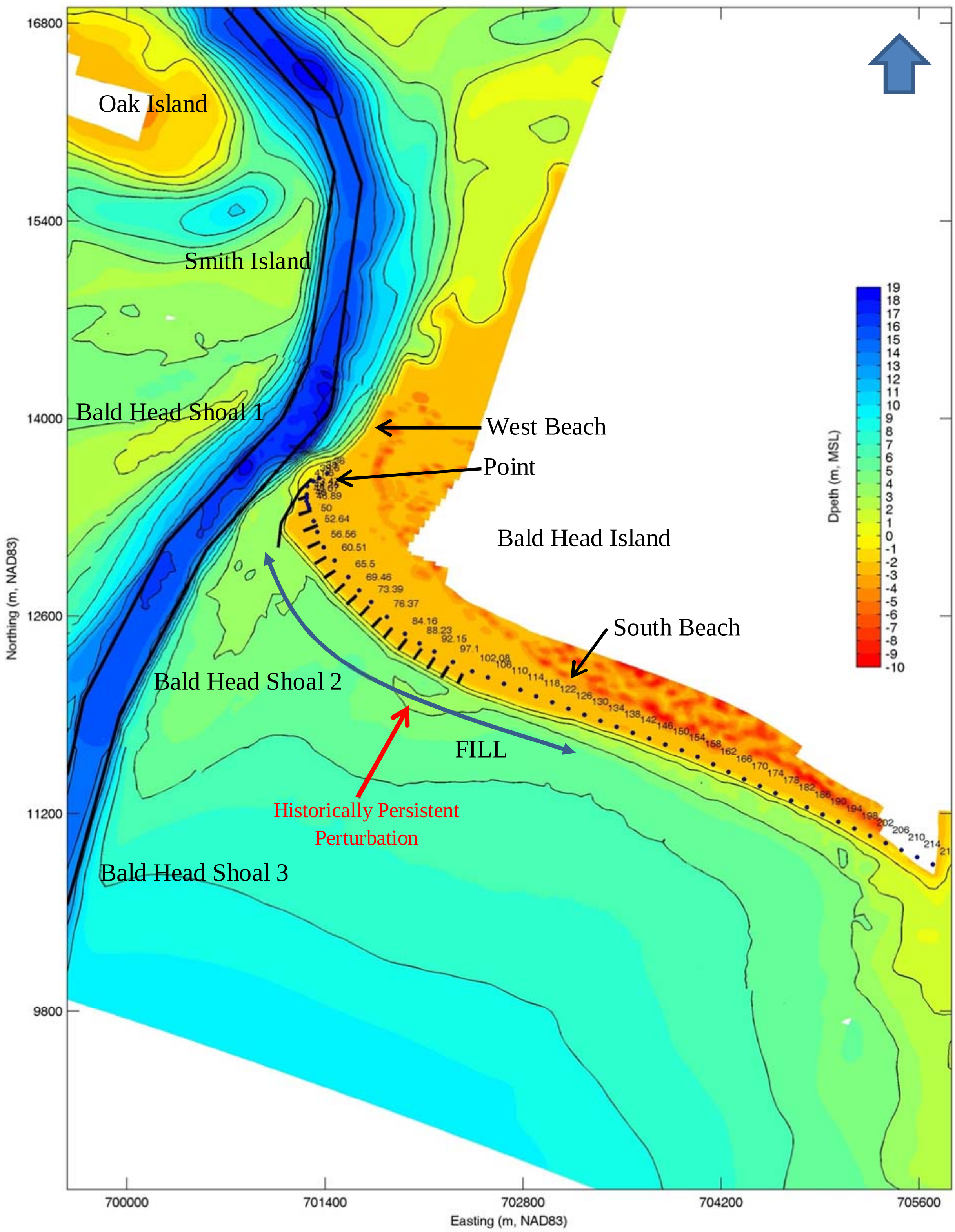

Figure 5: Nearshore bathymetry used for model input in the semi-permeable terminal groin simulation.

Model Results

Figures 6 and **7** present cumulative erosion and sedimentation patterns predicted for both without- and with-terminal groin simulations, respectively. Blue shading represents sedimentation (accretion) whereas red/yellow shading represents erosion (seabed deflation). The vectors on each plot describe mean total sediment transport over the four day simulation and are scaled identically for both with- and without-terminal groin conditions. **Figure 8** directly compares cumulative erosion and sedimentation magnitudes without mean transport vectors for increased readability. The beach fill only condition is shown on the top pane of the figure with the terminal groin result below.

Under both scenarios there is a storm-induced acceleration of transport, and subsequent erosion, immediately updrift (east) of the geotextile groin field. This is suggestive of an erosional "hot spot" which results in transport off the beach with deposition just offshore of the eastern tube groins. This pattern has been verified by field observations and is generally accurately predicted by the model. Further, the bathymetric record suggests a persistent sandy, subaqueous perturbation extending seaward at this location (demarked by a red arrow in **Figure 4**) which precedes the tube groin field and likely evidences previous erosion/accretion events like that described above.

Both simulations predict storm-related cross-shore equilibration of the south-facing (South Beach) shoreline. This is reflected by the blue shading immediately offshore of the intertidal beach. It is characteristic of sandbar formation commonly measured by survey along Bald Head Island. The western extent of sandbar formation differs between the two results, however. In the beach fill only condition, sediment is not deposited in the nearshore zone in the far western reaches of the tube groin field. The shoreline here is oriented nearly north-south and the model indicates accelerating erosion towards the inlet with no formation of a stabilizing bar. Eroded sediments are deposited into the inlet channel or large shoal off the Point and are ultimately lost from the island's littoral system.

With the terminal groin in place, however, there is relatively uniform sandbar formation throughout the project area along with predicted impoundment eastward of the structure. There is very little sediment movement predicted in the lee (west) of the terminal groin, excepting a localized area of erosion associated with a northward push of the existing Point sediments.

Both simulations predict storm-induced shoaling within the navigation channel, principally in the central portion of the Bald Head Shoal 1 cut. This shoal feature is much more spatially expansive under the fill only condition. The addition of the terminal groin appears to result in localized focusing of transport off the seaward end of the structure towards the channel. This process appears to greatly reduce the migration of the Point shoal towards the channel during the simulated storm event but results in some level of temporal scour at the seaward tip of the terminal groin, as expected.

In the beach fill only scenario with no terminal groin, the model indicates an acceleration of erosion throughout the western end of the tube groin field. The seabed erosion accelerates further north of the last groin. This suggests a strong possibility for failure of said groin, particularly considering the fact that the model describes conditions immediately after fill placement when the beach is technically at its least vulnerable. Increased erosion and recession along the Point is wholly consistent with observations from monitoring conducted over the last 10 years.

The simulations additionally suggest that the addition of the terminal groin results in an overall lower rate of sediment transport along the western South Beach shoreline of Bald Head Island. This is primarily associated with a reduction of the shoreline angle relative to the incident wave direction via prefilling the terminal groin. The apparent eastern extent of the “hot spot’’ at the east end of the groin field is potentially reduced by about 2,400 feet (+/-) under the with-terminal groin scenario (though some of this apparent benefit may be related to differences in the fill sectional densities between the two alternatives). The Point continues to migrate northward under both with- and without-terminal groin scenarios via erosion of its southern beach and subsequent deposition of this sediment further north, towards West beach (see **Figure 8**).

An accounting of sand lost within the respective areas of fill placement suggests that the addition of the terminal groin reduces net volume losses within the construction template by about 57 percent over the beach fill only condition (without terminal groin). More specifically, the construction template in the fill areas lost, in the net, about -97,400 cy without the terminal groin versus approximately -55,350 cy with the terminal groin. The fate of the higher losses from the beach fill only scenario is predominantly manifest as deposition north and west of the Point. Previous numerical analysis and physical monitoring observations suggest that this sand is effectively lost from the beaches’ littoral system to the navigation channel.

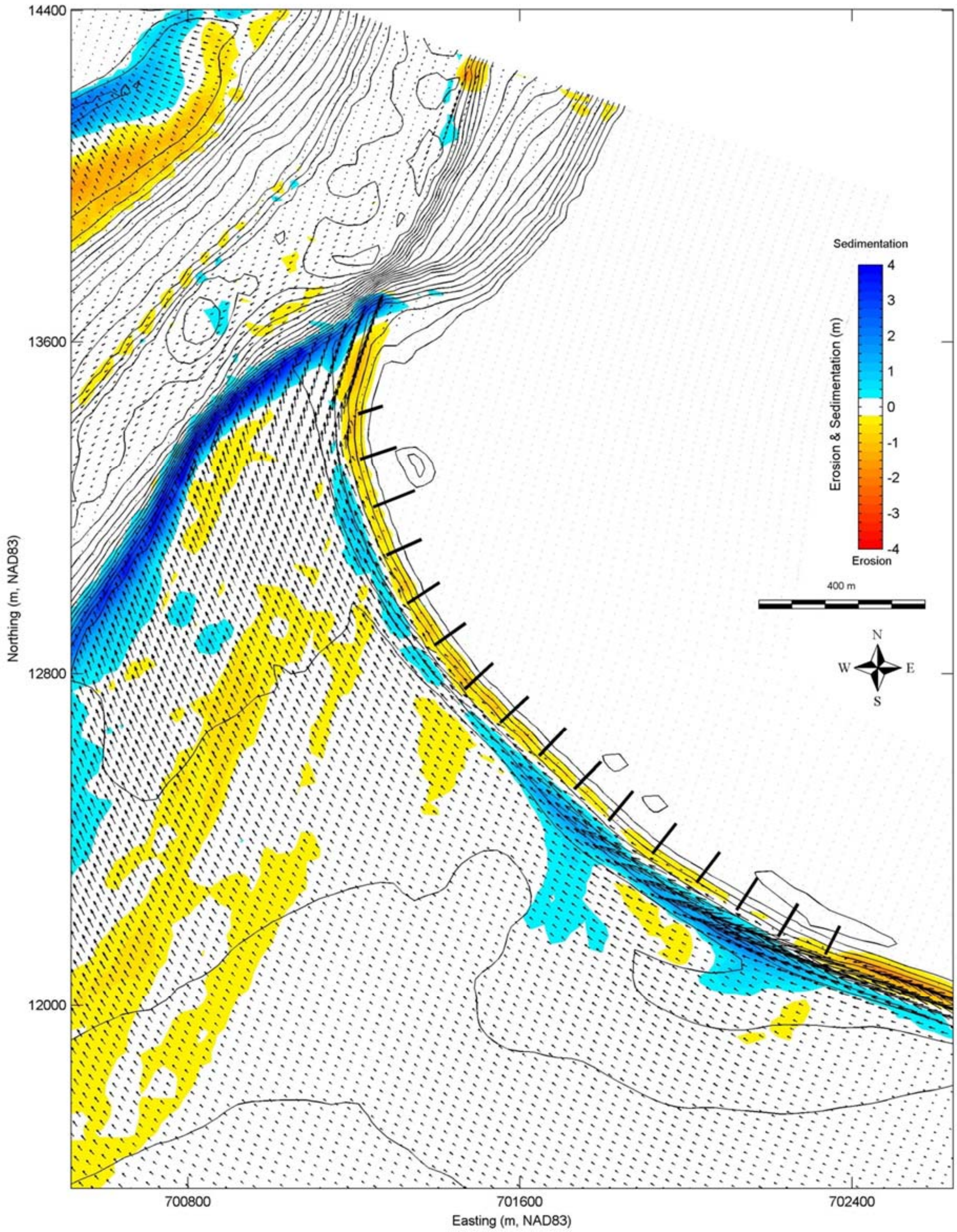

Figure 6: Cumulative sedimentation and erosion patterns and mean transport directions for the beach fill only condition following a Bertha-like tropical storm event.

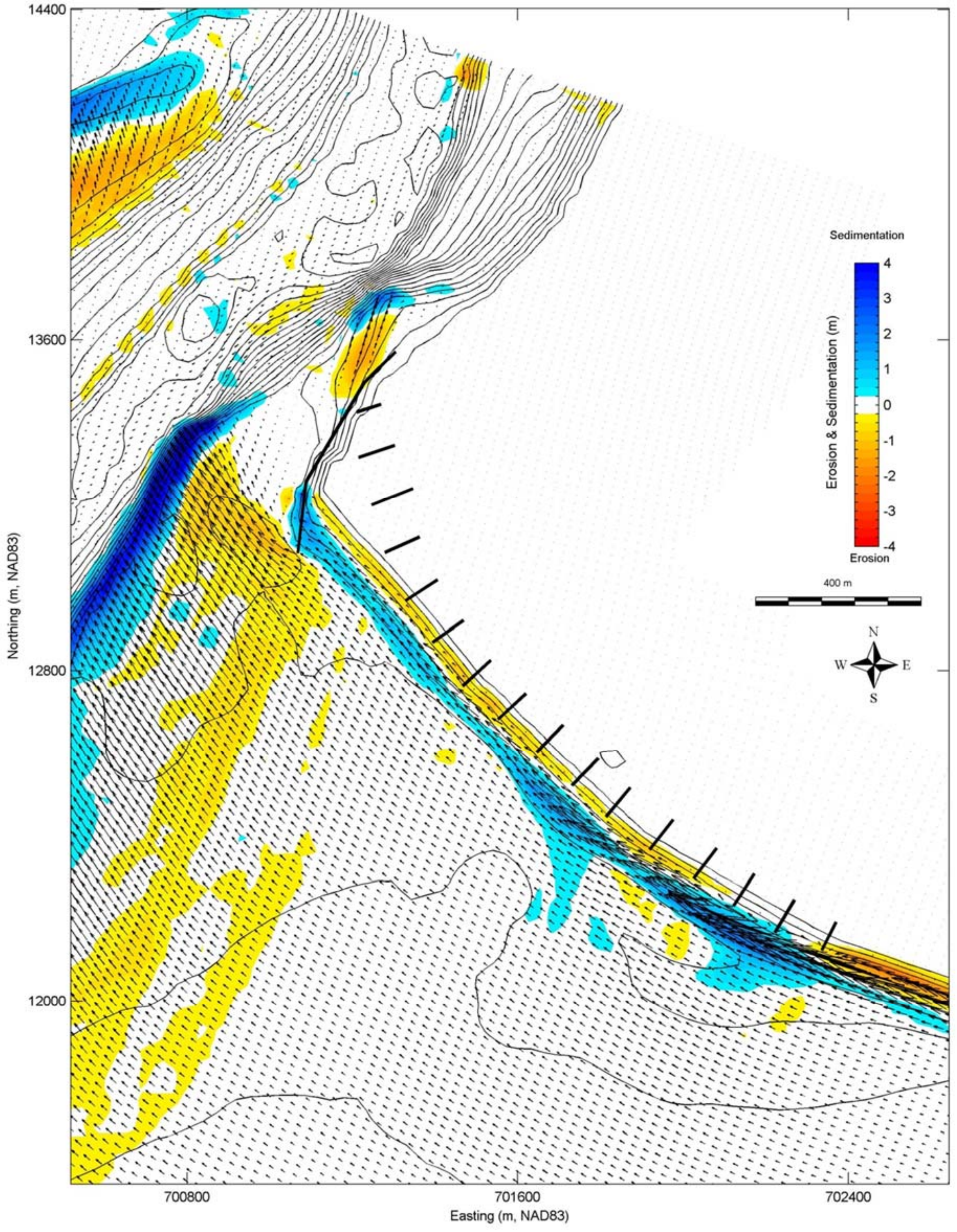

Figure 7: Predicted cumulative erosion and sedimentation patterns and mean transport directions for the with-terminal groin simulation following a Bertha-like tropical storm event.

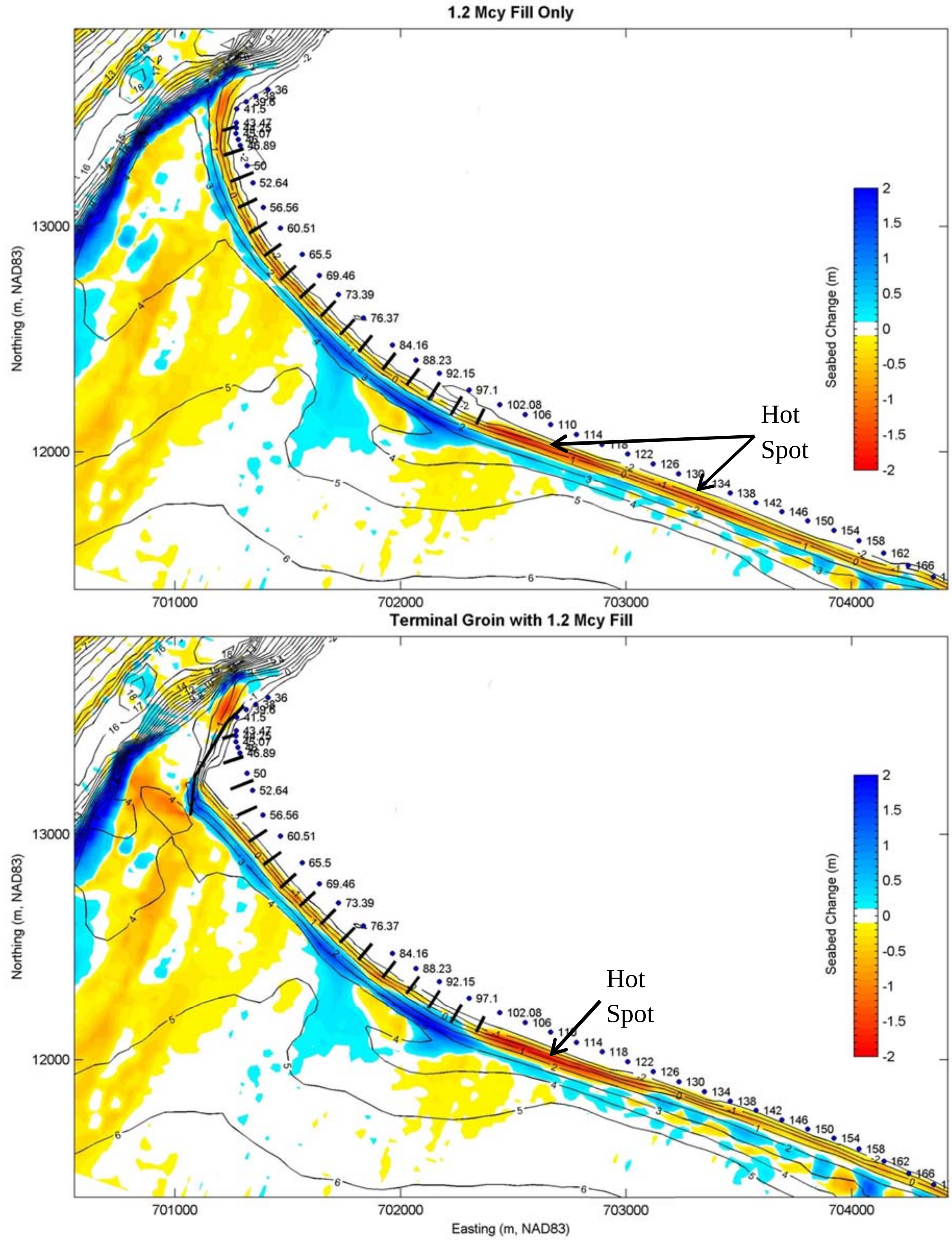

Figure 8: Predicted cumulative erosion and sedimentation patterns following a Bertha-like tropical storm event. Upper – without terminal groin; lower – with terminal groin.

The model results indicate an increase in sediment transport at the seaward tip of the terminal groin along with some scour at the tip of the jetty – as intuitively expected during the storm event. Longer term model simulations performed for the broader analysis of the terminal groin indicate a marked decrease in channel shoaling following construction of the terminal groin, particularly within the Bald Head Shoal 1 cut. The results of this storm simulation indicate that the apparent increase in transport towards the channel (at the structure's seaward end) is beneficially offset by a decrease in transport into the channel at the Point. The latter has been documented as an area of historically persistent shoaling.

Figure 9 plots the difference between the post-storm (final) bathymetries predicted under with and without terminal groin conditions. Yellow and red shading in the figure indicates areas where the seabed is lower due to the terminal groin and its corresponding beach fill, while blue shading represents a raised seabed attributable to the terminal groin and its fill. The dark blue fillet in the upland -- east of the terminal groin -- includes the beach fill sand that was initially added to pre-fill the terminal groin. Further seaward, the blue shading represents beneficial impoundment of material and/or deposition owing to reduced sediment transport rates along South Beach following terminal groin installation. The direct impoundment effect of the terminal groin appears to extend eastward to about Station 66+00 thence tapering off in magnitude until about Station 76+37. Much of the yellow shading in the lee (west and north) of the terminal groin represents reduced accretion and shoaling relative to the beach-fill only (no groin scenario. The model does suggest increased erosion along a small area at the landward end of the terminal groin, which is not unexpected. This is manifest as a modest increase in shoreline recession. The model results do not indicate any volume changes attributable to the terminal groin along West Beach, north of the Point.

As noted above, some of the differences in the project performance depicted in **Figure 9** reflect requisite differences in the initial beach fill geometry for the with- and without-terminal groin scenarios. **Figure 10** numerically removes these differences. That is, Figure 10 depicts the residual differences in the post-storm seabed elevations between the with- and without-terminal groin cases after accounting for (subtracting) the differences between the two cases' initial beach fill elevations. Again, yellow shading indicates areas where the post-storm seabed is lower due to the terminal groin – and blue shading indicates areas where the post-storm seabed is higher due to the terminal groin – relative to the beach fill only (no terminal groin) scenario. The direct effects of the terminal groin upon the beach and beach fill are evident in **Figure 10**. There is a net, substantial increase in sand volume retained along the west end of South Beach – within 750 meters updrift of the terminal groin. This is manifest as a reduction in erosion along the shoreline (blue band closest to land), cross-shore equilibration of sand placed and retained near the terminal groin (yellow/blue band in the middle of fillet), and some accumulation of sand at the terminal groin (blue band near the end of the terminal groin). At the same time, there is a reduction in sand volume that would otherwise accumulate along the Point and seabed nearest the channel (yellow/red areas westward and north of the terminal groin). Overall, reclaiming the shoreline under the terminal groin scenario results in a seaward shift of the beach equilibration process.

Figure 11 compares the approximate post-storm mean sea level (MSL) contours for with- and without-terminal groin conditions. Because Delft3D is a volume based model, the precise location of a tidally referenced shoreline should not be interpreted literally. That is, the Delft3D model predicts changes in seabed volumes, not shoreline locations. Comparatively speaking, the model results indicate the shoreline along South Beach remains much further seaward and more stable with the terminal groin relative to the beach fill only condition. This is attributable to the differences in placement of the initial nourishment and the ability of the terminal groin to quasi-stabilize the sand fill while impounding additional material.

The model suggests a localized difference in post-storm shoreline position at the Point, in the lee of the terminal groin. Specifically, a modest amount of additional Point shoreline recession is predicted under the with-terminal groin condition. This additional shoreline recession is not predicted to propagate north of the Point onto West Beach; that is, the predicted post-storm shorelines are identical along this area. The model suggests that post-storm net volume loss associated with the reduction in sediment supply to the Point under the leaky terminal groin scenario is about -5,100 cubic yards.

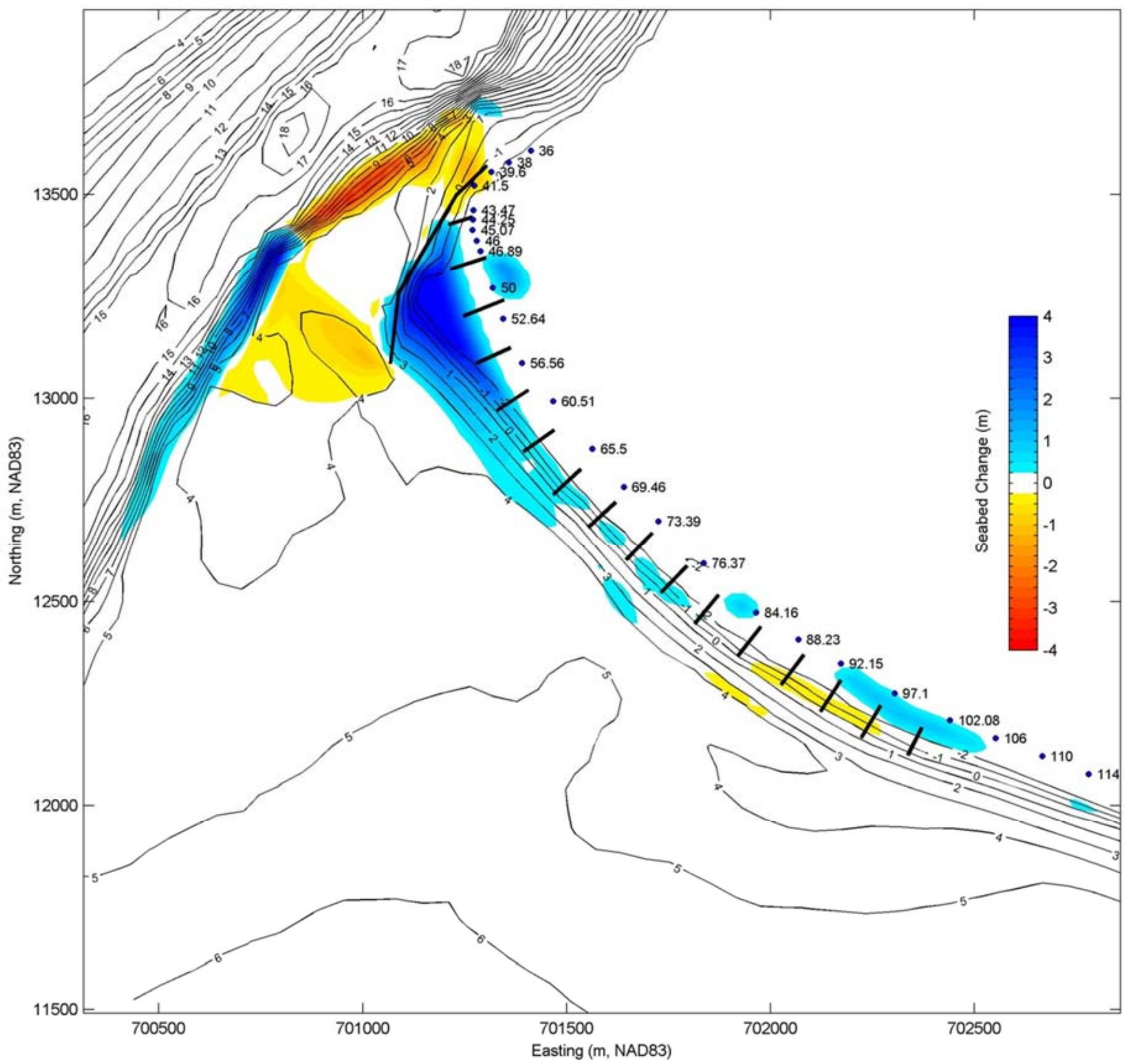

Figure 9: Predicted seabed differences attributable to the terminal groin following a Bertha-like storm event -- computed as the difference between post-storm (final) bathymetries for with- and without-terminal groin conditions. The effects of different initial beach fill geometries are included in the figure. Post-storm bathymetric contours are shown for the with-groin scenario and indicate that sediment was impounded by the terminal groin during the simulation.

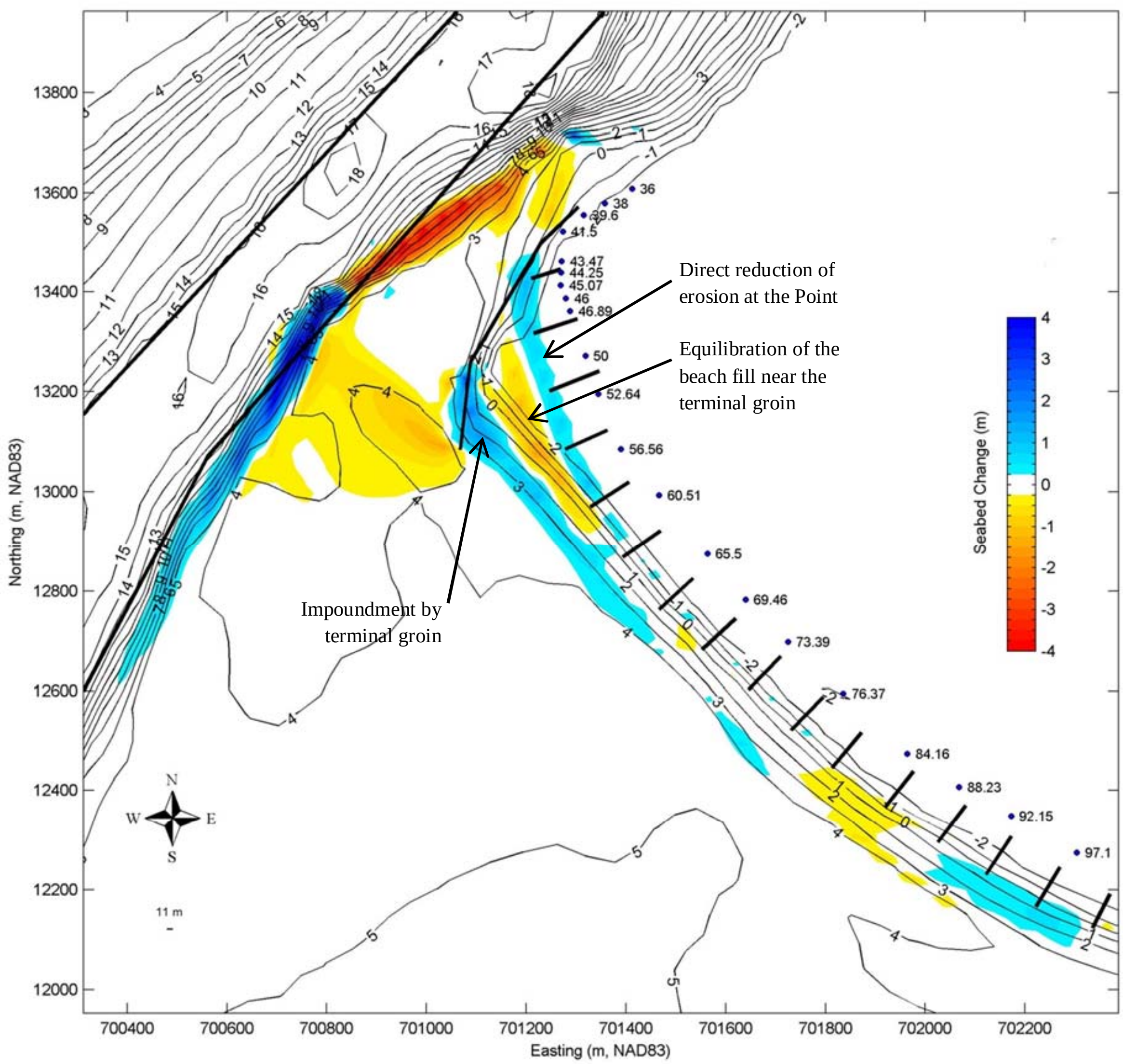

Figure 10: Predicted changes in the seabed attributable to the terminal groin following a Bertha-like storm event. Differences in the initial beach nourishment (between "with-groin" and "no terminal groin" scenarios) have been numerically removed from the results.

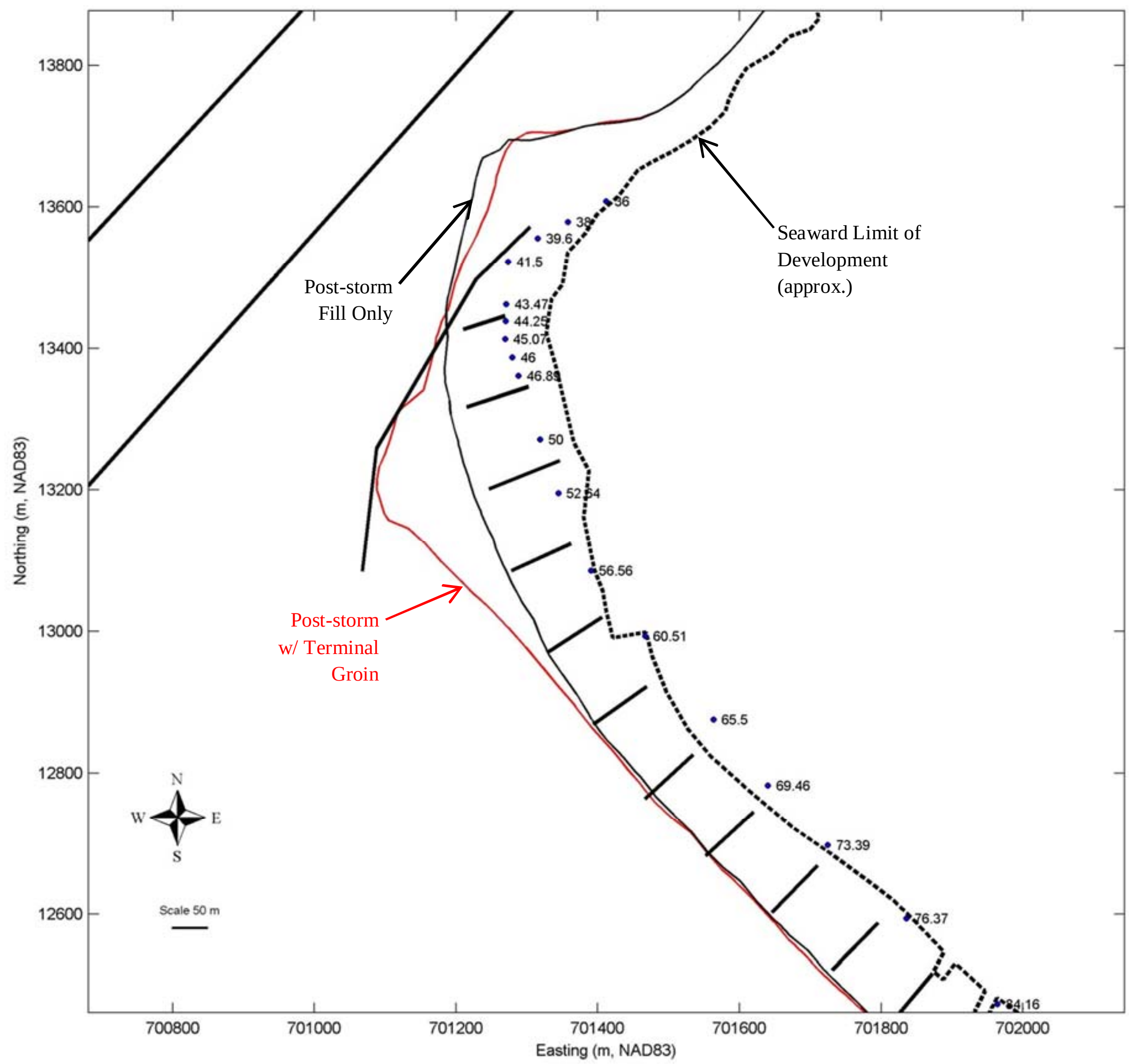

Figure 11: Approximate MSL shoreline response to a Bertha–like event for with- (red line) and without-terminal groin (black line) conditions.

Effect of Tube Groins

The scenarios described above were rerun to simulate the removal of all of the existing sand-filled tube groins along western Bald Head. The results were then directly compared to the "with tube groin" scenarios (described above) in order to determine the relative effect of the tube groins. All other parameters and initial conditions in the model remain the same. **Figure 12** compares the cumulative erosion and sedimentation patterns predicted under with and without tube groins for the beach fill only scenario (i.e., 1.2Mcy initial beach fill and no terminal structure). Vectors in the plots are identically scaled in both panes and represent mean total transport. An analysis of the volume change along Bald Head suggests that without the tube groins, the project is predicted to experience a net loss of approximately -105,300 cy within the limits of fill placement. In comparison, with the tube groins in place, the same fill limits were predicted to experience a net loss of about -97,400 cy, with the differences representing a direct benefit of the tube groins. Additional fill volume retained by the groin field is expectedly subtle in this simulation for two primary reasons:

- The initial bathymetry used as model input describes a post-nourishment condition which mostly buries the groin field thereby limiting the groins' exposure to incident waves, and
- The storm simulation is short in duration yielding less time for 'activated' structures to trap sediment once exposed by erosion.

That is, initiation of the storm simulation on an eroded beach (where the tube groins are initially exposed) would result in a proportionally larger effect (benefit) from the groins. Under this condition, the groins' ability to interrupt the alongshore transport of sediment would likely increase the downdrift erosion attributable to the groin field as well. The latter process is presently observable at the Point, immediately west of the tube groin field.

Figure 13 plots the difference between the post-storm (final) bathymetries predicted under with and without tube groins for the nourishment only condition. Yellow and red shading in the figure indicates areas where the seabed is lower due to the tube groins, while blue shading represents a raised seabed attributable to the tube groins. The results suggest a minimal lowering of seabed elevation at the Point and a modest decrease in material shoaling the channel due to the presence of the tube groins. Near the eastern limit of the groin field, however, the model predicts more significant differences in seabed elevation attributable to the tube groins. The model results suggest that the groin field physically interrupts the predicted nearshore erosional gradient extending east of about Station 92+15 (a historically erosional area), see **Figure 12**. The result is a predicted elevation increase across the easternmost three tube groins; i.e., retention of westerly-driven transport. The apparent seabed deflation immediately adjacent (west of) Station 92+15 due to the tube groins represents a decrease in sedimentation in the area where eroded sediments are deposited in the without tube groin model (Sta. 76+37 to 92+15).

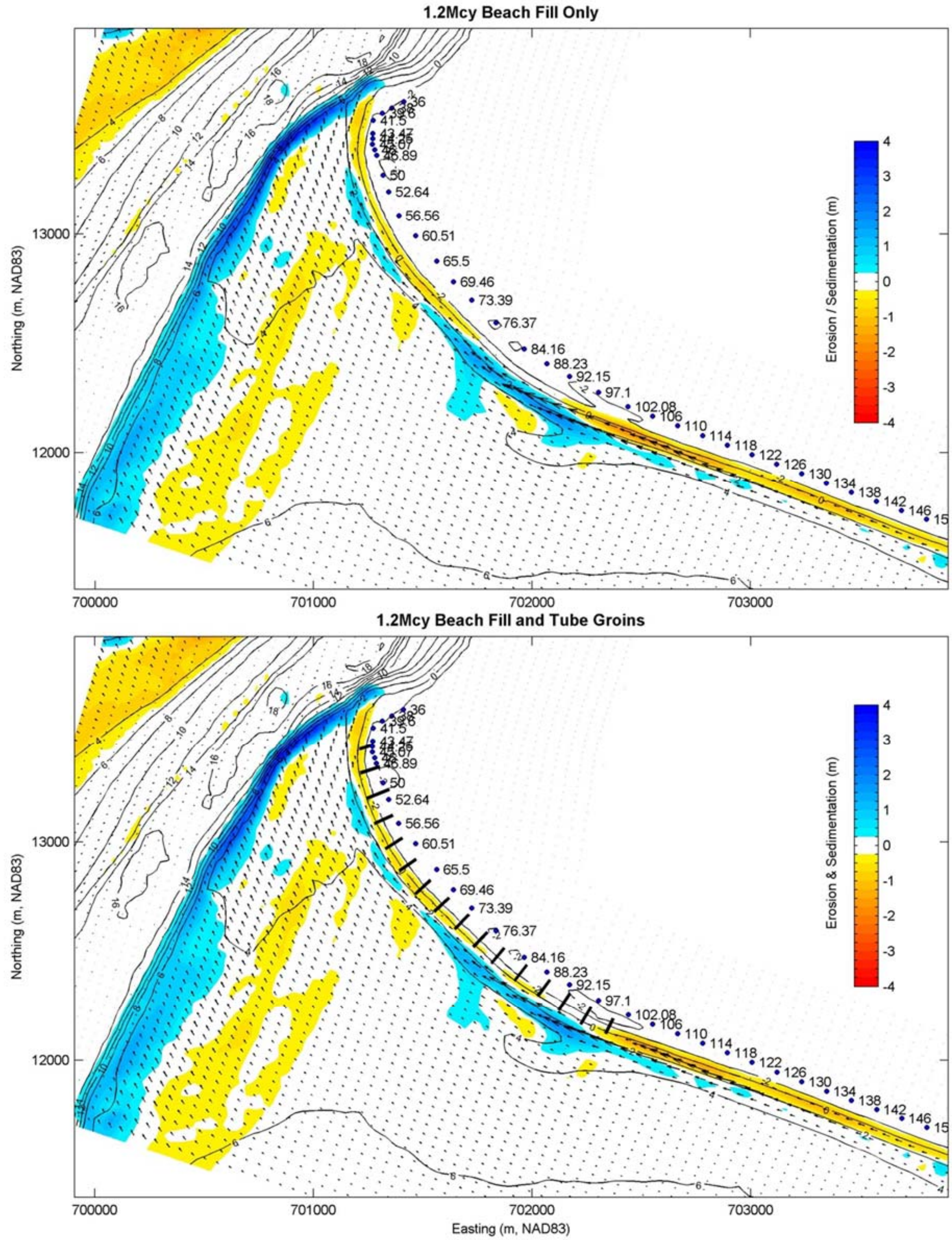

Figure 12: Comparison of predicted erosion/sedimentation patterns considering with and without the tube groins under the fill only scenario.

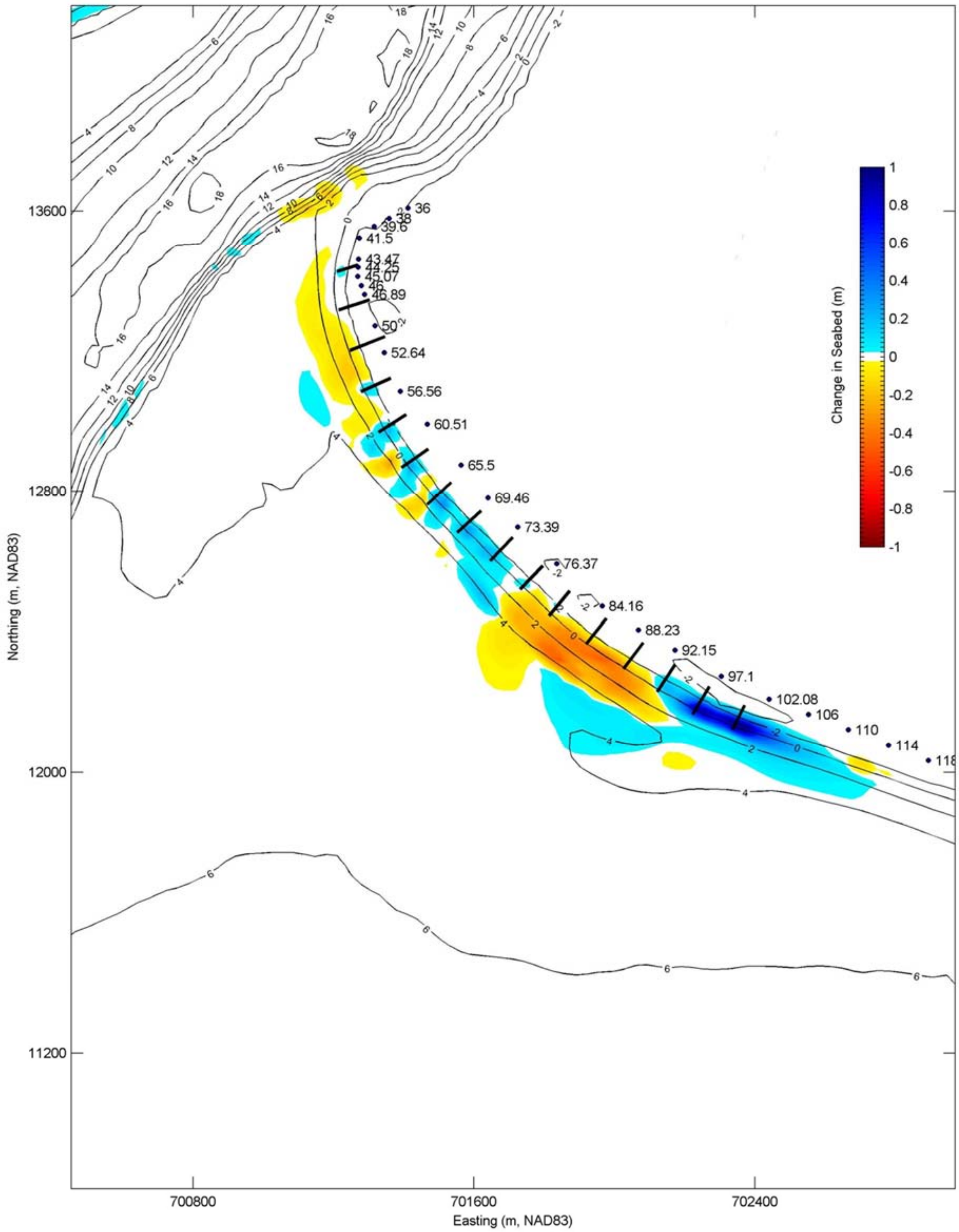

Figure 13: Predicted seabed differences attributable to the tube groins following a Bertha-like storm event following a 1.2Mcy fill -- computed as the difference between post-storm (final) bathymetries for with- and without-tube groin conditions. Yellow and red shading in the figure indicates areas where the seabed is lower due to the tube groins, while blue shading represents a raised seabed attributable to the tube groins.

Similar model simulations investigating the effects of inclusion and removal of the tube groins were completed for the with-terminal groin condition. **Figure 14** compares predicted erosion and sedimentation patterns under terminal groin with beach fill scenario both with and without the sand-filled tube groins. In the plots, yellow/red shading represents areas of erosion while blue shading represents sediment deposition resulting from the four-day storm. Overall, there are only minor differences in the predicted sediment transport pathways when the groins are not considered. Specifically, the presence of the tube groins appears to slightly slow sediment transport along western Bald Head Island. This is observable as moderate differences in color shading, particularly lesser shades of red/yellow east of the groin field and extending westward off the seaward end of the terminal groin; i.e., there is less predicted erosion/transport in these areas. Like the beach fill only example, these effects are expected to be stronger if the initial conditions did not represent a post-project beach in which the tube groins were mostly buried. The results suggest a net loss of approximately -58,450 cy from within the beach fill template without the tube groins. This represents a minimal increase in losses relative to the with tube groin condition where a net loss of about -55,350 cy was predicted within the same limits. Like the without terminal groin comparisons, the predicted decrease in sand losses with the tube groins in place is indicative of their net benefit, particularly considering they are not largely ‘active’ in this brief storm scenario.

Figure 15 plots the difference between the post-storm (final) bathymetries predicted with and without tube groins for the terminal groin and beach nourishment condition. Yellow and red shading in the figure indicates areas where the seabed is lower due to the tube groins, while blue shading represents a raised seabed attributable to the tube groins. Model results throughout the central and eastern portions of the groin field are similar to those discussed previously for the without terminal groin configuration. There are no significant changes in the post-storm seabed at the Point or on West Beach between the with- and without-tube groin scenarios.

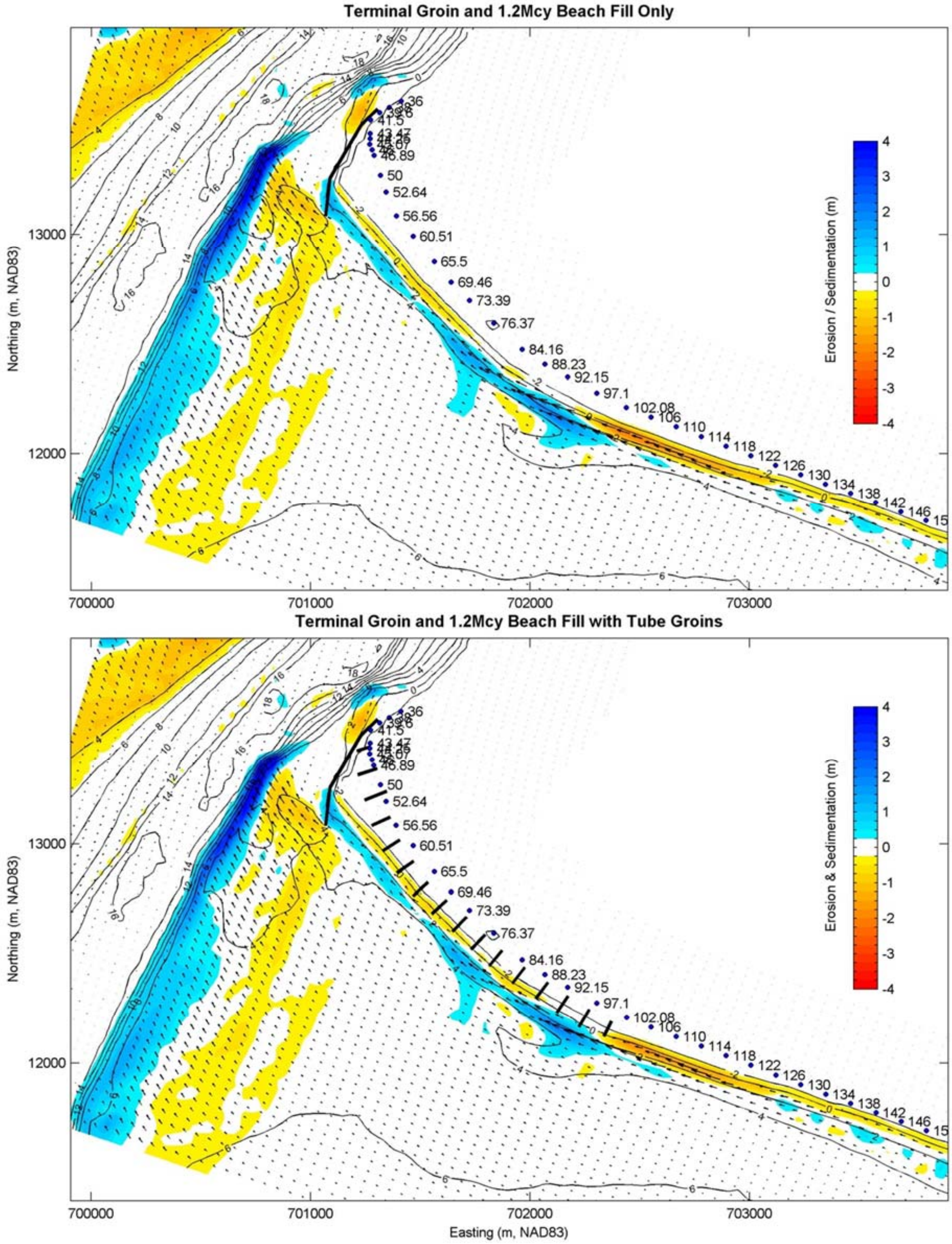

Figure 14: Comparison of predicted erosion/sedimentation patterns considering with and without the tube groins under the terminal groin with fill scenario.

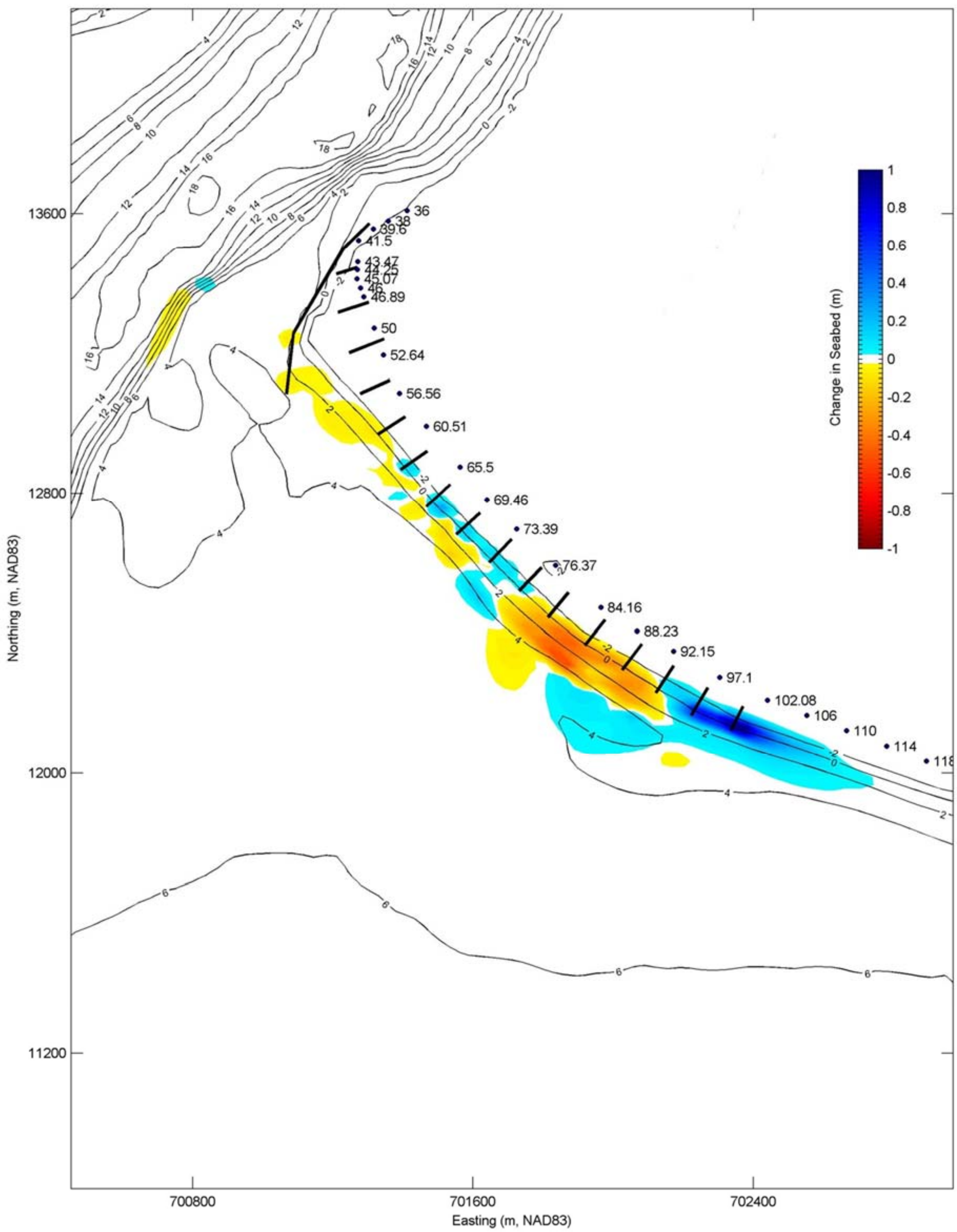

Figure 15: Predicted seabed differences attributable to the tube groins following a Bertha-like storm event following a 1.2Mcy fill with terminal groin -- computed as the difference between post-storm (final) bathymetries for with- and without-tube groin conditions. Yellow and red shading in the figure indicates areas where the seabed is lower due to the tube groins, while blue shading represents a raised seabed attributable to the tube groins.

In summary, the Delft3D model was used to simulate offshore storm conditions emanating from an event similar to the 1996 passage of Hurricane Bertha. The model results indicate that the terminal groin is capable of significantly reducing volume losses on South Beach while not meaningfully impacting the downdrift and West Beach shorelines, relative to a beach fill only condition. There is an indication of increased storm-related (seabed scour) erosion at the seaward tip of the terminal groin. Such scour is to be expected and will require attention in the detailed design phase to ensure long-term stability of the structure, typically through the use of a marine mattress foundation. Overall, the model predictions are generally consistent with those for typical annual conditions. The performance of the terminal groin and its beneficial effects upon both South Beach and neutral effects upon West Beach, relative to the without-terminal groin condition, are similar among both the severe storm and typical conditions. The presence of the sand-filled tube groins is predicted to have an overall positive (albeit limited) effect on the Island's ability to retain placed sediment when paired with the terminal groin. The limited nature of the tube groins' benefit in this simulation is principally due to the fact that the model simulates short-term morphological changes on a post-construction beach condition whereby the tube groins are largely buried in fill and do not significantly act upon the incident wave climate.

APPENDIX W

CUMULATIVE EFFECTS ANALYSIS

Village of Bald Head Island Shoreline Protection Project
Cumulative Effects Analysis

Table of Contents

1.0 INTRODUCTION

The purpose of the cumulative effects analysis is to ensure that regulatory agencies consider the full range of consequences (i.e. cumulative effects) on specific resources, ecosystems, and human communities as a result of private, state, or federal projects reviewed under the provisions of the National Environmental Policy Act (NEPA). The Council on Environmental Quality's (CEQ) regulations for implementing NEPA defines cumulative effects as;

> "*the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-federal) or person undertakes such actions (40 CFR §1508.7)*".

The cumulative effects analysis is composed of three principle components with corresponding steps as outlined in Table 1.

2.0 SCOPING

<u>2.1 Cumulative Effects Issues</u>

Depending upon specific project location and design, beach disposal/nourishment projects and hardened structures have the potential to beneficially or adversely affect the following resources, ecosystems, and communities:

(1) shorebirds and waterbirds (including the federally-protected piping plover and its critical habitat);
(2) seabeach amaranth (Amaranthus pumilus);
(3) sea turtles;
(4) intertidal and subtidal soft bottom (including benthic assemblages)
(5) water column (including federally-managed species)
(6) water quality; and
(7) human communities.

Table 1. Steps in the Cumulative Effects Analysis (CEA) (as adapted from CEQ 1997)

Environmental Impact Assessment Components	CEA Steps
I. Scoping	a. Identify the significant cumulative effects issues associated with the proposed action and define the assessment goals b. Establish the geographic scope for the analysis c. Establish the time frame for the analysis d. Identify other actions affecting the resources, ecosystems, and human communities of concern
II. Describing the Affected Environment	a. Characterize the resources, ecosystems, and human communities identified in scoping in terms of their response to change and capacity to withstand stresses b. Characterize the stresses affecting these resources, ecosystems, and human communities and their relation to regulatory thresholds c. Define a baseline condition for the resources, ecosystems, and human communities
III. Determining the Environmental Consequences	a. Identify the important cause-and-effect relationships between human activities and resources, ecosystems, and human communities b. Determine the magnitude and significance of the cumulative effects c. Modify or add alternatives to avoid, minimize, or mitigate significant cumulative effects d. Monitor the cumulative effects of the selected alternative and adapt management

These resources may be affected via the interactive or additive effects of a single project or of multiple projects occurring within an identified geographic and temporal scope. Examples of cumulative effects include time crowding (i.e. frequent and repetitive effects), space crowding (high abundance of stressors in a given spatial extent), or compounding effects. Each of the resources identified above will have different exposures and tolerance levels for actions associated with the type of project proposed.

Cumulative effects may arise from various stressors or impacts including: loss or disturbance to habitat; disturbance from mechanical operations of the dredge equipment and heavy machinery; indirect effects associated with short-term elevation of turbidity levels; expansion of supratidal beachfront; and structural impediments resulting from the installation of a terminal groin. These effects (and others) are evaluated in Section 5.0 of the EIS.

2.2 Geographic and Temporal Scope

The cumulative effects analysis takes into consideration coincident effects (adverse or beneficial) of the proposed project as well as all related actions occurring within specified spatial and temporal boundaries. The project impact zone is the area potentially affected by the proposed action. Environmental resources of the river mouth, nearshore subtidal zone, and beachfront area may be affected by the VBHI Shoreline Protection Project. For the purpose of this cumulative impact assessment, the identified geographic region evaluated encompasses all beachfront and nearshore coastal areas of Onslow Bay and Long Bay. This constitutes 141 miles of shoreline.

This analysis considers known past, present, and reasonably foreseeable future (RFF) dredge and disposal/nourishment projects within the project vicinity over a thirty-five year period (1980 to 2015). The time period was selected to include the increase in the number of federal disposal projects in the early 1980s and was extended to 2015 because this date represents a reasonably foreseeable future. The majority of remaining beaches that could reasonably be expected to have federal projects implemented is included in this analysis.

3.0 ACTIONS AFFECTING RESOURCES

Cumulative effects analysis not only considers the impacts of past, present and RFF actions on the identified resources, but also the impacts from unrelated actions occurring in the vicinity of the project area including regional beach nourishment/beach disposal projects, hardened structures along the North Carolina coast, storms and sea-level rise.

Table 2 lists similar dredge and beach nourishment/disposal projects occurring within the geographic scope of this analysis and approximate distance from the proposed project. These projects are applicable for this evaluation given the type of activity and the potential for disturbance to identified resources. The cumulative direct and/or indirect effects of these projects have been evaluated in the context of each resource type. The compilation of projects represents those recent, current, and RFF projects that are either federally-funded or are sponsored via local initiatives.

3.1 Dredging & Beach Nourishment/Disposal

For the purpose of this assessment, intertidal and shallow subtidal shoal habitats have been mapped from available GIS data of tidal inlets and interpretation of aerial photography. Based upon this mapping effort, there are approximately 11,500 total acres of flood and ebb tide delta shoals (intertidal and shallow subtidal bottom habitat) extending from Barden Inlet (at Cape Lookout) to Little River Inlet. Expansive, undisturbed shoal habitat (as part of Frying Pan Shoals) also exists east of the project area. Frying Pan Shoals extend southeastward from Cape Fear approximately 20 miles into the Atlantic Ocean. Most maintenance dredging and navigation projects affect a relatively small percentage of the total intertidal and subtidal habitat occurring within a coastal inlet. Cumulatively, twelve (12) of the fifteen (15) active inlets within the assessment area have been recently, or are currently authorized to be, dredged for navigational improvements. Of these inlet areas, it is estimated that there are over

Table 2. Summary of Recent, Current, and RFF Projects (Onslow Bay and Long Bay) and Proximity to Bald Head Island Project Area

Project	Source of Sand for Nourishment	Beachfront Nourished	Approximate Volume of Material and/or Length of Shoreline	Approximate Dates of Occurrence	Distance to Bald Head Island Project Area
Section 933 Project (Outer Harbor)	Beaufort Inlet Outer Harbor	Indian Beach, Salter Path, and portions of Pine Knoll Shores	7 miles	Feb/March 2004 Jan-April 2007	75 miles north
Emerald Isle FEMA Project	USACE ODMDS – Morehead City Port Shipping Channel	Emerald Isle	3.8 miles	Mar-04	75 miles north
Emerald Isle Post-Isabel, Ophelia, and Irene Projects (FEMA)	ODMDS	Eastern Emerald Isle, Indian Beach, Pine Knoll Shores	156,000 cy; 1.23 Mcy; 992,000 cy	2004, 2007, 2012	75 miles north
Bogue Banks FEMA Project	USACE ODMDS – Morehead City Port Shipping Channel	Emerald Isle (2 segments), Indian Beach, Salter Path, Pine Knoll Shores	13 miles (cumulatively)	Jan/Feb 2007	75 miles north
USACE Dredge Disposal to Eastern Bogue Banks (Federal)	Beaufort Inlet Inner Harbor and Brandt Island Pumpout	Fort Macon and Atlantic Beach	Varies (180,000 cy to 4.67 Mcy)	1978, 1986, 1994, 2002, 2005, 2007	75 miles north
Bogue Banks Shore Protection Project (Federal)	Offshore Borrow Sites	Communities of Bogue Banks	24 miles	2009-2011	75 miles north
Bogue Banks Restoration Project – Phase I – PKS/IB Joint Restoration	Offshore Borrow Areas	Pine Knoll Shores and Indian Beach	7.4 miles	Winter 2001/2002	75 miles north
Bogue Banks Restoration Project – Phase II – Eastern EI	Offshore Borrow Areas	Indian Beach and Emerald Isle	5.9 miles	Winter 2002/2003	75 miles north
Bogue Banks Restoration Project – Phase III– Bogue Inlet Channel Realignment Project	Bogue Inlet Channel	Western Emerald Isle	4.5 miles	March-05	72 miles north
AIWW Section 1 – Tangent B (Federal)	AIWW shoaling directly north of Pine Knoll Shores	Eastern limit of Pine Knoll Shores	2,000 lf	Jan-March 2008	75 miles north
Inlet Crossing at Bogue Inlet (Federal)	Bogue Inlet – ocean bar to AIWW via connecting channel	Western Emerald Isle	0.66 miles (38,000 cy per event)	Summer 2006 (anticipated frequency 1 to 3 years)	70 miles north
North Topsail Beach Nourishment (Federal)	New River Inlet Dredging	Surf City and North Topsail	11.1 miles	Maintenance dredging every four years	52 miles north
North Topsail Dune Restoration (Town of North Topsail Beach)	Upland borrow source near Town of Wallace, NC	North Topsail Beach	47,300 cy	2006	52 miles north
North Topsail Beach Shoreline Protection Project	New River Inlet Realignment and Offshore Borrow Area	Topsail Island	5 phases totaling 11 miles	Phase 1-5 occurring every other year 2009-2017 (subject to regulatory approval)	52 miles north
Topsail Island Beach Nourishment (Federal)	New Topsail Inlet	Topsail Island	Varies	Maintenance dredging	40 miles north
Figure Eight Island	Banks Channel and Nixon Channel	North & South Sections	2.5 miles	Winter 2005/2006	35 miles north
Figure Eight Island - Terminal Groin and Beach Nourishment		Figure Eight Island		TBD	35 miles north
Mason Inlet Relocation Project	Mason Inlet (new channel) and Mason Creek	North end of Wrightsville Beach and south end of Figure Eight Island	1.9 miles	Jan-March 2002 (smaller maintenance events of inlet throat, sedimentation basin, and AIWW on as needed basis)	30 miles north
Wrightsville Beach (Federal)	Masonboro Inlet	Wrightsville Beach	2.84 miles	4-year cycle: Winter 2004/2005 Proposed 2013/2014	25 miles north
Carolina Beach (Federal)	Carolina Beach Inlet	Carolina Beach	2.0 miles	3-year cycle: Dec 2006 – Feb 2007; winter 2012/2013	15 miles north
Kure Beach (Federal)	Wilmington Harbor CDF Area 4	Kure Beach	2.0 miles	3-year cycle: Dec 2006 - Feb 2007; February 2013	10 miles north
Wilmington Harbor Deepening (933 Project) Sand Management Plan	Wilmington Harbor Ocean Entrance Channels	Bald Head Island, Caswell Beach, Oak Island	Varies (2 to 4 miles)	6-year cycle: Winter 2001/2002; 2005/2007; 2012/2013	0 miles to 10 miles west
Brunswick County Beaches Project	Nearshore and Offshore Borrow Areas	Caswell Beach, Yaupon Beach, Long Beach, Holden Beach	30 miles +/-	Notice of Intent to Prepare EIS issued May 2012	0 miles to 20 miles west
Oak Island Section 1135 - Sea Turtle Haibtat Restoration	Upland Borrow Area - Yellow Banks	Oak Island	2 miles	Winter/Spring 2001	5 to 10 miles west
Bald Head Island Creek Project (non-federal)	Bald Head Creek	South Beach	1,800 lf	Winter 2006	0 miles
Bald Head Island Beach Nourishment	Jay Bird Shoals	West and South Beach	4 miles	Winter 2009/2010	0 miles
Bald Head Island Creek Project (non-federal)	Bald Head Creek	Western South Beach	140,000 cy	March 2012	0 miles
Bald Head Island Shoreline Protection Project	Wilmington Harbor Ocean Entrance Channels	West and South Beach	0.25 Mcy	TBD; anticipated winter 2015	0 miles
Holden Beach (933 Project)	Wilmington Harbor Ocean Entrance Channels	Holden Beach	1.9 miles	March-April 2002	16 miles west
Holden Beach East & West (sponsored by Town)	Upland truck hauling	Extension of 933 Project	160,000 cy	March-April 2002	16 miles west
Holden Beach East & West	Upland truck hauling	Extension of 933 Project	200,000 cy	December-03	16 miles west
Holden Beach - Terminal Groin and Beach Nourishment	TBD	Holden Beach within vicinity of Lockwood Folly Inlet	TBD	TBD	16 miles west
Holden Beach – AIWW 400-ft Widener (GP 2878)	AIWW at Lockwood Folly Inlet Crossing	East end of Holden Beach	100,000 cy	Winter 2014	16 miles west
Lockwood Folly Inlet Crossing (Federal)	Inlet crossing of AIWW	Long Beach and East end of Holden Beach	80,000 to 165,000 cy each event	November 2001 - April 2006	10 to 20 miles west
Shallotte Inlet (Federal)	Inlet crossing of AIWW	Ocean Isle Beach	5.3 miles in '01 48,000 cy in 06	Winter 2001, 2006, 2013/14	26 miles west
Ocean Isle - Terminal Groin and Beach Nourishment	TBD	OIB within vicinity of Shallotte Inlet	TBD	TBD	26 miles west

9,000 acres of ebb tide and flood tide shoals. Most inlet navigational projects affect a relatively small percentage of the total shoal habitat associated with an inlet. Considering that these areas are actively changing due to natural physical processes, the alteration from dredging is considered a temporal disturbance.

For the VBHI Shoreline Protection Project, it is the applicant's proposal that sand for the required groin fillet would be principally derived from the next maintenance event of the Wilmington Harbor federal navigation project. Additional sand source sites identified by the applicant to augment the fillet or for maintenance and future Village-sponsored nourishment are: (1) Jay Bird Shoals; (2) reaches of the Wilmington Harbor Channel demonstrated to contain beach-compatible material (i.e. Baldhead Shoal Channel 1, Baldhead Shoal Channel 2, and Smith Island Channel); (3) Bald Head Creek Shoal; and (4) Frying Pan Shoals.

Within the geographic scope of this analysis (141 miles of shoreline), there are ten (10) authorized and/or active inlet projects (federal and non-federal actions) and eleven (11) nourishment projects affecting approximately 50 miles of beachfront. Thus recent, current, and/or authorized beach nourishment projects affect approximately 35% of the total length of shoreline of Onslow Bay and Long Bay. On a broader geographic scale, North Carolina has 320 miles of shoreline. According to a recent cumulative impact assessment prepared by the USACE for the Bogue Banks Coastal Storm Damage Reduction Project (USACE 2013), existing or proposed federal projects total approximately 122 miles of beach or 38% of North Carolina beaches. Considering all existing and proposed federal and non-federal nourishment projects, and taking into consideration that some of the project footprints overlap, approximately 112 miles or 35% of the North Carolina coast could have beach nourishment or sand disposal projects by 2015.

The proposed terminal groin and fillet work area for the VBHI Shoreline Protection Project would be limited to the westernmost 2,500 lf of South Beach (an area of shoreline subject to severe and chronic erosion). This length of shoreline constitutes less than 12% of the total West Beach and South Beach shoreline. Cumulatively, over the life of the project (assuming implementation of nourishment for mitigative or maintenance purposes), up to 13,000 total linear feet of beachfront may be affected (South Beach and West Beach, combined). This represents approximately 0.8% of the 320 miles of beachfront in North Carolina and 1.7% of beachfront in the assessment area of Long Bay and Onslow Bay. There are approximately 8.5 miles of remaining undisturbed beach along eastern South Beach and East Beach of Bald Head Island. Therefore, the potential extent of nourished beach for this project represents approximately 22% of the beachfront on Bald Head Island.

Frequency of nourishment events for beach projects can vary dramatically pending a number of project-specific factors including funding, need (i.e. sediment losses), and the identified source of beach-compatible sand. Some level of maintenance is typically authorized over the life-span of a permit (often 30-year or 50-year periods). The proposed schedule for nourishment and/or maintenance events is commonly affected due to physical responses in the project area and funding issues. In addition, nourishment projects of a single beachfront may be the result of multiple initiatives through federal, municipal, or private entities. Therefore, determining specific interval frequencies is difficult. However, a review of available documents indicates that nourishment projects may range from one-time events to more frequent intervals of 2 to 4 years. In general, the frequency of occurrence has been such that biological recovery is likely over most stretches of shoreline. Cumulative effects (positive or negative) are discussed for each identified resource in Section 6.0 of this document.

3.1.1 Dredging and Disposal Actions associated with the Wilmington Harbor Project (Past, Present, and RFF)

In addition to spatial considerations, repeating actions may present additive effects of disturbance to affected resources. The Cape Fear River ocean bar channel has been maintained by the federal government for over 100 years. Over this time period, the width and depth of the navigational channel has been increased several times to accommodate larger vessels. By 1945, the federal channel had been deepened to 32 feet. In 1964, the US Army Corps of Engineers (USACE) initiated deepening of the main harbor channel to 38 feet to accommodate 34-foot-draft (26,000 deadweight ton) vessels to call at any tide. This project was completed in 1970. Since the 1970s, vessel sizes increased significantly. By the 1990s, approximately 50% of the ocean-going ships exceeded the 26,000 deadweight ton (DWT) design vessel. As such, these vessels could enter or leave Wilmington Harbor only at high tide or only when light-loaded (USACE 1996). The resultant increased shipping costs prompted the more recent Wilmington Harbor Deepening Project in 2001. The channel modifications included realignment of the ocean bar channel (30-degree southern shift); deepening of the ocean bar channel and entrance channel to 44 feet; and deepening of the 24.3-mile river reach (from Battery Island Channel to the Cape Fear Memorial Bridge) to 42 feet (USACE 2008).

Prior to channel entrance modifications in 2001, maintenance of the entrance channel required annual removal of between 500,000 and 1,000,000 cubic yards of material. Much of the material removed was placed in the Wilmington Ocean Dredge Material Disposal Site (ODMDS) located three (3) nautical miles offshore. The ODMDS was the primary disposal site for material dredged from three principal zones of the river: (1) ocean bar channels; (2) the navigation channel to Wilmington (excluding the ocean bar and reaches above the Lower Brunswick channel); and (3) Military Ocean Terminal at Sunny Point (MOTSU). Between 1976 and 2004, approximately 49 Mcy of material were placed in the Wilmington Harbor ODMDS. In 2000, the Sand Management Plan (SMP) for disposal of material derived from maintenance of the ocean entrance channels and other portions of the harbor was implemented. One of the goals of the SMP is to return beach-quality dredged material to the active littoral system when feasible. A new offshore ODMDS is still utilized for placement of non-compatible material high in silt and clay content or material consisting of woody debris. The Wilmington Harbor Dredge Material Management Plan (DMMP) provides more specific information related to dredge quantities and subsequent placement within the former and current ODMDS sites.

The Wilmington Harbor project, historically, did not provide for the placement of littoral sands on barrier island beachfronts due in large part to dredging technology and the lack of understanding for coastal processes (particularly with respect to the sand sharing system associated with tidal inlets and adjacent beaches) (USACE 2000). Over time, it has become well recognized that littoral material should be conserved (when practicable and economically feasible) via deposition directly on adjacent beaches or appropriate nearshore placement areas. As a result, the Wilmington Harbor SMP was developed and implemented as part of the larger Wilmington Harbor deepening project in 2000. Subsequent to the development of this plan, approximately 4.8 Mcy of ocean-derived sediments were dredged as part of the new alignment of the ocean entrance channel (USACE 2004). The beach-quality dredged material was distributed on Bald Head Island, East Oak Island-Caswell Beach, West Oak Island, and Holden Beach. Shoaling of the new entrance channel results, in part, from the combined effect of the eastward movement of Jay Bird Shoals; erosion from western South Beach; and the westward movement of Bald Head Shoal into the channel gorge. Based upon sediment transport analyses conducted by the USACE, approximately 66% of the sediment shoaling the channel is derived from the Bald Head Island side of the channel while 34% is derived from the Caswell Beach side (USACE 2000). In order to redistribute this material, sand is currently disposed on the shoreline of Bald Head Island in Year 2 and

Year 4 of each six-year disposal cycle and on Oak Island-Caswell Beach during the sixth year of the cycle subject to availability of funding and dependent upon navigation priorities.

The USACE has identified Frying Pan Shoals as the sand source for the Brunswick County Beaches (BCB) Coastal Storm Damage Reduction Project. The USACE is in the process of preparing an Integrated General Reevaluation Report (GRR) and Draft Environmental Impact Statement (DEIS) for the project in accordance with Corps' Planning Guidance and NEPA. Actual implementation of the Federal BCB project (if implemented at all) is likely to be at a much later date than the VBHI Shoreline Protection Project. As such, time crowding of actions and associated additive impacts would become less of an issue. Given the size of the shoal feature relative to any prospective borrow sites, spatial crowding effects are likewise to be minimal. As a result, cumulative impacts potentially affecting this resource are not anticipated.

3.1.2 Dredging and Nourishment Actions specific to Bald Head Island (Past, Present, and RFF)

Sand placement activities constructed at Bald Head Island since 1991 are summarized in Table 3. The three small scale disposal projects constructed between 1991 and 1997 were cost-shared or paid for by the Village of Bald Head Island. The 2001 disposal operation was constructed as an element of the Wilmington Harbor Deepening Project. The disposal sand was placed as a designed berm along 15,500 ft of shoreline on South Beach. In Year 2 of the SMP cycle, approximately 1.2 Mcy was placed on South Beach between November 3004 and January 2005. A small scale non-federal West Beach sand disposal project was constructed by the Village in 2006 as a by-product of the dredging to the entrance of Bald Head Creek. In response to erosion of the western end of South Beach, the Village designed and implemented a larger beach restoration project that resulted in the placement of 1.85 Mcy of beach sand during the 2009/2010 dredge and nourishment window. The sand source site for this project was approximately 158 acres of the distal, subtidal portions of Jay Bird Shoals.

Sand losses subsequent to the 1.85 Mcy project in 2010 prompted the Village to identify and permit the use of an approximate 21-acre sand source site at the mouth of Bald Head Creek. The purpose of the project was to provide supplemental sand to an eroded segment of western South Beach. In March 2012, the Village completed the dredge and placement of 140,000 cy. Most recently (during the Winter and early Spring of 2013), the maintenance dredging of the Federal channel has resulted in the disposal of approximately 1.8 Mcy along South Beach and a portion of West Beach.

Table 3: Beach disposal activities at Bald Head Island since 1991.

Year	Volume
1991	0.35 Mcy
1996	0.70± Mcy
1997	0.45 Mcy
2001	1.849± Mcy
2005	1.217 Mcy
2006	47,800 cy
2007	0.9785 Mcy
2010	1.85 Mcy
2012	102,000 cy
2013	1.8 Mcy

3.2 Hardened Structures

3.2.1 Hard Stabilization Actions in the State of North Carolina)(Past, Present, and RFF)

Until recently, it has been the State's policy to limit the use of hardened erosion control structures on oceanfront shorelines. Seawalls and similar structures were banned by the Coastal Resources Commission in 1985. In 2003, the CRC's prohibition of hardened structures was placed into law with House Bill 1028 which amended the NC Coastal Area Management Act (CAMA). The few engineered structures existing in the State are largely limited to structures which protect important transportation corridors, existing commercial navigation channels of regional importance, and locations of historical significance. Existing hardened structure include the following (NCCRC 2010);

- jetty and weir jetty - Masonboro Inlet
- rock revetment - Carolina Beach
- rock revetment – near Fort Fisher
- groins – Cape Hatteras Lighthouse and Coast Guard Station
- terminal groin – Pea Island and Oregon Inlet
- terminal groin – Fort Macon (Beaufort Inlet)

In June 2011, the General Assembly of North Carolina ratified Senate Bill 110 *("An Act To Authorize The Permitting And Construction Of Up To Four Terminal Groins at Inlets Under Certain Conditions*"). The legislation included various requirements that must be met prior to issuance of a CAMA Major Permit for a terminal groin. In July 2013, SB 151 ("*An Act to Amend Marine Fisheries Laws; Amend the Laws Governing the Construction of Terminal Groins, and Clarify that Cities May Enforce Ordinances within the State's Public Trust Areas*") was ratified by the NC General Assembly and subsequently approved as law in August 2013 (Session Law 2013-384). SB 151 reduced some of the requirements placed upon applicants seeking authorization to construct terminal groins. The specific provisions of SB 151 are discussed in the EIS. Currently, four proposed terminal groin projects (Figure Eight Island, Bald Head Island, Holden Beach, and Ocean

Isle Beach) are under review for authorization in North Carolina. Under the existing law, this is the maximum number of terminal groins that can be authorized in North Carolina.

3.2.2 Hardened Structures specific to Bald Head Island (Past, Present, and RFF)

A. Sand Tube Groinfield

Presently, the 5,300 ft westernmost segment of South Beach of Bald Head Island is quasi-stabilized by a sixteen (16) structure sand tube groinfield originally constructed in 1995 and subsequently replaced in its entirety in both 2005 and 2010. With the last two reconstruction programs, minor design changes to groin location, groin length, and (most importantly) geotextile materials comprising the individual tube structures have occurred in accordance with the original design precepts. The sand tube groinfield was authorized by CAMA Major Permit No. 9-95 (USACE Action ID No. SAW-1994-04687).

The current location, individual lengths and spacing of the sixteen (16) sand tube groins is depicted by Figure 1.3 of the EIS. The structures currently exist along South Beach between survey baseline Station 47+50 (on the west) and Station 100+00 (on the east). The groin tubes vary in length from 250 ft. to 350 ft. Each geotube is tapered and varies in height from 5.7 ft to approximately 4.0 ft at its seaward tip. For purposes of installation, the beach is excavated to elevation +2 ft. NGVD. Each tube is then filled within the excavated beach (*i.e.* in a trench) which is subsequently backfilled. During each beach fill operation, the groins are essentially buried (*i.e.* overfilled) by design and therefore remain inactive until the fill berm equilibrates to the point that the tubes are exposed to wave energy. Their effectiveness in reducing littoral transport and maintaining a protective beach berm within each groin cell (located between any two groins) varies over time depending on their level of interaction with waves.

B. Sand Bag Revetment

In July 2011, the North Carolina Division of Coastal Management (NCDCM) and the U.S. Army Corps of Engineers (USACE) granted a minor modification of existing CAMA Permit No. 9-95 and USACE Action ID SAW-1994-04687, respectively, thereby authorizing the construction of a 350 lf sandbag revetment beginning at sand tube groin No. 16 and extending in a general northwesterly alignment. The purpose of the temporary structure was to address chronic inlet-related beach and dune erosion and recession occurring westward of the last sand tube groin. Subsequently, in 2012 a second minor permit modification was issued to the Village which allowed for the placement of up to 1,200 cy of sand to be placed on top of the sand bag revetment. The source of the sand was the 2009-2010 Village beach fill project berm located to the east of the revetment. The selection of borrow areas was based upon existing dry beach width. All of the area subject to temporary borrowing was subsequently filled as a result of a large scale (1.8 Mcy) federal navigation maintenance project with beach disposal undertaken in the spring of 2013.

3.3 Storms

Major storms, such as hurricanes and northeasters, have been acknowledged as significant events that can affect the form of barrier islands. Storm tides associated with oceanic storm surges are extremely important to shoreline dynamics. Damage from wind, salt toxicity, and overwash, combined with shore retreat, can severely impact the biological integrity of the island. Hurricanes making landfall in the project area as well as winter storms with sustained northeasterly winds have been shown to exacerbate shoreline erosion and resultant biological impacts on the island. The NOAA National Weather Service maintains a database of hurricanes impacting the Atlantic Coast. Table 4 provides a summary of hurricanes which have impacted Bald Head Island since 1996.

3.4 Sea-level Rise

According to the NC Coastal Resource Commission Science Panel on Coastal Hazards, historical tide gauge data and geologic evidence obtained over the last several centuries provide evidence that sea level is steadily rising in the state of North Carolina. Additionally, data collected from scientific studies within the state suggest that relative sea level (RSL) change varies as a function of latitude along the North Carolina coast. RSL change is higher in the northern part of the state with lower documented rates in the south and varies from 2.04 mm/yr to 4.27 mm/yr (NCCRC 2010b).

NOAA maintains a detailed record of sea level trends at stations around the United States. The nearest such station to the study area is at Southport, immediately inside Cape Fear Inlet (Station 8659084). The measured data at Southport cover the period between 1933 and 2006 and suggest that the local water level rises approximately 2.08 mm/year, or about 0.21 meters (0.69 feet) per 100 years, on average.

Table 4: Hurricanes impacting Bald Head Island since 1996.

Hurricane	Year
Irene	2011
Hanna	2008
Ophelia	2005
Charley	2004
Irene	1999
Floyd	1999
Bonnie	1998
Fran	1996
Bertha	1996

Riggs and Ames (2003) predicted increased rates of sea-level rise will adversely impact the North Carolina coast in the following ways: accelerated rates of coastal erosion and land loss; increased economic losses due to flooding and storm damage; increased loss of urban infrastructure; collapse of some barrier island segments; and increased loss of estuarine wetlands and other coastal habitats. Sea-level rise has the potential to increase the volume of sand required for beach nourishment projects region-wide.

4.0 RESOURCE CAPACITY TO WITHSTAND STRESS AND REGULATORY THRESHOLDS

In 1972, Congress passed the Coastal Zone Management Act, which encouraged states to keep the coasts healthy by establishing programs to manage, protect, and promote the country's fragile coastal resources. Two years later, the North Carolina General Assembly passed the landmark Coastal Area Management Act (CAMA). CAMA established the Coastal Resources Commission, required local land use planning in 20 coastal counties, and provided for a program for regulating development. The North Carolina Coastal Management Program was federally approved in 1978 by NOAA.

Demands placed on lands and waters of the coastal zone from economic development and population growth require that new projects or actions be carefully planned in order to avoid stress on the coastal zone. This planning involves a review of state enforceable policies, which are designed to provide effective protection and use of land and water resources of the coastal zone. Under CAMA, the proposed work cannot cause significant damage to one or more of the historic, cultural, scientific, environmental or scenic values or natural systems identified in Areas of Environmental Concern (AECs). In addition, significant cumulative effects cannot result from a development project.

5.0 RESOURCE BASELINE CONDITIONS

The resources potentially affected by past, present, and RFF dredging; beach nourishment and sand disposal activities; and terminal groin construction are listed above in Section 2.0 above. Baseline conditions such as status of populations, life histories, stressors (both natural and anthropogenic), and ability to adapt to stressors for each of these resources are described in corresponding sections of the project EIS (Section 4.0 and 5.0), the Essential Fish Habitat (EFH) report, and the project Biological Assessment (BA) and corresponding US Fish & Wildlife Service's Biological Opinion (BO). Information pertaining to human communities in the context of the cumulative effects issues is provided below.

Development pressures along the coast of North Carolina have significantly increased over the years with the influx of people wanting to live near the water. The State's position regarding beach ownership is that the public has always enjoyed the right to use the dry sand beach located above the normal high water line until the growth of vegetation or dune line occurs. The preservation of a stable beachfront is a critical aspect of the State's tourist industry.

Development of Bald Head Island began in 1972 with the construction of an inn and 18-hole golf course. The developer, Bald Head Island Limited, designed the phased plan development of the Island which encompasses 2,000 acres. With increasing build-out and anticipated increase of both permanent and part-time residents, along with the inherent advantages of municipal form of government for achieving the planned community goals, the Village of Bald Head Island was incorporated as a municipality in 1988.

The island is accessible to the public by means of a passenger ferry which operates between Southport, NC and Bald Head Island Marina. The Village exists primarily as a second home community and is a well-known tourist and seasonal destination. Commercial activity is primarily limited to retail trade including: grocery, hardware and restaurants. Other than retail trade, the only other non-residential construction activity involves the marina, country club, multifamily common areas, Bald Head Island Conservancy, office space, and town-owned facilities.

While there is a relatively small population of permanent, year-round residents (approximately 220), Bald Head Island serves the public (including residents of North Carolina and visitors from others state and countries), with its beachfront being among its principal draws. There are on average 5,000 visitors to the Island during a typical summer weekend day. Water-related activities along Bald Head Island include, boating, diving, sailing, windsurfing, surfing, kite surfing, stand-up paddle boarding and canoeing. Numerous beach accesses are maintained to support the daily public demands. The Bald Head Island Conservancy offers organized hikes, nature walks and kayak tours to permanent residents, guests and the general public. An eighteen-hole golf course is also available at the Bald Head Island Club. The golf course is open to member guests and is available with rental properties that have memberships.

The project area, located at the confluence of the Cape Fear River and Atlantic Ocean, is public and provides unique and important public beach resources and access, as do all of Bald Head Island's beaches. Maintenance of the beachfront for recreational use is a critical component of the Island tourism. The beachfront has been nourished via federal sand disposal and Village-sponsored projects over the last decade. The net beneficial effect of these soft stabilization measures for the Bald Head Island community has been the protection of properties and infrastructure as well as the use of a more expansive and stable beachfront.

6.0 DETERMINATION OF MAGNITUDE AND SIGNIFICANCE OF CUMULATIVE EFFECTS

The following is a qualitative assessment of the potentially beneficial, adverse, or neutral cumulative effects of the proposed action and similar past, present, or reasonably foreseeable future actions on identified resources.

6.1 Shorebirds and Waterbirds

The federally-protected piping plover and a variety of other shorebirds and colonial waterbirds are known to forage within the surf zone along Bald Head Island throughout the year.

6.1.1 Effects of Actions at Dredge Site

Dredge operations and sand placement projects are generally confined to the period of the year between November 15th and April 1st coinciding with a period of migration or over-wintering for many species of shorebirds and colonial waterbirds. Impacts at dredge sites are typically associated with direct physical effects (i.e. removal or alteration) of foraging habitat and direct effects (i.e. loss) of prey items. If significant expanses of intertidal shoal and mudflat habitat are being excavated along a stretch of shoreline, then shorebirds and waterbirds are not only impacted by diminished food resources but by loss of habitat utilization as well. For the purpose of the proposed action (including dredging associated with longer term maintenance and mitigative actions), no intertidal shoal or mudflat habitat exists at any of the prospective sand source sites. Thus, cumulatively the proposed action will not affect this resource.

6.1.2 Effects of Actions at Nourishment Site and Terminal Groin Site

The proposed action has the potential to adversely affect shorebirds and colonial waterbirds via degradation of the quality of foraging habitat; physical alteration of roosting, foraging, and nesting habitat; and disturbance from construction and increased recreational use.

Placement of sand on highly eroded shorelines has the potential to provide for some level of beneficial effect on the foraging habitat of shorebirds. Narrow beaches that do not support a productive wrack line may not provide the same quality of foraging habitat as those beaches that support a more stable beach profile (USFWS 2014). However, moving sand to nourish or dispose of on the shoreline as well as short-term beach stabilization methods may bury intertidal macrofauna and reduce the available food resource to birds in this area. In general, beachfront fill placement results in short-term declines in species abundance, biomass, and taxa richness. Dredge operations and sand placement projects are generally confined to the period of the year between November 15th and April 1st thereby avoiding the larval recruitment period of coquina clams (spring and summer) and mole crabs (early October) (Donoghue, 1999). Studies have shown that intertidal macrofauna can recolonize a nourished area within one or two seasons (Ross and Lancaster, 1996; National Research Council, 1995; Van Dolah et al. 1984; Reilly and Bellis, 1978). Directly after impacts to macrofauna have occurred and numbers of these species are depressed, birds that prey upon these invertebrates, including plovers, would likely move to adjacent undisturbed beach areas or tidal flats for the temporary period of population re-establishment.

In addition to the direct, temporary loss of prey species (i.e. crabs and worms) for birds following placement of the dredged sand, longer-term foraging impacts could result if the disposal material does not closely match the recipient beach. Sediment that is too coarse and/or contains high shell content can inhibit a bird's ability to extract food particles from the sand (ASMFC 2002). The potential for any longer-term effects is mitigated via required documentation of the material from the source site being of high-quality and beach compatible sand. For the proposed action, ,material from the entrance channel reaches have been demonstrated to be compatible as evidenced through several federal disposal events. Likewise, geotechnical investigations of the Jay Bird Shoals and the Bald Head Creek

Shoal has demonstrated that material from theses prospective sand source sites is also highly compatible with the recipient beaches. In the event the VBHI utilizes sand from Frying Pan Shoals in the future, any excavated material would comply with the State of North Carolina Technical Standards for Beach Fill Projects (15A NCAC 07H .0312). As a result, risk of these latter effects is considered to be minimal.

The terminal groin as currently proposed by the Village of Bald Head Island would be porous and would thus allow for sediment passage both through and over the structure. Inlet-directed sediment losses (i.e. shoaling of the adjacent federal channel) would continue to occur. In addition, the Point is expected to continue to migrate north as has been documented over the last several years. While sediment transport rates will be reduced, the Point feature will continue to exist. As a result, the intertidal and supratidal areas associated with this feature should continue to provide foraging, resting, and nesting habitat for shorebirds and colonial waterbirds. As has been observed on the south end of Wrightsville Beach, the presence of a low-profile structure does not prohibit sand accretion to downdrift areas and can allow for conditions suitable for shorebird and colonial waterbird nesting.

Nourishment and associated construction activities within the intertidal surf zone could influence foraging and resting winter residents and spring migrants. For the Mason Inlet Relocation Project (which involved the backfilling of a small tidal inlet and its relocation 3,000 ft north), piping plover spring migrants were documented to pass over the Mason Inlet shoals during construction (2002) and instead favor Rich Inlet to the north for foraging and resting. Likewise, fall migrants avoided Mason Inlet later in the year, stopping again at Rich Inlet before continuing southward of the study area. Since that time, expansive mud flats have developed on the backside of the relocated inlet. These areas have become a favored foraging and resting site for both wintering and migrant piping plovers (Webster 2006).

Construction work will occur during the bird nesting season. As a result, the stockpiling and transport of construction materials (including armor stone) within the work zone could influence the behavior of nesting shorebirds or colonial waterbirds. The work zone does not generally support viable nesting habitat, and it is unlikely that nests would occur within or immediately adjacent to the work zone. Monitoring for potential shorebird and colonial waterbird nests will be performed by trained staff of the Bald Head Island Conservancy (Conservancy) from May 1 until August 31. Any identified nests and adjacent nesting habitat will be clearly marked to alert construction personnel to maintain a minimum 50-ft distance from these areas.

Additional cumulative effects may manifest from increased human disturbance via habitat encroachment. Continued beach nourishment projects could favor the increase of humans along the beachfront. The presence of hardened structure may have an indirect effect of promoting the construction of residences on currently undeveloped, platted lots that are at a higher risk of erosion threat under the existing condition. Any future construction would be subject to existing federal, state, and local regulatory requirements. In particular, note that N.C. G.S. § 146-6(f) provides that title to land raised by public dredging vests in the State. In addition, development along South Beach is limited by NC DCMs oceanfront shoreline construction setback (measured from the Static Vegetation line). Any change to the Static Vegetation line would require action by the Coastal Resources Commission (CRC). The potential for increased development pressure (above the existing trend of residential lot build-out[1]) would be applicable to only a few lots along South Beach.

While potentially detrimental, human encroachment and disturbance is not expected to be incrementally worse with multiple projects. Additionally, with awareness and educational

[1] Since 2000, the Village has issued an average of 68 building permits per year (VBHI 2012).

programs through the Bald Head Island Conservancy, any potential adverse effects of human activity along the BHI beachfront can be mitigated.

Other regional projects have incorporated mitigative measures that have resulted in a net benefit to shorebird and waterbird populations. The Mason Inlet project included creation of the Mason Inlet Waterbird Management Area that serves as a sanctuary for nesting birds. Audubon North Carolina (in cooperation with New Hanover County and the Town of Wrightsville Beach) has assumed the responsibility of monitoring and maintaining this area. In addition, Audubon offers conservation and educational programs for the public. Audubon has documented nesting species to include least terns, black skimmers, common terns, and Wilson's plovers within the Inlet Management Area.

Previous federal projects associated with maintenance of Wilmington Harbor have also resulted in the creation of colonial waterbird nesting islands within the Cape Fear River. These islands have been documented successful nesting sites for gulls, terns, and waders in the estuary (Parnell et al. 1997). The islands are suitable locations because they tend to be relatively stable, extend well above the high-tide line, and support appropriate vegetation. Additionally, many of these islands are surrounded by open water and are relatively inaccessible to mammalian predators.

The installation of a terminal groin is predicted to decrease both the frequency and volume requirements of non-federal beach nourishment actions. However, as a requirement of SB 151, mitigative measures need to be identified to address any potential downdrift effects of the proposed structure. These measures would include hydraulically or mechanically placed sand on West Beach. It is predicted that the West Beach shorefront will potentially require beach disposal on an approximate 3-year basis with or without the implementation of the terminal structure. This placement may be achieved through regularly scheduled federal disposal or through Village-sponsored nourishment and is predicted to offset any potential increase in erosion resulting from the installation of a terminal structure.

The Applicant has also identified the potential use of a sand bag revetment as mitigation. Such a response (if needed) would be targeted for the specific segment of shoreline under an emergency-level condition in which structures have become imminently threatened. Use of a sand-bag revetment would result in mortality to benthic fauna and thus has the potential to adversely affect the foraging habitat and behavior of shorebirds and colonial waterbirds.

6.1.3 Summary of Cumulative Effects

The southern and western-facing beaches of Bald Head Island have been the site of periodic nourishment and sand disposal in the past either through federal navigation disposal or Village-sponsored projects. Since 1991, there have been 10 sand placement events of varying size, which equates to one event every 2.3 years. Several of these projects have been small in scale and affected only a small section of the shoreline. Other projects have been much larger. However, all of the projects left an unaffected adjacent beachfront (specifically East Beach) and birds are presumably able to move to these areas to forage during and immediately after construction. Furthermore, benthic infaunal species have been demonstrated to re-populate nourished beaches over a relatively short period of time.

The site of the proposed terminal groin is an area characterized by chronic erosion and instability. In the absence of nourishment, the beach profile tends to slope steeply from upland dunes to wet beach. As a result, the existing condition provides little opportunity for suitable bird nesting habitat. The installation of the groin coupled with periodic nourishment would promote a more stable dry beach with the potential for increased nesting. However, more stable conditions can also favor the growth of upper beach or dune vegetation. Denser vegetation would provide increased cover for predators and would also restrict nesting of certain species including the American oystercatcher and the Wilson's plover.

Construction of the terminal groin and associated fillet would affect the westernmost section of South Beach including an approximate 2,500-lf section of beach immediately updrift of the proposed groin. Over the long-term, future nourishment actions would affect approximately 1.7% of the total length of shoreline of Onslow Bay and Long Bay. All recent, current, and/or authorized beach nourishment projects combined affect approximately 35% of the shoreline. When considering all of these projects, a large portion of the assessment area will have beach placement activities in the foreseeable future, which could affect benthic infauna populations. However, given funding constraints of these projects and the limited availability of dredging equipment, it is improbable that all or even most of these proposed projects would be constructed at once. Further, most of these projects will leave adjacent unaffected portions of beach that will be available habitat for food resources of shorebirds and waterbirds during and immediately following construction.

Implementation of conservation measures, reasonable and prudent measures, and terms and conditions as outlined in the project BO, project-related effects to shorebirds and colonial waterbirds would be minimized. In consideration of past, present, and reasonably foreseeable actions (including the potential for future mitigative actions), cumulative effects from projects in the assessment area are considered neutral.

6.2 Seabeach Amaranth

Seabeach amaranth is an annual herb that occurs on beaches, lower foredunes, and overwash flats (Fussell, 1996). Historically, seabeach amaranth was found from Massachusetts to South Carolina. The species is currently found in New York, New Jersey, Delaware, Maryland, Virginia, North Carolina, and South Carolina. The decline of this species is a result of beach stabilization efforts, storm-related erosion, and human recreational use of its habitat (USFWS, 1996). Weakley (1986) found that in North Carolina the plant is most common on overwash flats on accreting ends of barrier islands. This species occupies elevations ranging from 0.2 to 1.5 m above mean high tide (Weakley and Bucher, 1992). Since dredging of the borrow area will be performed within open waters of the Cape Fear River or nearshore waters of the Atlantic Ocean in the event that the federal navigation channel is unavailable at the time of project implementation, no impacts to amaranth plants will occur from this action. Project-related beach nourishment would take place no earlier than November 16th, when amaranth plants have already released seeds. Deeply burying existing seeds via nourishment could negatively affect the amaranth population in later seasons. Assuming that seeds are located in the general position of former parent plants observed in past surveys, sediment placed on the beach may bury seeds and delay germination the following year.

Groin construction would occur immediately following a federal disposal operation and extend throughout the summer months. Construction actions (including the excavation and reworking of recently nourished sand) could have an effect on amaranth germination. However, the site of the proposed groin is within a chronically and severely eroded condition that is not well-suited for the occurrence of seabeach amaranth. Studies have found that groins have mixed effects on seabeach amaranth (USFWS, 1996). Immediately updrift from a groin, accretion sometimes provides or maintains habitat suitable for seabeach amaranth. Immediately downdrift of a groin, seabeach amaranth habitat may become degraded if the area is sediment-starved. However, in 1991 Long Island's (New York) largest population occurred along a groin field. Furthermore, the porous design will allow for sand passage through and over the proposed structure to minimize any potential downdrift impacts to the upper beach. It should be noted that updrift stabilization of the dry beach could potentially expand areas suitable for perennial vegetation that can outcompete seabeach amaranth. Overall, it is likely that a more expansive dry beach area would result in a net benefit to seabeach amaranth.

Research on the consequences of beach nourishment to amaranth seeds is inconclusive. The U.S. Army Corps of Engineers (1995) found that amaranth at Masonboro Inlet was more abundant in areas that recently received dredged material. Dredging activities could uncover buried seeds and allow them to germinate in deposited areas. (This benefit is unlikely to occur during this project if dredged material is supplied from areas offshore that do not contain amaranth seeds.) In contrast, Hancock (1995) concluded that amaranth seedlings generally do not emerge from depths of sand greater than 1 cm and beach nourishment may be detrimental if placed on top of seeds.

Although the proposed project will ultimately enhance seabeach amaranth habitat, the disposal of sand may initially bury seeds and slow germination. Therefore, the proposed project may affect but is not likely to adversely affect seabeach amaranth.

As stated above, the BHI project would affect approximately 1.7% of the total length of shoreline of Onslow Bay and Long Bay. Given funding and logistical constraints of these projects, it is improbable that all or even most of these projects would be constructed at once. Assuming these projects follow avoidance measures, adjacent unaffected portions of beach will be available for germination of this plant while nourishment activities in other areas potentially expand its habitat for germination in later seasons. The beach nourishment and groin construction (including any longer term maintenance or mitigative actions) will occur on chronically eroded segments of shoreline and should ultimately maintain or expand habitat for seabeach amaranth. For these reasons, cumulative effects to seabeach amaranth would be neutral.

6.3 <u>Sea Turtles</u>

In North Carolina, the Kemp's ridley sea turtle is known to occur in estuarine and oceanic waters, whereas the hawksbill and leatherback are found primarily in oceanic waters (Schwartz 1977, Epperly et al. 1995). These species are found in North Carolina waters all year but can be present in inshore waters April through December (Epperly et al. 1995). The hawksbill sea turtle and Kemp's ridley sea turtle are not known to nest along the Brunswick County beaches. The leatherback sea turtle primarily nests on beaches in the tropics, but is occasionally observed nesting in areas north of Florida (Rabon et al. 2003). In 2010, one leatherback sea turtle laid a nest on East Beach on Bald Head Island. Prior to that, the closest known leatherback nesting sites to the project area were in Georgetown County, SC and Carteret County, NC.

In North Carolina, the loggerhead and green sea turtles are found in North Carolina waters all year but can be present in inshore waters April through December (Epperly et al. 1995). Both species are known to frequently use coastal waters as travel corridors and have been observed migrating along the North Carolina coast (Epperly et al. 1995). Loggerhead turtles are known to regularly nest at Bald Head Island. Staff of the Bald Head Island Conservancy (BHIC) patrol the beach front daily during the nesting season to document and monitor sea turtle nests. Between 1980 and 2011, an average of 97.4 nests per year was recorded on Bald Head Island, with the majority of the nests occurring along South Beach and East Beach (BHIC sea turtle data). Between 2007 and 2011 an average of 19 nests per year were noted within the project area. In 2006, one green sea turtle nest successfully hatched from the south-facing beach of the project area (Dewire, personal communication.). In 2011, three nests successfully hatched from the south-facing beach of the project area. Since green sea turtles appear to have strong nesting site fidelity and often lay eggs on the same beach on which they hatched (USFWS 1992, Carr et al. 1978), surviving female green sea turtles will likely return to Bald Head Island for future nesting habitat.

In March 2013, the U.S. Fish and Wildlife Service proposed the designation of 739.3 miles of shoreline, 84% of all known nesting area, in the states of North Carolina, South Carolina, Georgia, Florida, Alabama, and Mississippi as critical habitat for the Northwest Atlantic Ocean Distinct Population Segment (DPS) of the loggerhead sea turtle. Bald Head Island is included in this proposed critical habitat protection area. Likewise, the National Marine Fisheries Service (NMFS), proposed critical habitat for this DPS of the loggerhead within the Atlantic Ocean and the Gulf of Mexico. Specific areas proposed for designation by NMFS include 36 occupied marine areas within the range of the Northwest Atlantic Ocean DPS. These areas contain one or a combination of nearshore reproductive habitat, winter area, breeding areas, and migratory corridors.

6.3.1 Effects of Dredge and Nourishment Actions

Dredge and nourishment associated with the construction of the groin and hydraulically placed fillet would be accomplished via the use of the federal sand disposal associated with the maintenance of the Wilmington Harbor Project. Generally, this work is performed during the environmental windows and avoids the sea turtle nesting season. Any potential augmentation of the fillet is likewise planned to occur outside of the dredge moratorium. As a result, the actual dredge and sand placement actions are unlikely to affect adult nesting sea turtles or emergent hatchlings.

Beach nourishment in chronically eroded areas has the potential to beneficially affect sea turtles by providing for increased and more stable nesting habitat particularly when utilizing highly compatible sand with the recipient beach. Habitat alteration may also result in indirect, adverse effects to sea turtles. The potential and magnitude for these effects are largely dependent upon the mitigative measures employed both during and subsequent to construction. If the beach becomes too hard through the compaction of deposited nourishment sediments by construction equipment, it could present a physical barrier to turtle nest digging. Furthermore, placement of sand on beaches may influence physical characteristics of beaches such as sand-grain size and shape, silt-clay content, sand compaction, moisture content, porosity/water retention, gas diffusion rates, and color of sand grains which could alter the temperature of the beach. These factors could reduce reproductive success of nests laid in nourished areas (Crain et al., 1995; Ackerman, 1996).

However, more stringent sediment compatibility standards and well-established mitigation measures will help to avoid or reduce any potentially adverse cumulative effects. On nourished beaches, there is the potential for escarpment formation as beach profiles equilibrate from a post-construction profile to a more natural beach profile. The presence of escarpments can impede or prevent access to the nesting site for adult female turtles. Post-construction monitoring and leveling of any escarpments can offset such effects.

6.3.2 Effects of Proposed Terminal Groin

The proposed terminal groin and continued maintenance and occurrence of the sand tube groinfield has the potential to result in direct and indirect effects to both adult nesting females and emerging hatchlings. During construction, movement of equipment has the potential to disrupt and disorient nesting females and emerging hatchlings. While construction areas will be intensively monitored throughout the nesting period, any nest not identified has the potential to be affected. Vehicular traffic on the beach during construction has the potential to disrupt or slow hatchlings from reaching the ocean. This, in turn, has the potential to increase the risk of predation or dehydration for the hatchlings (USFWS 2014). Several conservation measures would be employed by the Village and its contractors to minimize the effects of construction activities on adult females, their nests, and emerging hatchlings. These measures are described in detail in the project BO (Appendix S of the EIS) and summarized in Section 6.0 of the EIS.

Subsequent to construction, the presence of a hardened structure exposed above the beach or buried by accreting sand has the potential to adversely affect nesting turtles during nest site selection or during nest digging (resulting in false crawls or false digs). Groin structures may also concentrate predators (either birds or fish) and present physical impediments to hatchlings. Resultant increased energy expenditure by hatchlings can affect their ability to reach offshore developmental areas (Davis et al., 2002).

The installation of a terminal groin is predicted to decrease both the frequency and volume requirements of non-federal beach nourishment actions. However, as a requirement of SB 151, mitigative measures need to be identified to address any potential downdrift effects of the proposed structure. These measures would include hydraulically or mechanically placed sand on West Beach. It is predicted that the West Beach shorefront will potentially require beach disposal on an approximate 3-year basis with or without the implementation of the terminal structure. This placement may be achieved through regularly scheduled federal disposal or through Village-sponsored nourishment and is predicted to offset any potential increase in erosion resulting from the installation of a terminal structure.

The Applicant has also identified the potential use of a sand bag revetment as mitigation. Such a response (if needed) would be targeted for the specific segment of shoreline under an emergency-level condition in which structures have become imminently threatened. Use of a sand-bag revetment has the potential to adversely affect nesting sea turtles by increasing the potential for false crawls; altering beach profiles to an extent that may increase the risk of nest inundation waterward of the revetment; and potentially increasing debris along the beachfront should the structure fail and break apart (this in turn could further impede nesting turtles or their hatchlings) (USFWS 2014). Any potential indirect effects to sea turtles should be considered in the context of the existing condition of West Beach which is an area of shoreline with historically low nest occurrences due to its chronically eroded condition and proximity to the river mouth. Those nests that are laid are subject to inundation, and absent relocation by the Bald Head Island Conservancy, have low success.

As described in Section 6.1.2 above, the presence of hardened structure may have an indirect effect of promoting the construction of residences on currently undeveloped, platted lots that are at a higher risk of erosion threat under the existing condition. Any future construction would be subject to existing federal, state, and local regulatory requirements. In particular, N.C. G.S. § 146-6(f) provides that title to land raised by public dredging vests in the State. In addition, development along South Beach is limited by NC DCMs oceanfront shoreline construction setback (measured from the Static Vegetation line). Any change to the Static Vegetation line would require action by the Coastal Resources Commission (CRC). The potential for increased development pressure (above the existing trend of residential lot build-out) would be applicable to only a few lots along South Beach.

6.3.3 Summary of Cumulative Effects

The proposed project and other beach nourishment projects of its kind are designed to offset the erosive loss of sand. The net result of a widened, more stable beachfront has been cited to facilitate turtle nesting. Beach nourishment projects have been most abundant (both in numbers and length of shoreline) in Florida, a state with a documented upward trend in turtle nesting sites. North Carolina provides vast beachfront area considered suitable for nesting of the five species of sea turtles. Overall, the actual number of sea turtle nesting sites occurring in North Carolina is relatively small compared to the entire southeastern coast (i.e. beaches of Florida, Georgia, South Carolina, and North Carolina, combined).

In consideration of the proposed action and reasonably foreseeable future actions, including identified mitigation actions in response to adverse effects to the downdrift shoreline (such as mechanical sand placement from the updrift impoundment fillet of the groin, hydraulic placement from a compatible, beach quality sand borrow site, or sandbag revetment for small-scale emergency response), cumulative effects to sea turtles are considered neutral. Identified conservation measures, reasonable and prudent measures, and terms and conditions of the BO will help to minimize potential adverse effects to these species. Any direct or indirect effects of the proposed action and reasonably foreseeable future actions (including potential mitigation actions) would be offset by the predicted increase in dry beach and sea turtle nesting habitat along an area of chronically eroded shoreline.

6.4 Intertidal and Subtidal Soft bottom Habitat (including shoals)

Benthic infauna (e.g. polychaete worms, amphipods, and mollusks) will be subject to immediate adverse impacts associated with the removal of sand and entrainment of infaunal and non-motile epibenthic organisms. Physical removal of sediments from a borrow site removes benthic habitat, along with resident infauna and epifauna incapable of avoiding the dredge head, and can yield pronounced population effects to the benthos (USFWS 2000). Studies along the east, gulf and west coasts of the United States document similar trends of 84% to 90% decrease in the number of benthic organisms post-dredge (ASFMC 2002). Continual maintenance of Wilmington Harbor began in 1870 and harbor dimensions have been increased incrementally for over 100 years. Ongoing channel maintenance operations of the harbor routinely disturb benthic populations in the existing deep water channel and nearby side slopes. The benthic assemblages characteristic of the Cape Fear River and nearshore ocean (including the prospective sand source sites) are dominated by opportunistic species which recover quickly from environmental disturbances.

Potential physical effects of dredging typically include alteration of wave dynamics and sediment transport mechanisms; shoal deflation; and exposure of sediments with different physical characteristics (grain size, chemical composition, etc.). The rate of sediment recovery will fluctuate based on location, time of dredging, volume of sediment removed, sediment transport rate and storm characteristics following dredge events. In high energy sandy environments, the effects of sediment alteration are often minimized (Saloman et al. 1982, Pullen and Naqvi 1983). Studies have documented recovery of sediment characteristics within several months (Bowen and Marsh 1988).

While species abundances has been shown to return to pre-dredging conditions rather quickly, species composition and diversity indices may remain altered for a period of time subsequent to excavation. Posey and Alphin (2002) concluded that the rapid infilling of a borrow site (resulting from strong water currents and dynamic sand movement) contributed to a relatively quick species recovery. Based upon the results of this study, inter-annual variability contributed more to the observed differences in species abundance than the sediment removal effects (Posey and Alphin 2002). Similar benthic recovery trends were documented during biological monitoring efforts initiated by VBHI following excavation of Jay Bird Shoals in 2010. Data collected over the four year course of study indicate that the benthic community inhabiting the Jay Bird Shoals borrow site recovered quickly from any potential deleterious effects of project activities (LMG 2011, 2012, 2013). During pre-construction and post-construction monitoring, Jay Bird Shoals was dominated by amphipods, particularly *Protohaustorius wigley*, and other taxa which are adapted to life in environments prone to natural disturbance. These taxa presumably recolonized quickly after project construction and were joined by other taxa that may have capitalized on the reduced competition for space associated with recently disturbed habitats. While there were noticeable dominance patterns throughout the course of study, there was some deviation in the species present between years, likely a reflection of natural inter-annual variability typical of benthic infaunal communities. The rapid re-colonization of Jay Bird Shoals resulted in a relatively stable benthic community assemblage which persisted during subsequent monitoring events.

The recovery of the benthos at the recipient site would be reliant on immigration (active or passive) of organisms from the adjacent undisturbed areas and larval recolonization from the water column. A number of studies have indicated relatively rapid recolonization and recovery of the benthos subsequent to dredging operations provided that the post-dredge environment is favorable for colonization and peak periods of larval recruitment are avoided (Pullen and Naqvi 1983; NRC 1995; Hackney et al. 1996; Schaffner et al. 1996; Bergquist et al. 2008).

Placement of sand at the beach fill site will bury the majority of benthic infauna as existing soft bottom habitat is converted to dry beach and wet beach habitat. Nourishment impacts on the target beach would be most severe for small, relatively immobile species that are unable to burrow through the new sediment. Larger, more mobile organisms will burrow through the newly placed sediment or avoid the area of disturbance by migrating to neighboring unaffected areas. As a result of the dredge and pump processes, it is likely that disposal materials will be devoid of live benthic species. Benthic regeneration within soft bottom habitat will vary depending upon the magnitude of the disturbance, the character of the new sediment interface, rate of sediment recovery duration and timing of the dredging, the type of equipment used to extract the sediment, life history characteristics of colonizing species and water quality (Pullen and Naqvi 1983; NRC 1995). Areas that are slow to return to pre-nourishment conditions may never fully recover before subsequent nourishment events. However, relatively small, opportunistic species of polychaetes and amphipods tend to be the numerically dominant benthic macrofauna of intertidal and subtidal flats. In addition, implementation of the state sediment criteria would ensure the use of beach compatible sediment for present and future nourishment/disposal projects facilitating a favorable environment for recovery of the benthos.

Federal dredge disposal and Village-sponsored nourishment efforts on Bald Head Island would contribute to the removal of subtidal bottom and/or sandy shoals of the area, which in turn, has the potential to result in cumulative impacts to benthic communities residing within these habitats. However, the cumulative amount of sediment removed for disposal and nourishment efforts on Bald Head Island reflects a small percentage of the overall soft bottom and sandy shoal habitat identified in the region. Any impact to soft bottom habitat would be offset to a degree by the predicted increase in soft bottom resulting from erosion of upland habitats. Furthermore, the extent of the potential adverse impact relative to the amount of soft bottom habitat on a regional scale, in conjunction with the capacity of this type of habitat to accommodate additive effects, would minimize the risk of any cumulative impacts.

The USACE has identified Frying Pan Shoals as the sand source for the Brunswick County Beaches Coastal Storm Damage Reduction Project. The USACE is in the process of preparing a DEIS for the project in accordance with NEPA. Actual implementation of the project is likely to be at a much later date (if implemented at all) than the VBHI Shoreline Protection Project. As such, time crowding of actions and associated additive impacts would become less of an issue. Given the size of the shoal feature relative to any prospective borrow sites, spatial crowding effects are likewise to be minimal. As a result, cumulative impacts potentially affecting this resource are not anticipated.

Construction of the terminal groin would permanently replace part of the beach with granite armor rock. Benthic infauna incapable of horizontal movement would be permanently lost and eventually replaced with species capable of inhabiting rock substrate and interstitial spaces between the rocks. While construction of the terminal groin would contribute to the loss of benthos, the cumulative loss of benthic infauna associated with construction of hard structures is offset by the amount of undisturbed soft bottom along the coast of the Cape Fear region. As previously noted, the extent of existing soft bottom habitat in conjunction with its resilience to disturbance (either natural or anthropogenic) reduces the risk of cumulative impacts.

6.5 Water Column (including federally-managed species)

The water column provides a basic ecological role in the assimilation of energy and nutrients at the base of the food chain through primary productivity, largely by phytoplankton, and benthic-pelagic coupling. The water column also serves as habitat for pelagic species in varying life stages while providing a corridor for numerous anadromous and catadromous species.

6.5.1 Water Column Effects at Borrow Sites

It is the applicant's proposal that the sand fillet for the proposed terminal groin be augmented by the disposal of the next federal navigation channel maintenance event. Supplemental sand (as needed) would be sourced from either Jay Bird Shoals or Bald Head Creek Shoals. The proposed Jay Bird Shoals borrow area is located within the undredged portions of the borrow site that had been previously authorized for the Village-sponsored beach nourishment project constructed in the winter of 2009/2010[2]. Other sources of sand for fillet maintenance and maintenance of West Beach include the federal navigation channel and the ebb tidal shoal of Bald Head Creek. Frying Pan Shoals has been identified as a future borrow source for nourishment beyond Year 3 (particularly for anticipated nourishment needs in Year 12, 21, and 30).

Impacts to the water column associated with dredging are associated principally with the entrainment of infauna, epifauna, and demersal species. Mortality of organisms (i.e. plankton, pelagic eggs and larvae to pre-flexion stage individuals) within the water column that lack the ability to escape the suction field of an operating dredge and subsequent entrainment in the flow of water and sediment passing through its pumping equipment is likely. However, the effect is believed to be negligible based upon: (1) the very small volumes of water pumped by dredges relative to the total amount of water in the water in the vicinity of the operating dredge; (2) the extremely large numbers of larvae that are produced by most estuarine-dependent species; and (3) the high natural mortality rate for early life stages of many fish species (USACE 2000). The risk of entrainment has been evaluated for the Cape Fear River mouth itself. The USACE (2000) estimated that the

[2] The previous authorization for use of the Jay Bird Shoals borrow site was for the specific action completed in 2010 and has no bearing on permit decisions for future proposed actions.

amount of water intercepted by the largest operating hydraulic dredge (30-inch diameter pipe) is less than 8/10ths of 1% of the average daily river flow. Motile organisms, including most fish assemblages capable of escaping the suction field will likely relocate to other areas while dredging activities take place.

Localized turbidity impacts are anticipated by the removal of substrate from the borrow site as well as overspill associated with the dewatering of dredge sediment. While the identified borrow sites are characterized as high-energy, sandy environments, background turbidity levels are expected to increase during project implementation. However, these effects are expected to be localized and short-term. Turbidity levels in waters outside of the immediate vicinity of the operating dredge should be less than 25 NTUs (USACE 2000).

Pullen and Naqvi (1983) found that motile animals were the least affected by dredging and concluded that benthic and fish utilization likely depends upon water quality of the dredge area. Provided the dredge area does not form an anaerobic pit of organic-laden sediment, biological communities may be restored rather quickly. In addition, multiple studies have indicated rapid recovery of fish utilization at locations with high water and sediment dynamics such as tidal channels (Pullen and Naqvi 1983; Van Der Veer et al. 1985; Musick 1998; Schaffer et al. 1996). The prospective sand source sites considered for Village-sponsored nourishment are sandy, depositional features and thus should not be susceptible to water column impairments nor to the subsequent secondary effects on benthic and fish resources.

6.5.2 Water Column Effects at Nourishment Site

The potential effects to water column in the littoral zone during nourishment are minimized through the use of beach-compatible sediments consisting of more than 90% sand (USACE 1997). In general, the spatial scale of elevated turbidity related to beachfront disposal is very small (USACE 2001). Federal disposal actions have been demonstrated to utilize beach-compatible sand since much of the source material is derived from the adjacent beaches and shoals. Prior to use of any sand source site by the Village, minimum state sediment compatibility standards must be met. Available sediment data from each of the four prospective sites indicate the presence of beach-compatible sand in sufficient volumes for nourishment. Each of the sites consists of sediments characterized by a high percentage of sand by percent weight and low percentage of fines (see Olsen 2007, Athena Technologies 2009, Catlin 2010, and LMG 2013). Thus, effects to the water column from nourishment are expected to be spatially confined and temporal.

The indirect impact of turbidity on mortality, growth, and spawning behavior for surf zone fish is not well documented but is likely not significant since most adult fish are mobile enough to avoid areas of highest turbidity. Given the avoidance behavior of mobile species, nourishment is expected to influence fish distribution. However, many surf zone species are adapted to relatively high ambient turbidity levels and it is largely inferred in the literature that impacts to fish are more closely related to changes in and/or loss of benthic prey resources than temporary changes in water column characteristics (USACE 2001; Hackney et al. 1996). Ross and Lancaster (2002) reported that species (such as pompano and kingfish) that utilize the surf zone for nursery areas exhibit high site fidelity and are therefore more vulnerable to localized effects to benthic assemblages (Ross and Lancaster 2002). Increases in suspended sediments may also adversely affect the feeding behavior of visually-orienting fish (Wilber et al. 2003).

The construction of the terminal groin is proposed to be implemented immediately following the federal disposal event. A portion of the stem section and all of the head section will likely be constructed in open water. Placement of the armor stone would be accomplished using a barge and crane or potentially through the use of a temporary trestle structure constructed parallel to the terminal groin. The trestle would be supported by steel pilings jetted into the substrate and removed once construction is complete.

However, phasing of the project would reduce the need for the use of a trestle. Depending upon conditions at the time of the groin installation, it is likely that equipment will be able to be operated from sand pads formed from the fillet. Any effects to the water column as a result of increased turbidity from construction would be expected to be localized and short-lived.

Due to their mobility and range, surf zone fishes utilizing the project area to forage upon benthic macrofauna (e.g. mole crabs and coquina clams) would move to adjacent undisturbed beach areas and other suitable feeding zones for the temporary period of construction. Surf zone conditions would resume a pre-construction mode relatively quickly.

It has been reported that shore-perpendicular structures such as groins or jetties have the potential to impede longshore transport of larvae and natural passage into estuaries or sounds and thus negatively impact recruitment success (Blanton et al. 1999; Hare et al. 1999). In particular, the presence of jetties has the potential to deflect larvae to an extent that would eliminate the opportunity for the larvae to be entrained into the estuary (particularly for relatively small coastal inlets). For the Oregon Inlet project, it was asserted that construction of duel jetties would result in the reduction of ocean-spawned larvae from reaching estuarine nursery areas (USACE 1999).

While a dual jetty system of an inlet presents a vastly different set of physical and biological conditions than that of the proposed terminal groin on Bald Head Island near the mouth of the Cape Fear River, hypothetical particle ingress into the Cape Fear River estuary was nonetheless simulated via Delft 3D modeling by Olsen Associates. The drogue simulations were intended to represent larval fish pathways into the estuary under two scenarios: (1) ingress with beach fill; and (2) ingress with beach fill and a terminal groin in place. The presence of the terminal groin appears to have no significant limiting influence on the ability of particles (hypothetical larval fish) to enter the estuary. The complete model report of findings is provided in Appendix R of the EIS. The size of the structure relative to the hydraulic field of the Cape Fear River mouth is negligible. As a result, larval entrainment into the Cape Fear River estuary will remain unaffected. In addition, the post-construction template would result in a shoreline configuration that effectively extends the shoreline to the waterward extent of the structure. Given these considerations, it is believed that the post-construction condition would be conducive for unimpeded passage of fish and larvae into the Cape Fear River estuary.

The terminal structure will likely provide foraging and shelter opportunities for surf zone fishes thus adding to species abundance and richness to the soft bottom community (Peters and Nelson 1987; Clark et al. 1996). Cenci et al.'s (2010) study focused on installation of shoreline stabilization structures in areas characterized by soft bottom habitats. The data collected on fish populations indicates that during the early stages following new groin construction, species diversity and richness increased dramatically. These new structures become fish "producers" by providing habitat for local and transient fish assemblages. However, introduction of artificial structures may also be viewed as a habitat trade-off in which species assemblages may be altered. In addition, hardened structures have been cited as being susceptible to invasion by non-native species (Bulleri and Chapman 2010).

The hydrodynamics of the lower Cape Fear Estuary create a dynamic environment. The water column is subject to wind and current-induced mixing and daily tidal exchange with the Atlantic Ocean. Additionally, the presence of the terminal groin appears to have no significant limiting influence on the ability of particles (hypothetical larval fish) to enter the estuary. In consideration of other past, present, and reasonably foreseeable future actions in the coastal Cape Fear region, no cumulative impacts to the water column are anticipated.

6.6 Water Quality

Marine and estuarine waters may experience elevated, localized turbidity as a result of the placement of disposal materials on the beach as well as dredging activities in the channel. As part of the federal navigation project, beach-compatible dredged material (sands) dredged from the ocean bar or river channel is regularly placed on the recipient beach. Turbidity effects from fill placement are directly related to grain size. The high percentage of sand in the dredged material will allow for more rapid settling of sediment following placement activities. In addition, the tidal currents and hydrodynamics of the Cape Fear River estuary provide a means for water mixing and dilution. Turbidity created by the disposal operation normally does not persist beyond more than one or two tidal cycles (12 to 24 hours) following the cessation of the disposal operation (USACE 2000).

Dredging and associated suspended sediment plumes can have short-term and localized effects on water quality. These include chemical transformations resulting from the oxidation of sulfides and of ferrous iron (Fe^{2+}) which in turn can lead to reductions in dissolved oxygen (DO). Oxidation of sulfides can also lead to localized reduction in pH levels in the water column (Jabusch et al. 2008). DO levels over the dredge site can also be suppressed via the release of oxygen-demanding material (e.g. organics). However, bottom sediments of the proposed borrow sites exhibit a high percentage of sand by weight with low percent organic matter. In addition, the waters at the mouth of the Cape Fear River tend to be well-oxygenated (Mallin et al. 2012) and thus less susceptible to impairment from any localized increases in DO.

Disturbance activities associated with federal maintenance of the channel (i.e. dredging and dredge disposal) would occur within the open waters of the Cape Fear River estuary where hydrodynamics of the water column are subject to semi-diurnal tidal exchange as well as wind and current induced mixing. Elevated turbidity levels would be localized and temporary due to mixing and dilution. The incremental contribution to cumulative water quality impacts from the proposed action in combination with other regional navigation projects and water dependent development activities would be negligible.

6.7. Human Communities

The net beneficial effect of soft stabilization measures (i.e. beach nourishment) and engineered structures is the protection of properties and infrastructure as well as the use of a more expansive and stable beachfront. Since Bald Head Island is a planned unit development, efforts to widen and stabilize the beachfront protect existing platted lots, constructed residences, and existing infrastructure. Beach restoration will not allow for the recordation of new lots on the Island. As stated previously, development along South Beach is restricted by the oceanfront setback measured from the existing Static Vegetation line. Any exception to this line would need to be authorized by the CRC. Assuming an exception is granted, there is potential for a few residential lots (less than 10) to be developed that would otherwise be likely undevelopable under the current condition. The cumulative benefit of the proposed action to the human community is protection of existing structures/infrastructure and enhanced recreational use. These benefits are realized by permanent residents, part-time residents, vacationers, and visitors to the Island.

The Applicant has recently advocated for coastal management rules (via NC DCM's Cape Fear River AEC Study) that would increase the number and variety of shore stabilization measures allowed on Bald Head Island. It is reasonable to expect that the Applicant will continue to advocate for changes to regulatory systems that would allow for additional use of sandbags, rock groins, breakwaters, and jetties in and will continue to advocate for more lenient rules related to setbacks and static lines. That said, the Applicant has unequivocally stated that no such plan exists for these types of shoreline stabilization strategies. The Applicant has stated that the proposed action is intended to be a single and complete erosion control project for this part of the island.

Stabilization measures along the coast of North Carolina help to protect a significant property tax base to local municipalities. In addition, protection of existing structures, infrastructure, and recreational beach ensures a viable and critical tourist industry for the State. Thus, multiple projects occurring in a single location (e.g. Bald Head Island) or in multiple locations (e.g. beachfront communities of North Carolina) are considered cumulatively beneficial to the human community resource.

7.0 ACTIONS TO REDUCE CUMULATIVE IMPACTS

Cumulative impacts from the Village of Bald Head Island Shoreline Protection Project are expected to be minimal and insignificant. Over the course of the last few years, the applicant has evaluated numerous alternatives and implemented various measures in an effort to mitigate environmental impacts potentially resulting from nourishment activities. Section 6.0 of the EIS describes the mitigative measures to be employed by the Village of Bald Head Island. In addition, several conservation measures, reasonable and prudent measures, and terms and conditions to minimize adverse effects to threatened and endangered species (and their habitats) are identified in the BO prepared by the USFWS. Detailed monitoring and mitigation efforts associated with construction of the terminal groin are also included within the Inlet Management Plan (Appendix B of the EIS). Collectively, monitoring and mitigative measures will reduce the potential for cumulative impacts related to proposed dredging, nourishment, and terminal groin construction.

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