Brunswick Harbor Modifications Study
Glynn County, Georgia

Draft Integrated Feasibility Report and Environmental Assessment
Coastal Zone Management Federal Consistency Determination

Appendix J

U.S. ARMY CORPS OF ENGINEERS
SAVANNAH DISTRICT
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February 2021

**Federal Consistency Determination
for the
Georgia Coastal Zone Management Program**

1.0 INTRODUCTION

The Federal Coastal Zone Management Act (CZMA), 16 U.S.C. 1451 et seq., as amended, requires each Federal agency activity performed within or outside the coastal zone (including development projects) that affects land or water use, or natural resources of the coastal zone to be carried out in a manner which is consistent to the maximum extent practicable with the enforceable policies of approved state management programs. A direct Federal activity is defined as any function, including the planning and/or construction of facilities, which is performed by or on behalf of a Federal agency in the exercise of its statutory responsibilities. A Federal development project is a Federal activity involving the planning, construction, modification or removal of public works, facilities or other structures, and the acquisition, use or disposal of land or water resources.

To implement the CZMA and to establish procedures for compliance with its Federal consistency provisions, the US Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), has promulgated regulations which are contained in 15 C.F.R. Part 930. This Consistency Determination is being submitted in compliance with Part 930.30 through 930.44 of those regulations.

This evaluation was prepared to determine if the proposed Brunswick Harbor Modification Study (BHMS), including existing and future operations and maintenance (O&M) of Brunswick Harbor is consistent with the Georgia Coastal Management Program (GCMP) to the maximum extent practicable.

For purposes of the CZMA, the enforceable policies of the Georgia Coastal Management Plan constitute the approved state program. In accordance with the CZMA, the Corps has determined that the proposed BHMS new work and O&M would be carried out in a manner which is fully consistent with the enforceable policies of the Georgia Coastal Management Program.

2.0 BACKGROUND

The purpose of the BHMS is to investigate the feasibility of reducing transportation cost inefficiencies associated with the Federal deep draft navigation channel at Brunswick Harbor, Georgia. The study is authorized by Section 1201 of the Water Resources Development Act (WRDA) 2016. The Corps is undertaking this action in partnership with the Georgia Ports Authority (GPA), the study’s non-Federal sponsor. The Integrated Feasibility Report and Environment Assessment (IFR/EA) describes the recommended plan for reducing transportation cost inefficiencies and how it is economically justified and promotes National Economic Development (NED) while protecting the Nation’s environment. As detailed in the

IFR/EA, Alternative 8 (Bend Widener, Turning Basin, and Meeting Area at St. Simon's Sound) has the greatest net benefit and is the selected alternative.

The existing O&M annual average quantity for Brunswick Harbor is about 2,204,00 cubic yards. This amount includes about 400,00 cubic yards in the inner harbor reach, 1,414,000 cubic yards in the outer harbor or entrance channel, and about 390,000 cubic yards for the bend widener and the turning basin.

3.0 GCMP Jurisdiction

Brunswick Harbor is located in Glynn County, GA approximately 70 miles south of Savannah, GA. It is a deep-draft navigation harbor that serves three distinct commercial facilities. Glynn County is one of the six Georgia counties lying adjacent to the coast and is included in the Georgia Coastal Management Plan as one of the eleven counties that are within the coastal area. The GCMP lists dredging, channel improvements, and other navigational works conducted by the Corps as being direct Federal activities that are subject to Federal Consistency.

4.0 PROJECT DESCRIPTION

The proposed project includes the removal of 205,000 cubic yards of material at the bend widener and 346,000 cubic yards at the turning basin expansion. A total of approximately 551,000 cubic yards of dredged material will be removed to construct the project. At this time the dredged material would be placed in the Andrews Island Dredged Material Containment Area (DMCA). No dredging is needed at St. Simons Sound as it is naturally deep and only requires the addition of the area into the Federal navigation channel.

Upon project commencement, dredging activities (cutterhead) are anticipated to continue for approximately 12 months. Upon construction completion, O&M dredging (all dredge types) would occur annually as needed based on shoaling rates. The average shoaling rate for the turning basin and bend widener is expected to be approximately 14,900 cubic yards per year and 2,000 cubic yards per year, respectively.

The proposed new work dredging will be accomplished through the exclusive use of a cutterhead dredge. Cutterhead dredging typically occurs on a fixed boat/barge system and is used for new work and maintenance projects where suitable placement/disposal areas are available and operate in an almost continuous dredging cycle resulting in maximum production, economy, and efficiency. Pipeline dredges are rarely self-propelled, and typically must be transported to and from the dredge site where they are secured in place by special anchor pilings, called spuds. They require an extensive array of support equipment including pipeline (floating, shore, and submerged), boats (crew, work, survey), barges, and pipe handling equipment.

With implementation of the proposed project, the anticipated O&M annual average quality of for Brunswick Harbor in the bend widener and turning basin would increase from approximately 390,000 yards to approximately 406,900 cubic yards. It is anticipated that the shoaling rates in both the inner harbor reach and the outer harbor or entrance channel would not change from the proposed project and would on average continue to be 400,000 cubic yards and 1,414,000 cubic yards respectively on an annual basis.

5.0 EFFECTS OF PROPOSED PROJECT (BHMS- ALTERNATIVE #8)

Relevant Enforceable Policies:

The River and Harbor Development Act (O.C.G.A. 52-9-1 et seq)

The River and Harbor Development Act states that "there shall be no net loss of sand from the state's coastal barrier beaches resulting from dredging activities to deepen or maintain navigation channels within tidal inlets, as well as the entrances to harbors and rivers." Dredging and disposal of sediment for this project is not expected to result in a net loss of sand from the state's coastal barrier beaches. The BHMS PDT has reviewed available data on the physical and chemical characteristics of the sediment from previous investigations. Alternative 8 includes relatively small additions to the overall Federal navigation project that are located directly adjacent to the existing channel. The presence of clays, silts, and gravels (i.e. weathered limestone rock) from existing boring logs indicates that there is not likely to be a quantity of material at sufficient quality to be feasible for direct beach placement or nearshore littoral placement. However, new sediment borings will be collected in the footprint of the proposed dredging in order to better characterize the sediment for either upland disposal or for beneficial use. The proposed testing will be used in conjunction with state resource agencies to assess whether or not proposed beneficial use options (see section 5.2.2 of the BHMS main report) warrant further consideration. It is understood that any potential beneficial use project may require additional project-specific testing.

Coastal Marshlands Protection Act– O.C.G.A. 12-5-280, 12-5-282(3), 12-5-286(a) & 12-5-295(3)

This law does not apply to the Corps due to our “responsibility of keeping the rivers and harbors of this state open for navigation” [O.C.G.A. 12-5-295(3)], however the guiding principles to safeguard the loss of values and functions [of coastal marshlands and tidal waterbottoms] are applicable to the project.

Georgia Endangered Wildlife Act (GEWA) – O.C.G.A. 27-3-130

The implementing rule for the GEWA, Rule 391-4-10 protection of endangered, threatened, rare, or unusual species is applicable to this project, and the Corps is fully consistent. Specifically, there are four Prohibited Acts detailed in Rule 391-4-10.06. These acts are:

1. Any activities which are intended to harass, capture, kill, or otherwise directly cause death of any protected animal species are prohibited, except as specifically authorized by law or by regulation as adopted by the Board of Natural Resources.
2. The sale or purchase of any protected animal species or parts thereof is prohibited and the possession of any such species or parts thereof is prohibited unless the possession is authorized by a scientific collecting, wildlife exhibition, or other permit or license issued by the Department.

3. The destruction of the habitat of any protected animal species on public lands is prohibited.
4. The authorization to take certain nongame animal species set forth in O.C.G.A. Section 27-1-28 shall not apply to any protected species whether on public or private land.

Regarding Prohibited Act 1, the activity is not “intended” to harass, capture, kill, or otherwise directly cause death of any protected animal species. More importantly, the USACE’s activities are specifically authorized by the ESA and its implementing regulations through a Biological Opinion (2020 SARBO). The ESA is incorporated by reference in this GA Rule. Therefore, the USACE’s proposed activity is fully consistent with this part because the activities you propose to restrict are specifically authorized by law.

Prohibited Act 2 does not apply to this project.

Prohibited Act 3 also does not apply as there is no “destruction” of habitat proposed.

Prohibited Act 4 references TITLE 27 - GAME AND FISH, CHAPTER 1 – GENERAL PROVISIONS, § 27-1-28 - Taking of nongame species indicates that “(a) Except as otherwise provided by law, rule, or regulation, it shall be unlawful to hunt, trap, fish, take, possess, or transport any nongame species of wildlife, except that the following species may be taken by any method except those specifically prohibited by law or regulation:” The USACE’s activities are specifically authorized by the ESA and its implementing regulations through a Biological Opinion (2020 SARBO). The ESA is incorporated by reference in this GA Rule. Therefore, the USACE’s proposed activity is fully consistent with this part because the activities you propose to restrict are specifically authorized by law.

Georgia Environmental Policy Act – O.C.G.A. 12-16-1

“The Georgia Environmental Policy Act (GEPA) requires that all State agencies and activities prepare an Environmental Impact Report as part of the decision-making process.” An EA for the proposed project has been prepared in accordance with the National Environmental Policy Act of 1969, as amended.

Georgia Erosion and Sedimentation Act – O.C.G.A. 12-7-1

“One provision of the Erosion and Sedimentation Act requires that land-disturbing activities shall not be conducted within 25 feet of the banks of any State waters unless a variance is granted (O.C.G.A 12-7-6-(15)).” Dredge activity for this project is anticipated to be exclusively within the south Brunswick river and St. Simons sound. No land disturbance activities beyond moving dredge material to the Brunswick DMCA are anticipated. Therefore, a variance for this activity would not be required prior to the construction of the proposed action.

Mountain and River Corridor Protection Act – O.C.G.A. 12-2-1

Provisions of the Act include a requirement for a 100-foot vegetative buffer on both sides of rivers and consistency with the Georgia Erosion and Sedimentation Act. The proposed action may require dredge activity within the 100-foot buffer due to the nature of the action. If required, an erosion and sediment control plan would be developed and implemented during construction. Therefore, the proposed action is consistent with the Georgia Erosion and Sedimentation Act.

Georgia Water Quality Control Act – O.C.G.A. 12-5-20

"This Act makes it unlawful for any person to dispose of sewage, industrial wastes, or other wastes, or to withdraw, divert, or impound any surface waters of the State without a permit." A Spill Pollution Prevention Plan would be developed and implemented prior to the start of any construction activities. Therefore, the proposed action is consistent with the Georgia Water Quality Control Act.

Conclusion

The proposed project will have localized, minor adverse impacts on coastal resources within the existing previously disturbed project area. The proposed project will have beneficial impacts to coastal uses by reducing transportation cost inefficiencies resulting from navigation maneuverability limitations due primarily to the existing width of a channel bend near the Cedar Hammock Range and turning basin near Colonel's Island Terminal. In accordance with Section 307(c)(1) of the Federal Coastal Zone Management Act of 1972, as amended, the NPS and FHWA have determined that the proposed action is consistent to the maximum extent practicable with the enforceable policies of Georgia's approved coastal management program. This determination is based on the review of the proposed project's conformance with the enforceable policies of the State's coastal program.

Conformity

This application is submitted to ensure conformity with NOAA's Federal Consistency provisions (15 CFR 930), under which Federal agencies must determine if their proposed project directly affects Georgia's coastal zone. Georgia's coastal zone includes Glynn County.

The Corps will follow the Reasonable and Prudent Measures and the Terms and Conditions per the NMFS 2020 SARBO for any activities in Brunswick Harbor.

Actions to Reduce Impacts

The 2020 SARBO (the Opinion), which was completed in March 2020, considered the regional cumulative effects to ESA-listed species and designated critical habitat under NMFS purview for dredging and material placement projects in the South Atlantic Region. The Opinion provides a suite of measures including Project Design Criteria (PDC), assessments, and coordination that will allow the USACE to manage dredging in a manner which will reduce impacts to the overall environment in a way that is most cost effective for all federal taxpayers (not just GA residents) and most protective of the most imperiled species by avoiding or minimizing impacts to ESA-listed species and designated critical habitat. As such, this project will abide by all appropriate PDCs identified in the Opinion as well as other applicable laws, including the MMPA, MSA, FWCA, and other federal, state, or local requirements.

6.0 SEDIMENT QUALITY

The material to be dredged and placed in the Andrews Island DMCA will be new work dredged material from the Bend Widener and Turning Basin. Subsequent maintenance material will also be dredged from the area as part of routine operations. Based on the historical boring logs within the general area, it is expected that the material proposed to be removed during construction of the bend widener consists of poorly graded sands, silty sands, and highly weathered limestone. For the turning basin, expected material to be removed during construction consists of poorly graded sands, clayey sands, sandy clays, highly weathered limestone and highly plastic clays. Additional description of regional geology and materials characteristics can be found in Appendix B.

A subsurface investigation to collect geologic and geotechnical data to inform the Brunswick Harbor Modification design will occur prior to construction. Testing includes the following based on GADNR-EPD's concurrence with the Corps proposed analysis:

-20 sediment samples (1 at each boring location)
-7 elutriate samples (5 from the turning basin, 2 from the bend widener)
-2 surface water samples (Needed to compare with elutriate results, 1 from the turning basin, 1 from the bend widener)".

This investigation will also provide site specific geotechnical data for the proposed new features including the Bend Widener and the Turning Basin.

6.1 Beach Erosion

For impacts specific to the areas to be dredged under Alternative 8, no impact to the St. Simons and Jekyll Island shorelines are anticipated. The closest project location to the mouth of St. Simons sound is at the St. Simons meeting area of which, with the selection Alternative 8, 0 cubic yards of dredged material will be taken. Since the vessel meeting area located at St. Simon's Sound near the entrance channel to Brunswick Harbor is naturally deep water (>38 feet MLLW), no dredging would be required. Creating a meeting area at St. Simon's Sound would re-locate the north toe of the existing channel approximately 800 feet to the north from stations -6+800 to 4+300. The existing navigational channel centerline would not change. In addition, the project is not anticipating an increase in the frequency of vessels, more so improving the maneuverability of vessels that will already call.

6.2 Groundwater

The proposed activity under Alternative #8 focuses more so on widening rather than deepening. Normal O+M dredge operations occur on an annual basis in the South Brunswick River area and no impacts to the aquifer have been documented. No deeper dredge activity beyond the annual O+M dredge operations occurring in the South Brunswick River area is expected.

7.0 CONCLUSIONS

Therefore, in accordance with the CZMA it has been determined that the proposed project would be carried out in a manner which is fully consistent with the enforceable policies of the GCMP. This determination applies to the preferred alternative and the effects of the preferred alternative on the land or water uses or natural resources of the coastal zone.

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April 23, 2021

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RE: CZMA Federal Consistency Determination **Conditional Concurrence**: Brunswick Harbor Modifications Study and O&M Dredging, Brunswick Harbor, Glynn County, Georgia

Dear Ms. Garvey:

Staff of the Georgia Department of Natural Resources Coastal Resources Division (GADNR/CRD) Georgia Coastal Management Program (GCMP) have reviewed the revised Federal Consistency Determination, dated February 10, 2021 and received February 11, 2021, for the Brunswick Harbor Modification Study Draft Integrated Feasibility Report and Environmental Assessment and Draft Findings of No Significant Impact (BHMS). We appreciate the 15-day time extension granted by your office to April 23, 2021 to allow us to thoroughly review the project and incorporate public comments. The U.S Army Corps of Engineers (USACE), Savannah District is investigating the feasibility of navigation channel improvements in the Brunswick Harbor from St. Simons Sound to the Colonel's Island Terminal to reduce transportation cost inefficiencies experienced by the largest ship type utilizing the harbor.

Background

The BHMS was originally distributed for public and resource agency comment on June 9, 2020. The Tentatively Selected Plan, Alternative 8, described the proposed project as dredging 205,000 cubic yards (cy) of material from a 321' x 2,700' (maximum) bend widener; 346,000 cy from a 100'-170' x 1,000' turning basin expansion; and 0 cy from a naturally deep 800' x 10,000' meeting area at St. Simons Sound via cutterhead dredge. We have no issues with this proposed new work since a hopper dredge will not be used. However, the BHMS did not state that future annual operation and maintenance (O&M) dredging may be conducted via hopper dredge, known to cause lethal takes of threatened and endangered sea turtles, in the warm water months when nesting sea turtles are abundant in coastal Georgia. The GCMP did not obtain clarification that summer hopper dredging was being contemplated until October 26, 2020[1].

The BHMS states a key assumption underlying the alternatives analysis is that all dredged material is

[1] Email: Brunswick Harbor Modification: Clarification on Inclusion of O&M, Hopper Dredges, and Bed Levelers, from Kim Garvey to Kelie Moore, October 26, 2020 4:24 PM

capable of being removed using a hydraulic cutterhead dredge[2] and that the Environmental Consequences of Alternatives analysis involves actions and activities both during the construction phase and for periodic and routine maintenance dredging after construction has been completed[3]. Resource agencies reviewing the BHMS in June and July of 2020 do not appear to have been aware that summer hopper dredging was being contemplated either, with USFWS even stating in their report "Cutterhead dredges, historically known to have less ESA impacts than other dredge types, are proposed to construct this project. Neither hopper dredges nor clamshell/bucket dredges will be used." [4] Certainly the public was not aware summer hopper dredging would be incorporated into BHMS when USACE solicited public comments from June 9, 2020 – July 9, 2020.

USACE submitted a revised Coastal Zone Management Federal Consistency Determination February 10, 2021[5] that added a new section 4.0 Project Description making clear that "O&M dredging (all dredge types) would occur annually as needed based on shoaling rates", but did not expressly state it was USACE's intention to use hopper dredges or to dredge outside the previously authorized winter dredge window. The revised Appendix J implies the possibility of summer dredging by referencing the 2020 SARBO[6], which states "The Corps will follow the Reasonable and Prudent Measures (RPMs) and the Terms and Conditions (T&Cs) per the NMFS 2020 SARBO for any activities in Brunswick Harbor". The 2020 SARBO is in response to USACE's 2018 request to dredge six (6) South Atlantic channels, including Brunswick Harbor, during warmer months[7] as opposed to the winter months previously authorized by NMFS[8] and USACE South Atlantic Division[9] for hopper dredging.

The GCMP solicited public comments advertising the revised February 2021 Appendix J Federal Consistency Determination and 2020 SARBO from March 12, 2021 to March 29, 2021 and received over 1,500 public comments. Every comment received opposed hopper dredging outside the previously-authorized December 15 – March 31 winter dredge window, when sea turtle abundance is low, and that has been in place in Brunswick Harbor for over 30 years. Most comments cited increased impacts to sea turtles or other environmental damage and inconsistency with Georgia's state environmental laws and rules. This overwhelming public response to a two-week comment period underscores the highly controversial and consequential impacts of USACE's intention to shift O&M practices from the sea turtle-centric 1997 BO to the purportedly North Atlantic right whale-centric 2020 SARBO.

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[2] BHMS Section 3.7 Final Array of Alternatives, page 81
[3] BHMS Section 4.0 Environmental Consequences of Alternatives, page 84
[4] Draft Appendix I, USFWS FWCA Report, page 5.
[5] BHMS Appendix J, February 2021
[6] NOAA NMFS 2020 South Atlantic Regional Biological Opinion for Dredging and Material Placement Activities in the Southeast United States
[7] 2020 SARBO, page 321, "The USACE has stated they plan to dredge some navigation channels during warmer months, outside of the North Atlantic right whale migration season, since navigation channels require the use of high speed survey vessels that are of greatest risk of a vessel strike to North Atlantic right whales." and page 344, "The USACE stated that 6 channels (Brunswick Harbor, Savannah Harbor, Charleston Harbor, Wilmington Harbor Entrance/Inner Ocean Bar, Morehead City, and the Manteo Entrance Channel) may be dredged in the summer by hopper dredging..."
[8] 1997 NMFS Regional Biological Opinion on Hopper Dredging Along the South Atlantic Coast
[9] 1998 South Atlantic Division Corps of Engineers Hopper Dredging Protocols for Atlantic Coast FY98-03

Enforceable Policy Considerations:

The Georgia Coastal Marshlands Protection Act (CMPA) (O.C.G.A. 12-5-280 et seq.) is an enforceable policy of the GCMP but a CMPA permit is not required for the proposed project due to USACE's responsibility of "keeping rivers and harbors of this state open for navigation" [12-5-295(3)]. However, USACE acknowledges (Appendix J Section 5.0) that the guiding principles of the CMPA are applicable. As such, impacts to coastal marshlands from the proposed project should be minimized. Andrews Island Confined Dredge Material Area (CDMA) experienced intertidal erosion and vegetative saltmarsh loss (coastal resource issues covered under CMPA) at the Weir #3 outfall since its installation in 2005 for the last Brunswick Harbor deepening project. Extended use of the outfall during deepening over a period of several months led to the loss of approximately ¼ - ½ acre of *Spartina alterniflora*. While some corrective action was taken in 2009, including placement of rock along the eroding bank and under the mouth of the outfall, saltmarsh loss continues. This indirect impact was not foreseen during the 2005/2008 deepening, but additional vegetative loss is a reasonably foreseeable coastal impact if dredge material from the Brunswick Harbor modification project is placed in Andrews Island CDMA. Pre- and post-construction assessment of the intertidal mudflats and vegetative saltmarsh around the Weir #3 outfall should be conducted to determine if additional loss results from the currently proposed modification project. If post-construction assessment indicates there is a loss in this tidal area steps must be taken to restore the area and to reduce reasonably anticipated future loss from O&M dredging. Such steps may include, but are not limited to:

1. Include language in the dredging contract stating that pre- and post-construction surveys of the saltmarsh vegetation surrounding Weir #3 outfall are required (e.g. via unmanned aerial vehicle photos) and that any loss in vegetation will be rectified by restoring the area to its pre-construction elevation and replanted with *Spartina alterniflora;*
2. Place coarse, uncontaminated, material from the Turning Basin (346,000 cy material available) in the scour hole and on adjacent mudflat to an elevation that will support vegetation;
3. Extend the weir pipe past the vegetated area so source of scour is farther from vegetation;
4. Install a diffuser on the end of the pipe to reduce energy to the surrounding marsh; and/or
5. Reduce the outflow volume/rate to reduce scour energy when operating the weir.

The Georgia Endangered Wildlife Act (GEWA) of 1973[10] and Game and Fish Code[11] afford protection to Georgia's threatened and endangered sea turtles, whales and sturgeon through regulation[12] and both are enforceable policies of the GCMP. Additionally, Georgia has a Cooperative Agreement with NMFS under ESA Section 6 pursuant to both laws[13] to conserve threatened and endangered species[14]. Ongoing projects under this Agreement include North Atlantic right whale recovery efforts that specifically

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[10] O.C.G.A. 27-3-130, et seq.

[11] O.C.G.A. 27-1-1, et seq.

[12] Georgia Regulation 391-4-10, Protection of Endangered, Threatened, or Unusual Species

[13] Georgia Endangered Wildlife Act of 1973 and Georgia Game and Fish Code

[14] Limited Cooperative Agreement Between the United States Department of Commerce National Oceanic and Atmospheric Administration National Marine Fisheries Service and the Georgia Department of Natural Resources for the Conservation of Threatened and Endangered Species, October 1, 2020

mandate Georgia to review federal actions having the potential to impact right whales and provide comments and/or recommendations aimed at minimizing or eliminating impacts to them, as well as taking management steps to reduce or eliminate injury or mortality to right whales caused by ship collisions[15]. Therefore, the GCMP, as a networked program that includes all Divisions of GADNR, has an affirmative duty to conserve and minimize impacts to threatened and endangered species in coastal Georgia. The proposed project is not consistent with GEWA or the Georgia Game and Fish Code to the maximum extent practicable as described below.

Right whales

USACE (personal communication, K. Garvey) contends that summer dredging is required by the 2020 SARBO to minimize right whale interactions. However, nothing in the 2020 SARBO prevents Brunswick Harbor O&M hopper dredging from being conducted between December 15th and March 31st. The primary justification provided in the 2020 SARBO for eliminating seasonal dredging restrictions in Georgia was to shift dredging effort outside the winter right whale calving season to minimize the chance of vessel collision. The 2020 SARBO states that "ESA-listed whales [including North Atlantic right whales] are known to be susceptible to vessel strike collisions that can lead to death; however, we believe that a vessel strike is extremely unlikely and that this route of effect will be discountable based on the PDCs[16] of this Opinion"[17]. The 2020 SARBO USACE and BOEM North Atlantic Right Whale Conservation Plan (NARWCP) outlines the PDCs that USACE must follow when dredging[18], but specifies that USACE and/or BOEM will determine project timing and necessary minimization measures to reduce the risk of ESA-listed species through the Risk Based Adaptive Management Process[19]. Given that a vessel strike is extremely unlikely, NMFS' decision to incorporate in the 2020 SARBO a PDC (North American right whale avoidance PDC, NARW.1) that requires survey vessels 33 foot or greater to be scheduled outside the NARW migration and calving season (November 1 – April 30), **to the maximum extent practicable** (emphasis added) should not be erroneously interpreted by USACE as a restriction to schedule all hopper dredge projects in the summer. Note that it is only the survey vessels, and not the dredge or attendant vessels, that should be scheduled outside of the migration and calving season when practicable. Hopper dredging projects are not precluded during winter months and smaller survey vessels could be used or the surveys could be conducted prior to November 1st and/or after April 30th. In our opinion, USACE's interpretation of the 2020 SARBO intentionally and unnecessarily shifts increased risk to ESA-listed sea turtles.

USACE contends that "high speed" survey vessels are necessary for channel maintenance dredging and pose risks to right whales[20]. The available data does not support either of these arguments. First, hopper dredges have been used in Georgia channels during right whale calving season with restrictive measures in place for 30 years and with no resulting whale fatalities. The 2020 SARBO describes the only potential interaction between a whale and a dredge in the United

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[15] Implement North Atlantic Right Whale Recovery Activities in the Southeast U.S., September 11, 2016 – August 31, 2021, GADNR Wildlife Resourced Division, FY16FFO#: NOAA-NMFS-SE-2016-200489

[16] Project Design Criteria

[17] 2020 SARBO, page 122

[18] 2020 SARBO, Appendix F

[19] 2020 SARBO, page 520 and 593

[20] 2020 SARBO, page 321 and 327

States in 2005, but a dead or injured whale was not observed, and the encounter was never verified. The incident is also contested by USACE as a confirmed collision[21]. Second, "high speed surveys vessels" are not required for dredging operations (survey and transit) in Georgia. Survey vessels can travel at a range of speeds including slower speeds ($\leq$ 10 knots) where they will not pose a threat to right whales when transiting an active Seasonal Management Area (SMA) and most survey work is conducted at speeds less than 10 knots. High speed survey vessels pose a higher threat of killing or injuring whales[22]. However, St. Marys Entrance Channel was not one of the six (6) channels USACE proposed for summer dredging. According to 2020 SARBO it can be dredged during any month if deemed appropriate based on the initial risk assessment analysis[23]. If the initial risk assessment for the St. Marys Entrance Channel using a high speed survey vessel has been deemed suitable for winter dredging, despite that it is one of three (3) channels with the highest documented right whale abundance during calving season, it is reasonable to assume the risk assessment for Brunswick Harbor, which uses much smaller survey vessels that are not required to transit offshore, would be even more favorable for winter dredging.

Nothing in the Endangered Species Act prevents USACE from adopting additional management measures that are more restrictive than those contained in the 2020 SARBO. The North American right whale minimization PDC, NARW.3, is a collection of dynamic speed reduction measures which only apply when whales are sighted near project vessels. These will not mitigate vessel strike risk as well as the static, seasonal measures contained in the NOAA Right Whale Vessel Speed Rule[24] that apply to all other commercial vessels 65 feet or greater in length. NOAA exempted federal agencies and their contractors from the Right Whale Vessel Speed Rule with the justification that federal operations would be mitigated through ESA Section 7 consultations[25]. Right whales can be present any time SMAs are active and the 2020 SARBO does not require any speed reductions within the Mid-Atlantic SMAs. In our opinion, it does not make sense environmentally for a dredge contractor that is not hired by a federal agency to follow the Vessel Speed Rule but be exempted from the same Vessel Speed Rule when hired by a federal agency. USACE can adopt the Vessel Speed Rule for BHMS dredging without violating any 2020 SARBO requirements. Furthermore, future amendments to the NOAA Right Whale Vessel Speed Rule should be incorporated automatically into BHMS, including changes to the size of regulated vessels, SMA boundaries, and SMA seasons. All vessels associated with BHMS dredge operations should be equipped with functional automatic information systems (AIS) so that speeds can be monitored for compliance.

Based on the discussion above the GCMP finds USACE's interpretation of the 2020 SARBO as a mandate for summer dredging to minimize right whale interactions, while not incorporating the Vessel Speed Rule for dredging projects that is known to minimize right whale vessel interactions and shifting risk to ESA-listed sea turtles during higher abundance periods to be inconsistent with the Georgia's

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[21] 2020 SARBO, page 124, "One report occurred in South Africa in 1984 involving a Southern right whale and the other report occurred in Brunswick Harbor (within the action area) in 2005, though the report is contested by the USACE".

[22] 2020 SARBO, page 327

[23] 2020 SARBO, page 327

[24] 50 CFR 224.105

[25] 73 FR 60181, October 10, 2018

enforceable policies to the maximum extent practicable as defined in 15 CFR 930.32.

Sea Turtles

The proposed project does not minimize reasonably foreseeable effects to sea turtles because the removal of seasonal dredging windows may result in increased mortality that may affect population recovery of the loggerhead sea turtle Northern Recovery Unit (NRU). We disagree with USACE's interpretation of the 2020 SARBO as having the discretion to eliminate hopper dredging windows in Georgia for the first time in decades in that the 2020 SARBO is insufficient to accurately determine that reasonably foreseeable effects to Georgia's loggerhead sea turtle population have been minimized to the maximum extent practicable[26]:

1. The 2020 SARBO allows the take of 214 loggerhead sea turtles over a 3-year rolling average[27] based on the number of loggerhead nests within the Northwest Atlantic Ocean Distinct Population Segment (DPS)[28]. This assumes a homogenous population evenly distributed throughout the South Atlantic Division to which the SARBO applies. The NW Atlantic DPS includes five (5) distinct Recovery Units that are geographically and genetically identifiable, each of which is essential to the recovery of the species[29]. If even one Recovery Unit does not recover, the entire species cannot recover. There are approximately 71,000 loggerhead nests in the NW Atlantic DPS and 80% occur in southeastern Florida[30]. Given a take limit of 214 loggerheads from the 71,000 DPS, the 2020 SARBO allows 0.003 or 3/1,000 loggerheads to be taken over a 3-year period, or approximately 1/1,000 annually.

   The Northern Recovery Unit (NRU) spans from the Florida-Georgia border to southern Virginia and encompasses all six (6) channels for which USACE has proposed summer dredging. With a population of just over 5,000 nests[31] and no distinction between recovery units in the SARBO, all 214 could be taken from the NRU at a rate of 0.04 or 4/100 over a 3-year period, which is 13 times higher than SARBO found acceptable for the NW Atlantic DPS as a whole. The proposed project *disproportionately shifts impacts* from Florida's Peninsular Recovery Unit to Georgia's NRU loggerhead population by analyzing the NW Atlantic DPS as a whole. The USACE has not determined the reasonably foreseeable effects the proposed project will have on the NRU and has not proposed any specific mitigation measures to offset this disproportionate impact shift.

2. The 2020 SARBO does not take seasonal age-class abundance into account. Loggerhead turtles

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[26] *Ocean Mammal Inst. V. Gates*, 546 F. Supp. 2d 960, 981-82 (D. Haw. 2008) *modified*, No. CV 07-00254 DEA-LEK, 2008 WL 11348364 (D. How. Mar. 19, 2008), and *modified in part*, No. CIV. 07-00254DAELEK, 2008 WL 2020406 (D. Haw. May 9, 2008)

[27] 2020 SARBO, page 352, Table 46

[28] Personal communication, Debby Scerno, USACE SAD, March 16, 2021

[29] Fish and Wildlife Service, North Florida Ecological Services Office, Listing Status and Biological Information of Loggerhead Sea Turtles, https://www.fws.gov/northflorida/Sea_Turtles/ : Northern Recovery Unit = 5,215; Peninsular Florida Recovery Unit = 64,513; Dry Tortugas Recovery Unit = 246; Northern Gulf of Mexico = 906; Greater Caribbean = not available but under 1,000; Total = approximately 71,000.

[30] NMFS & USFWS, Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle, 2nd Revision, 2008

[31] 5,215 nests

occur in Georgia ship channels year-round and abundance is low during the winter months (15 December-31 March), increases in early spring (1 April) and peaks during the fall (September)[32]. Adult nesting loggerheads are found in ship channels from 1 April through 31 August. Hopper dredging in Georgia during the cold water dredge window (December 15 – March 31, typically 16°C or below water temperature) that has been in place for over 30 years based on previous SARBOs, impacted primarily juvenile loggerhead turtles since egg-bearing females are not present during that period. Given the size of the NRU population, it's unlikely that the potential loss of 214 benthic juvenile loggerheads over 3 years will influence population recovery. The loss of 214 adult female loggerheads over a 3-year period; however, could result in NRU population decline or declines in local populations adjacent to shipping channels. Based on genetic data collected from loggerhead nests, 2,022 females used Georgia beaches over the most recent 3-year period (2017-2019). The 2020 SARBO allows the USACE to legally take approximately 11% (214/2,022) of the adult female nesting population in Georgia over a 3-year period. The number of loggerhead females using beaches adjacent to the Brunswick ship channel (Jekyll, St. Simons, Sea Island) and the Savannah ship channel (little Tybee, Tybee, Daufuskie, Hilton Head Island) was 245 and 456, respectively. The SARBO allows the USACE to legally take up to 87% (214/245) and 47% (214/456) of the females nesting in the vicinity of the Brunswick and Savannah ship channels over a 3-year period. Data was not available from Florida beaches at the writing of this summary, so a similar estimate could not be generated for the St. Marys Entrance channel. Georgia has three (3) ship channels which means a significant proportion of Georgia's sea turtle nesting population may be affected by hopper dredge mortality. This level of mortality could lead to significant declines in local loggerhead nesting populations. In our opinion, USACE has not assessed the impact of the proposed project on adult nesting females in Georgia or how mitigation measures will reduce takes of this segment of the population.

3. A recent summer dredging project conducted by USACE in Brunswick and Savannah channels resulted in high mortality of sea turtles. Two (2) dredges began work in Brunswick on 1 September 2009. Four (4) loggerheads were killed in nine (9) days of dredging and the project was discontinued there. One of the loggerheads had an estimated straight carapace length (SCL) of 81.5 cm (presumed subadult or adult). Dredging began in Savannah on 11 September 2009 after 12 hours of open net trawling. Two (2) loggerheads were killed in six (6) days of dredging. One of the animals was considered adult sized. Overall, six (6) loggerheads were taken in 15 days of dredging. The catch per unit effort (CPUE) for the summer demonstration project was 0.000020 turtle mortalities/cu yd (6/292,734 cu yd), over eight (8) times higher than the overall CPUE for sea turtle mortality during the winter dredging window (0.0000024). The hypothesis put forth by Dickerson et al. 2007 that capture rates of sea turtles may be lower in the summer due to higher activity rates and less time on the bottom was not supported by this study. Overall, the study showed that capture rates of turtles were substantially higher during the summer/fall than winter months[33].

[32] Dickerson, et al., 1995
[33] February 22, 2021. Memorandum, Mark Dodd to Kelie Moore

4. GADNR recently collaborated with the University of Georgia Warnell School of Forestry and Natural Resources USGS Georgia Cooperative Fish and Wildlife Unit, North Carolina Wildlife Commission and South Carolina DNR to develop a Bayesian integrated population model for NRU loggerhead turtles that allows prediction of the population trajectory into the future[34]. Modeling exercises predict that the population will plateau and possibly decline slightly as a result of lack of recruitment from low nesting in the early 2000s.[35] The model is particularly sensitive to adult female mortality and suggests that, at a minimum, protections for reproductive age loggerheads should stay in place over the next 20 years to ensure the population does not decline from current levels. Loggerhead turtles are not sexually mature until approximately 30 years of age. Other species of concern in Georgia (Atlantic sturgeon and right whales) are sexually mature at an average age of 8-10 years. If all current management protections stay in place, including limiting hopper dredging to winter months, the NRU population is expected to remain stable or decline slightly until hatchlings from increased nesting recorded over the past 10 years become mature in 2040[36].

5. The U.S. Army Engineer Research and Development Center (ERDC) tested several shapes of bed-leveling devices in 2012 as a means of reducing sea turtle injury or mortality during dredging operations. They determined that devices designed to create a sand wave intended to disturb sea turtles off the channel bottom and away from the bed leveler, and that did not have any structure that could serve as "pinch points" for impinging sea turtles, were most effective[37]. The specific design analyzed in a 2012-2014 Brunswick Harbor Study weighed 40,000 pounds and was 32' long by 4' high. It specifically incorporated an 11.5" strip of steel welded along the bottom length angling approximately 45 degrees forward of the blade and metal plate additions extending two feet on either side of the blade in front of the secondary attachment points, which could potentially serve as "pinch points"[38]. This 'Brunswick Harbor' design is specified as meeting 2020 SARBO criteria[39] and is a mitigation measure that should be considered by USACE to minimize effects to sea turtles in this proposed project.

The 2020 SARBO allows substantial and significant differences when compared to the 1997 SARBO and shifts risk between endangered species. There may be consequential and controversial impacts of the proposed project that we feel have not been adequately evaluated by USACE. Under the 1997 SARBO, USACE retained flexibility, within defined seasonal dredging windows, to decide when and where a project would occur and the equipment type that would be used for a particular project. USACE South Atlantic Division (SAD) developed a *Risk Assessment and Risk Management Plan* to help guide the

[34] October 21, 2020.l An integrated population model for loggerhead sea turtles in the Northern Recovery Unit, Nuse, Dodd & Shamblin

[35] October 21, 2020.l An integrated population model for loggerhead sea turtles in the Northern Recovery Unit, Nuse, Dodd & Shamblin, Appendix 1

[36] February 22, 2021 Memorandum, Mark Dodd to Kelie Moore

[37] Bed Leveler Evaluation Report, U.S. Army Corps of Engineers, Savannah District, January 2015

[38] USACE Savannah District, Bed Leveler Evaluation Report, January 2015, Section 2.0 Evaluation Procedures and Methods

[39] 2020 SARBO Section 3.4 Bed-Leveling Requirements LEVEL.1, page 532

decision-making process and to address circumstances which may have contributed to incidental take. The Plan included documenting how required hopper dredge conditions were met, etc.[40] This Plan has been used post-project to inform the adaptive management process.

The 2020 SARBO formalizes and expands the risk assessment process by requiring USACE to prepare a pre-construction risk assessment, including timing considerations, that minimize the risk of impacts to ESA-listed species based on project-specific timing, location, and equipment[41]. The pre-construction risk assessment for BHMS should include review of the Loggerhead Recovery Team Assessment of Progress Toward Recovery (2019)[42] and the Bayesian integrated population model for NRU[43] to overcome insufficient analyses in the 2020 SARBO for loggerhead sea turtles based on the NW Atlantic DPS.

We find that the June 2020 Draft Integrated Feasibility Report and Environmental Assessment and Draft Findings of No Significant Impact, along with the February 2021 Coastal Zone Management Federal Consistency Determination Appendix J, do not adequately address the increased risk to Georgia's sea turtle population, do not provide justification for changing from the winter hopper dredge window that has been successful in Georgia for over 30 years in minimizing and balancing impacts to North Atlantic right whales, loggerhead sea turtles, and sturgeon, and have not shown that changing to a summer hopper dredging window will have similar or less reasonably foreseeable impacts to those resources.

The USACE's apparent sole reliance on the 2020 SARBO to accurately determine that reasonably foreseeable effects to Georgia's loggerhead sea turtle population have been minimized[44] is insufficient and not consistent with the Georgia Endangered Wildlife Act and Game and Fish Code's mandates. Furthermore, USACE did not demonstrate how the proposed use of hopper dredges in Georgia during warm water months will protect sea turtles from takes such that Georgia's loggerheads will not be disproportionately affected, and how 2020 SARBO risk management metrics have been incorporated, makes it clear that the proposed project is not consistent to the maximum extent practicable.

Conclusions
The Coastal Zone Management Act was intended to cause substantive changes in federal agency decision-making within the context of discretionary powers residing in such agencies[45]. The BHMS has not proposed to incorporate a seasonal hopper dredge window to minimize impacts to loggerhead turtles

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[40] 2020 SARBO, page 69, Section 2.9.1. History of Adaptive Management

[41] 2020 SARBO, page 70, Section 2.9.2.2. SARBO Risk Assessment and Risk Management Process

[42] National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2019. Recovery plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle (Caretta caretta) Second Revision (2008). Assessment of progress toward recovery. Silver Spring, MD. 21 pp.

[43] October 21, 2020.I An integrated population model for loggerhead sea turtles in the Northern Recovery Unit, Nuse, Dodd & Shamblin

[44] *Ocean Mammal Inst. V. Gates*, 546 F. Supp. 2d 960, 981-82 (D. Haw. 2008) *modified*, No. CV 07-00254 DEA-LEK, 2008 WL 11348364 (D. How. Mar. 19, 2008), and *modified in part*, No. CIV. 07-00254DAELEK, 2008 WL 2020406 (D. Haw. May 9, 2008)

[45] 15 CFR 930.32(a)(2)

or provided adequate analysis that the elimination of a seasonal hopper dredge window will also minimize or not increase reasonably foreseeable impacts to loggerhead sea turtles in the Northern Recovery Unit in compliance with Georgia's Endangered Species Act and Fish and Game Code. The BHMS has not proposed to incorporate static vessel speed reductions for dredge vessels in active Seasonal Management Areas or provided adequate analysis that dynamic speed reductions for dredge operations in only the Southeast SMA will minimize or not increase reasonably foreseeable impacts to North Atlantic right whales in compliance with Georgia's Endangered Species Act and Fish and Game Code.

The 2020 SARBO requires the USACE team to conduct a preconstruction risk assessment for each proposed project to evaluate project-specific risks and minimization measures. Planning projects to minimize the risk of impacts to ESA-listed species based on specific timing, location, and equipment used, as appropriate, is required. The assessment must include interactions with species expected to be present and the history of interactions at a project site. The preconstruction assessment must consider species population assessments and recovery plans.[46] All of this information arguably leads to a defensible prediction of the reasonably foreseeable impacts to Georgia's coastal resources and we feel should have been the basis for the federal consistency determination. We requested additional information in March 2021, including a copy of the annual list of upcoming projects, pre-construction risk assessment (including the relevant minimization measures)[47], most recent regional dredge contract[48], and USACE's original ESA consultation request letter that led to development of 2020 SARBO[49]. None of this information has been provided to date. This leaves us no choice but to recommend as alternative measures those standard conditions and seasonal dredge window restrictions that have been used successfully in previous years.

The action agency is required to comply with enforceable policies of the GCMP to the maximum extent practicable. The phrase "consistent to the maximum extent practicable" means "fully consistent with the enforceable policies of management programs unless full consistency *is prohibited by existing law* applicable to the Federal agency."[50] In other words, "whenever legally permissible, Federal agencies shall consider the enforceable policies of management programs as requirements to be adhered to in addition to existing Federal agency statutory mandates."[51] Although the 2020 SARBO *recommends* that hopper dredging occur outside winter months to avoid North American Right Whale calving season, it acknowledges that dredging outside winter months may not be practicable.[46] Because the 2020 SARBO acknowledges that winter dredging is permissible under these circumstances, the SARBO is not an adequate legal basis to depart from the enforceable policies of the GCMP.

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[46] 2020 SARBO Appendix J, Section 1.B and 1.D
[47] March 23, 2021 BHMS Federal Consistency Additional Information Request: Pre-Construction Risk Assessment & Annual Proposed Project List for Georgia
[48] March 30, 2021 BHMS Federal Consistency Additional Information Request: Regional Dredging Contract
[49] March 30, 2021 BHMS Federal Consistency Additional Information Request: ESA Consultation Request Letter
[50] 15 CFR 930.32(a)(1)
[51] 15 CFR 930.32(a)(2)

The Georgia Coastal Management Program **conditionally concurs** that the BHMS may be revised to be consistent to the maximum extent practicable upon USACE's inclusion of the conditions described below. Adoption of these long-standing and proven alternative measures aimed at reducing reasonably foreseeable impacts to Georgia's coastal resources would allow the proposed project to be consistent with Georgia's enforceable policies to the maximum extent practicable.

Alternative Measures/Conditions:

1. Include language in the dredging contract that pre- and post-construction surveys will document vegetation surrounding Weir #3 outfall at Andrews Island (e.g. via UAV photos) and any loss of elevation or vegetation will be restored;
2. Notify GCMP of any modifications to the proposed activity;
3. All hopper dredging activities are restricted to 15 December through 31 March unless prior approval, based on extraordinary justification, is obtained from GCMP;
4. Hopper dredges must have 100% inflow and overflow screening with a maximum opening size of 4" x 4" unless adjustments are made for safety due to clogging. USACE will provide notification to GADNR/WRD when screen sizes are increased or screens are removed that will include an explanation of what attempts were made to reduce the clogging problem and how long the problem may persist;
5. Hopper dredge inspection checklists must be provided to GADNR/WRD prior to commencing dredging;
6. Hopper dredges must have NMFS-approved protected species observers onboard while operating. USACE must notify GADNR/WRD if conditions limit the ability to safely monitor dredging operations;
7. Sea turtle takes must be reported to GADNR/WRD within 24 hours and animals should be transported to GADNR/WRD staff when requested for necropsy;
8. GADNR/WRD personnel shall be allowed onboard each hopper dredge at least once during each dredge event. USACE personnel must coordinate access to hopper dredges for GADNR/WRD personnel within a reasonable timeframe of request, not to exceed three (3) business days;
9. Contact information for Savannah District Corps access coordinators must be provided to GADNR/WRD prior to each dredging event;
10. Bed leveling equipment may not be used unless it is a "Brunswick Harbor" design that includes a 45 degree blade across the bottom or it is a design that has been tested in waters clear enough to determine if it produces a sand wave in front of the leading face of the device such that it disturbs sea turtles off the sea/channel floor bottom and is approved by GADNR/WRD;
11. All vessels 65 feet in length or greater engaged in dredging projects must follow the NOAA Right Whale Vessel Speed Rule. Any future amendments to the NOAA Right Whale Vessel Speed Rule are automatically incorporated into this authorization; and
12. Automatic Information Systems (AIS) must be properly installed and operational on all dredges and project vessels 33 feet in length or greater.

The Brunswick Harbor Modification Study for which the federal consistency determination was developed[52] includes the entire limit of the maintained federal channel, extending approximately 11 miles offshore and includes areas outside State of Georgia waters[53]. The GCMP enforceable policies listed above are applicable to all areas of the project. The alternative measures listed above, which if adopted by USACE to allow the Brunswick Harbor Modification and O&M project to proceed in a manner that is consistent to the maximum extent practicable, would also be applicable to those areas of the proposed project outside of State of Georgia waters. This means that hopper dredges working in the outer harbor channel would be restricted to the colder water dredge window if these alternative measures are adopted by USACE.

Pursuant to 15 C.F.R. § 930.43(a)(1), if USACE does not agree to the above conditions, then all parties shall treat this conditional concurrence letter as an objection. You must immediately notify us if the alternative measures/conditions are not acceptable [15 C.F.R. § 930.43(a)(2)]. We may use the remainder of the 90-day review period, through May 10th, to resolve any differences [15 C.F.R. § 930.43 (d)]. If we have not reached resolution by May 11, 2021 and you treat this as an objection, you shall not proceed with the activity unless:

1. 15 C.F.R. § 930.43(d)(1): You have concluded under the "consistent to the maximum extent practicable" standard described in section 930.32 that consistency with enforceable policies of the management program is prohibited by existing law applicable to USACE and clearly describe, in writing, to GCMP the legal impediments to full consistency [930.32(a) and 930.39(a)], or
2. 15 C.F.R. § 930.43(d)(2): You have concluded that the project is fully consistent with the enforceable policies of the management program, though GCMP objects, and
3. 15 C.F.R. § 930.43(e): if USACE decides to proceed with the project that is objected to by GCMP, or to follow the alternatives suggested above, USACE must notify GCMP of the decision to proceed before the project commences.

General Comments Not Subject to Federal Consistency:
The GCMP is compelled to mention the following procedural deficiencies that are not contemplated in the federal consistency determination above. First, USACE is required to prepare an Environmental Assessment (EA) to determine if a project will have any significant environmental impacts under NEPA. If the EA shows that significant environmental impacts might result, USACE must prepare an Environmental Impact Statement (EIS) to evaluate environmental impacts. The 2020 SARBO allows substantial and significant differences when compared to the 1997 SARBO and increases risk to sea turtle species. These are consequential and controversial differences that may have population level impacts, and an Environmental Assessment is not sufficient to adequately evaluate these impacts. The proposed project represents a significant change to the management of Georgia's sea turtles and should require the preparation of an EIS.

In addition, the USFWS Fish and Wildlife Coordination Act (FWCA) Report for the BHMS is not valid. The scope of the project has expanded to include the use of hopper dredges for channel maintenance

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[52] Brunswick Harbor Modifications Study, Glynn County, GA, Draft Integrated Feasibility Report and Environmental Assessment and Draft FONSI, June 2020

[53] 15 CFR 930.33(c)

dredging since the initial review by USFWS. This represents a substantial change, and USFWS should reconsult to assess the effects of the project on species under their purview.

Finally, USACE did not provide adequate opportunity for public comment on the EA. The full scope of the project, including USACE's intention to eliminate the use of hopper dredging windows, was not provided to the public during the comment period.

The GCMP urges USACE to modify the proposed project, specifically Operations and Maintenance, to incorporate the alternative measures outlined and submit a revised federal consistency determination. We welcome continued discussion to resolve these matters so that the project can move forward in an expeditious and environmentally responsible manner.

Please contact Jason Lee at (912) 262-3128 with GADNR/WRD if you have technical questions regarding Georgia wildlife, or Kelie Moore at (912) 262-2334 if you have questions about GCMP federal consistency provisions.

Sincerely,

Doug Haymans
Director

DH/km

Enclosures:

November 3, 2020 Draft Federal Consistency Determination Conditional Concurrence
October 21, 2020 Northern Recovery Unit Loggerhead Genetic Demographic Project Final Report
January 2015, FY14 Bed Leveler Evaluation Final Report
FY98-FY03 South Atlantic Division Hopper Dredging Protocol for Atlantic Coast
March 15, 2021 Brunswick Harbor Supplemental Information
March 15, 2021 Brunswick Harbor Items for Discussion
February 22, 2021 GADNR Memo on USACE Summer Dredging Concerns, M. Dodd
October 21, 2020 NUSE Loggerhead Final Report
October 1, 2020 Limited Cooperative Agreement
September 1, 2007 Cooperative Agreement
GADNR FY16-20 Right Whale Project Description with Amendments
March 29, 2021 BHMS FCD Time Extension Request
March 23, 2021 BHMS Federal Consistency Additional Information Request: List of Upcoming Projects & Pre-Construction Risk Assessment with Minimization Measures
March 30, 2021 BHMS Federal Consistency Additional Information Request: Regional Dredging Contract
March 30, 2021 BHMS Federal Consistency Additional Information Request: ESA Consultation

Request Letter

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MARK WILLIAMS
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November 3, 2020

Ms. Kim Garvey, Chief
USACE Savannah District Planning Branch
CESAS-PD.SAS@usace.army.mil
Kimberly.L.Garvey@usace.army.mil

RE: CZMA Federal Consistency Determination **Conditional** Concurrence: Brunswick Harbor Modifications Study, Brunswick Harbor, Glynn County, Georgia

Dear Ms. Garvey:

Staff of the Georgia Department of Natural Resources Coastal Resources Division (GADNR/CRD) Georgia Coastal Management Program (GCMP, the Program) have reviewed your June 9, 2020 letter requesting concurrence with the federal consistency determination contained in the June 2020 Brunswick Harbor Modification Study Draft Integrated Feasibility Report and Environmental Assessment and Draft Findings of No Significant Impact (The Study). We appreciate the time extension granted August 4, 2020 based on receipt of the Section 401 Water Quality Certification. The U.S Army Corps of Engineers (USACE), Savannah District (the Corps) is investigating the feasibility of navigation channel improvements in the Brunswick Harbor from St. Simons Sound to the Colonel's Island Terminal to reduce transportation cost inefficiencies experienced by the largest ship type utilizing the harbor.

The Tentatively Selected Plan, Alternative 8, includes dredging 205,000 cubic yards (cy) of material from a 321' x 2,700' (maximum) bend widener; 346,000 cy from a 100'-170' x 1,000' turning basin expansion, and 0 cy from a naturally deep 800' x 10,000' meeting area at St. Simons Sound. Dredge material from the bend widener would first be considered for beneficial use (BU) on Bird Island. Otherwise it will be placed in the Andrews Island Dredge Material Containment Area (DMCA). It is expected that all dredge material from the turning basin expansion will be placed in Andrews Island DMCA. Beneficial use has been considered, but no suitable location has been identified. Additional borings and sediment data will be collected from the area to be modified as part of the feasibility-level engineering design and included in a final report. Sampling and analysis of new work sediments will be conducted to determine the presence of contaminant levels[1]. New work material will be removed using a hydraulic cutterhead dredge[2]. Future operation and maintenance (O&M) dredging of the modified Brunswick Harbor is incorporated into the proposed activity[3] and may include use of a hopper dredge[4]

The Program **conditionally concurs** that the Brunswick Harbor Modification Study may be revised to be consistent to the maximum extent practicable with the GCMP upon the Corps' inclusion of the conditions described below. Primarily, the March 2020 South Atlantic Regional Biological Opinion for Dredging and Material Placement Activities in the Southeast United States (2020 SARBO) disregards long-standing measures aimed at reducing reasonably foreseeable impacts to Georgia's coastal resources and is not consistent with enforceable policies of the Program and the alternative measures described below. The proposed project must be fully consistent with the enforceable policies unless full consistency is prohibited by existing law applicable to the Corps[5]. The Coastal Zone Management Act was intended to cause substantive changes in federal agency decision-making within the context of discretionary powers residing in such agencies[6].

We strongly support BU of uncontaminated dredge material. As such, the State of Georgia adopted the River and Harbor Development Act[7] into law and as an enforceable policy of the GCMP in 2005. We request that you expand the federal consistency determination[8] to include this law in the Final Environmental Assessment (FEA). This Act directs the Department to determine the criteria for BU. Grain size analyses (percent sand, clay and silt) must be conducted to determine if material can be used beneficially, and materials containing a majority (51%) of sand should be considered for BU. The Act also requires cost estimates (the cost over and above the Federal Standard) for beneficially using suitable material to determine if BU projects are feasible. If sediment sampling and analysis determines the material is free of contaminants and the Corps wishes to proceed with a BU placement option, we request the Corps submit a supplemental federal consistency determination that fully describes the BU in detail.

The Study includes marsh thin layer placement (TLP) as a potential BU[9]. Georgia partnered with the Corps in 2019 to construct a 5-acre TLP demonstration project on Jekyll Island to beneficially use dredge material

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[1] EPD Water Quality Certification item 3, October 26, 2020
[2] Brunswick Harbor Modifications Study, Glynn County, GA, Draft Integrated Feasibility Report and Environmental Assessment and Draft FONSI, June 2020, Section 5.2 Dredging and Dredged Material Management
[3] Brunswick Harbor Modifications Study, Glynn County, GA, Draft Integrated Feasibility Report and Environmental Assessment and Draft FONSI, June 2020, Section 4.0 Environmental Consequences of Alternatives
[4] Personal communication, Kim Garvey, October 26, 2020.
[5] 15 CFR 930.32(a)(1)
[6] 15 CFR 930.32(a)(2)
[7] O.C.G.A. 52-9-1
[8] Brunswick Harbor Modifications Study, Glynn County, GA, Draft Integrated Feasibility Report and Environmental Assessment and Draft FONSI, June 2020, Appendix J
[9] Brunswick Harbor Modifications Study, Glynn County, GA, Draft Integrated Feasibility Report and Environmental Assessment and Draft FONSI, June 2020, Section 4.8 Cultural Resources, Future Condition with Alternative 2

from the Atlantic Intracoastal Waterway (AIWW). This is the first time this technique has been used in Georgia in a controlled environment that includes extensive (multi-year) data collection to evaluate its merits and/or impacts. It has not yet been determined if this is a successful BU approach for Georgia and we do not recommend TLP as a BU option at this time.

The St. Simons Sound Meeting Area expansion appears to encompass the naturally deep hole that was used to place dredge material from the Jekyll Creek section of the AIWW in 2019 as a BU project[10]. If this placement site falls into the expanded Federal Project, can it be used for future disposal of Jekyll Creek material and would additional permitting be required (e.g. Section 408) that could delay the project? We request this be addressed in the FEA as a potential secondary impact (i.e. time delays for permitting and/or loss of an AIWW disposal site).

The Coastal Marshlands Protection Act[11] (CMPA) listed in the Study[12] is an important law regulating dredging and other activities in coastal marshlands and tidal waterbottoms to ensure that values and functions are not impaired by these activities. The Corps is specifically exempt from obtaining a permit under this law[13] and the Study[14] should be updated to reflect that. The Act should remain listed as a relevant enforceable policy even though an actual permit will not be required, since the guiding principles to safeguard the loss of values and functions remains applicable to this project.

Andrews Island Dredged Material Containment Area (DMCA) experienced intertidal erosion and vegetative saltmarsh loss (coastal resources covered under CMPA) at the Weir #3 outfall since its installation in 2005 for the last Brunswick Harbor deepening project. Extended use of the outfall during deepening over a period of several months led to the loss of approximately ¼ - ½ acre of *Spartina alterniflora*. While some corrective action was taken in 2009, including placement of rock along the eroding bank and under the mouth of the outfall, saltmarsh loss continues. This indirect impact was not foreseen during the 2005/2008 deepening, but additional vegetative loss is a reasonably foreseeable coastal impact if dredge material from the Study is placed in Andrews Island DMCA. Pre- and post-construction assessment of the intertidal mudflats and vegetative saltmarsh around the Weir #3 outfall should be conducted to determine if additional loss results from the currently proposed modification project. If post-construction assessment indicates there is a loss in this tidal area steps must be taken to

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[10] Placement area approximately 800' x 1,700' with center at 31.131486 x -81.401328
[11] O.C.G.A. 12-5-280 et seq.
[12] Brunswick Harbor Modifications Study, Glynn County, GA, Draft Integrated Feasibility Report and Environmental Assessment and Draft FONSI, June 2020, Appendix J, Federal Consistency Determination, Section 4.0 Effects of Proposed Project - Relevant Enforceable Policies
[13] O.C.G.A. 12-5-295(3)
[14] Brunswick Harbor Modifications Study, Glynn County, GA, Draft Integrated Feasibility Report and Environmental Assessment and Draft FONSI, June 2020, Appendix J, Federal Consistency Determination, Section 4.0 Effects of Proposed Project – Required State, Federal, and Local Permits

restore the area and to reduce reasonably anticipated future loss from O&M dredging. Such steps may include, but are not limited to:

- Include language in the dredging contract that pre- and post-construction surveys of the saltmarsh vegetation surrounding Weir #3 outfall is documented (e.g. via unmanned aerial vehicle photos) and any loss in vegetation will be rectified by restoring the area to its pre-construction elevation and replanted with *Spartina alternaflora;*
- Place coarse, uncontaminated, material from the Turning Basin (346,000 cy material available) in the scour hole and on adjacent mudflat to an elevation that would support vegetation;
- Extend the weir pipe past the vegetated area so source of scour is further from vegetation;
- Install a diffuser on the end of the pipe to reduce energy to the surrounding marsh; or
- Reduce the outflow volume/rate to reduce scour energy when operating the weir.

The Georgia Endangered Wildlife Act (GEWA) of 1973[15] and Game and Fish Code[16] afford protection to Georgia's threatened and endangered sea turtles through regulation[17]. Green sea turtles are listed as threatened[18] and Loggerhead sea turtles, Leatherback sea turtles, Hawksbill sea turtles, and Kemp's Ridley sea turtles are listed as endangered[19]. Loggerheads were originally listed as threatened in Georgia and their status was upgraded to endangered in 2006 due to significant declines in nesting. Under GEWA, any activities which are intended to harass, capture, kill or otherwise directly cause the death of any protected animal species are prohibited, except as specifically authorized by law or regulation adopted by the Board of Natural Resources[20]. To protect sea turtle species from mortality incidental to otherwise legal activities, sea turtles and their eggs have been defined as Game Animals under the Georgia Game and Fish Code[21]. It is unlawful to hunt game species except in accordance with rules and regulations established by the Board of Natural Resources[22]. Hunting[23] is further defined as pursuing, shooting, killing, taking or capturing wildlife[24]. The Board has not promulgated any rules or regulations defining hunting seasons for sea turtles, which effectively protects them from directed and incidental take. We request that you expand the federal consistency determination[25] to include the Georgia Game and Fish Code in the FEA.

[15] O.C.G.A. 27-3-130
[16] O.C.G.A. 27-1-1, et seq.
[17] Georgia Regulation 391-4-10, Protection of Endangered, Threatened, Rare or Unusual Species
[18] Georgia Regulation 391-4-10-.09(3)(b)
[19] Georgia Regulation 391-4-10-.09(3)(a), (d), (f), and (m), respectively
[20] Georgia Regulation 391-4-10-.06(a)(1)
[21] O.C.G.A. 27-1-2(34)
[22] O.C.G.A. 27-1-3(f)
[23] O.C.G.A. 27-1-2(39)
[24] O.C.G.A. 27-1-2(77)
[25] Brunswick Harbor Modifications Study, Glynn County, GA, Draft Integrated Feasibility Report and Environmental Assessment and Draft FONSI, June 2020, Appendix J

Historically, southeastern shipping channels have been maintained by using trailing suction hopper dredges. Hopper dredges have been used for past Brunswick Harbor O&M activities and pose a greater risk of reasonably foreseeable effects to sea turtles than other types of dredges. In 1991, protected species observers were placed on hopper dredges and documented significant sea turtle mortality associated with channel maintenance dredging in the Savannah, Brunswick, and Charleston ship channels. National Marine Fisheries Service (NMFS) determined that the observed level of mortality could jeopardize the continued existence of sea turtles. A Biological Opinion was developed with reasonable and prudent alternatives to unrestricted dredging which included a requirement to dredge during the colder months when sea turtles are known to be less abundant. The winter dredging windows were adjusted several times over the following seven (7) years using sea turtle mortality data collected by observers on dredges.

In 1998 the Corps' South Atlantic Division (SAD) developed a protocol based on negotiation with southeastern state resource agencies that restricted hopper dredging in southeast channels to 15 December-31 March annually. During the same period the Corps', NMFS and other agencies developed protocols to mitigate risk to right whales, including the Early Warning System (EWS) aerial surveys, speed measures for hopper dredges and requirements for dredge observers to report all whale sightings and collisions. For over two decades the Corps' successfully maintained shipping channels for commerce while simultaneously restricting dredging activities to the winter months to protect sea turtles. No lethal or injurious collisions between right whales and hopper dredges or dredge support vessels were confirmed during that time.

In 2009 the Corps conducted a demonstration project to assess the effects of hopper dredging activity on sea turtles in the summer months. Hopper dredging was initiated in the Brunswick ship channel on 1 September and the Savannah channel on 11 September. Sweep trawling was used to disturb turtles in the channel in the hope of reducing sea turtle mortality. Seven loggerhead turtles were taken in 15 days including two large loggerheads that were either large subadults or adults. Loggerhead turtles that nest on Georgia beaches require 30-35 years to reach sexual maturity. The loss of reproductively active loggerhead females is not sustainable for population recovery. The results from the demonstration project showed that summer dredging was not feasible due to high sea turtle capture rates, including mortality of reproductively active loggerhead turtles.

The 2020 SARBO would allow hopper dredging to resume during the summer months. The Tentatively Selected Plan, Alternative 8, allows hopper dredging year around, including during warm water months. Experience in Georgia shows that summer dredging will lead to increased mortality of nesting female loggerhead turtles and other turtles, undermining decades of species recovery efforts. It does not provide adequate biological or logistical justification for not complying with winter dredging windows that have been in effect in Georgia for decades. Currently, the Corps proposes to follow the 2020 SARBO to dredge 7 channels in the warmer months including Brunswick, Savannah, and Kings Bay. The justification for warm water dredging[26] is to reduce the threat of right whale vessel collisions due to the required use of high-speed survey vessels. This justification has no basis since high-speed offshore survey vessels are not required for channel surveys. Small trailerable vessels launched from inshore boat ramps can be used by the Corps to conduct channel surveys. Larger survey vessels can transit between channels using the AIWW. In particular, the high-speed survey vessel currently used by the Corps in NE Florida and SE Georgia (Florida II) is unsuited for offshore use in seasonal right whale habitat and could instead be transiting the AIWW.

The 2020 SARBO acknowledges that shifting dredging projects to warmer months may increase the risk to sea turtles by hopper dredges and that dredging in warmer months should only be allowed in limited circumstances and after a risk-based assessment is completed[27]. NMFS recommends that to minimize risk of hopper dredging takes of Endangered Species Act (ESA) listed sea turtles, water temperature should be considered, and that completing hopper dredge projects when water temperatures are colder and sea turtles are less abundant, may reduce the risk of take[28]. They further recommend review of species population assessments and recovery plans which can provide additional species information and use of an area[29]. The proposed use of hopper dredges in Georgia during warm water months is not consistent to the maximum extent practicable with Georgia's enforceable policies under GEWA or the Game and Fish Code to protect sea turtles from takes since these 2020 SARBO considerations have not been incorporated.

The U.S. Army Engineer Research and Development Center (ERDC) tested several shapes of bed-leveling devices in 2012. They determined that devices designed to create a sand wave intended to disturb sea turtles off the channel bottom and away from the bed leveler, and that did not have any structure that could serve as "pinch points" for impinging sea turtles, were most effective at reducing sea turtle injury or mortality[30]. The specific design analyzed in a 2012-2014 Brunswick Harbor Study weighed 40,000 pounds and was 32' long by 4' high. It specifically incorporated an 11.5" strip of steel welded along the bottom length angling approximately 45 degrees forward of the blade and metal plate additions extending two feet on either side of the blade in front of the secondary attachment points, which could potentially serve as "pinch points"[31]. This 'Brunswick Harbor' design is specified as meeting 2020 SARBO criteria[32]. Other designs, including those that may have been tested by ERDC and not found to be effective in reducing turtle interactions, may be used but must only be documented and photographed to monitor the designs used under the 2020 SARBO. Other designs that have not been tested cannot be said to

[26] 2020 SARBO Section 6.1.2
[27] 2020 SARBO Section 2.5.2 Discussions Relating to Project Timing, page 644
[28] 2020 SARBO Appendix J Pre-Construction Risk Assessment, Section 1.D
[29] 2020 SARBO Appendix J Pre-Construction Risk Assessment, Section 1.B
[30] Bed Leveler Evaluation Report, U.S. Army Corps of Engineers, Savannah District, January 2015
[31] USACE Savannah District, Bed Leveler Evaluation Report, January 2015, Section 2.0 Evaluation Procedures and Methods
[32] 2020 SARBO Section 3.4 Bed-Leveling Requirements LEVEL.1, page 532

minimize takes and are therefore not consistent with Georgia's enforceable policies in GEWA and Game and Fish Code.

The results of a recent four-year study funded by the National Oceanic and Atmospheric Administration (NOAA) ESA Section 6 Competitive Grant Program further supports the importance of continued protection of adult female turtles to population recovery[33]. GADNR collaborated with Warnell School of Forest Resources and the United States Geological Survey (USGS) Coop Unit at the University of Georgia, North Carolina Wildlife Commission and South Carolina DNR to develop a Bayesian integrated population model for the Northern Recovery Unit (NRU) loggerhead population (see attached). A matrix population model operating at the level of the NRU linked to a multi-state mark-recapture model using nesting data and genetic date collected for over 30 years by state resource agencies was used to assess population status. Parameters are shared between the model components improving estimation and allowing prediction of the population trajectory into the future. Results from the model show that the NRU loggerhead population was very close to extirpation in the late 1990s, and that the population abundance is currently approximately half to a third of the size it was in the 1960s. A pulse of hatchlings from early nest protection efforts in the 1970s and 1980's and the implementation of Turtle Excluder Devices (TEDs) resulted in recent increases in nesting (last 10 years). The model predicts that a lack of recruitment from low nesting in the early 2000s will result in a plateau in population growth at current levels. If all current management protections stay in place, the population is predicted to remain stable or decline slightly until 2040. At that point, the population is expected to begin increasing toward historic levels. The model is particularly sensitive to adult female mortality and suggests that, at a minimum, protections for reproductive age loggerheads should stay in place over the next 20 years to ensure the population does not decline from current levels. It is reasonably foreseeable that a reduction in the current management protections, such as removing the cold water dredge window in Georgia as suggested by the 2020 SARBO, will result in increased mortality to reproductive age loggerheads that could put the entire NRU recovering loggerhead population at risk. This report was submitted to NOAA October 21, 2020.

In light of this study which contains new information and data that was not available to NMFS during development of the 2020 SARBO, risk assessment factors listed in the 2020 SARBO to be considered for any proposed dredging activity in the South Atlantic Region, and long-standing practices in Georgia to minimize impacts to protected sea turtles, the following alternative measures, which if adopted by the Corps, would allow the Brunswick Harbor Modification and O&M project to proceed in a manner that is consistent to the maximum extent practicable[34]:

- The Corps' shall notify GCMP of any modifications to the proposed activity;

[33] Grant Number NA16NMF4720076: Assessment of the Demographic Recovery Criteria for the Northern Recovery Unit of Loggerhead Turtles (*Caretta caretta)* Using Genetic Mark-Recapture Implementation of High Priority Recovery Actions
[34] 15 CFR 930.43(a)(3)

- All hopper dredging activities shall be restricted to 15 December through 31 March unless prior approval is obtained from GCMP;
- Hopper dredges shall have 100% inflow and outflow screening that is kept functional to the maximum extent practicable. Should inflow screening become inoperable for more than 48 continuous hours, approval must be obtained by GADNR Wildlife Resources Division (GADNR/WRD) to continue operations with only outflow screens;
- Hopper dredge inspection checklists shall be provided to GADNR/WRD prior to commencing dredging;
- Hopper dredges shall have protected species observers onboard to monitor each dredging event as unseasonably warm waters can cause higher than anticipated turtle abundance during the winter months, unless a variance is approved by GADNR/WRD;
- Sea turtle takes shall be reported to GADNR/WRD within 24 hours;
- GADNR/WRD personnel shall be allowed onboard the dredge at least once during each dredging event. Savannah District Corps' personnel shall coordinate access to hopper dredges for GADNR/WRD personnel within a reasonable timeframe of request, not to exceed 3 business days;
- Contact information for Savannah District Corps access coordinators shall be provided to GCMP prior to each dredging event;
- Hopper dredging activities will be halted if sea turtle takes exceed the limits specified by NOAA; and
- Bed leveling equipment may not be used unless it is a 'Brunswick Harbor' design that includes a 45 degree blade across the bottom with no support structures extending beyond the blade, or it is a design that has been tested in waters clear enough to determine if it produces a sand wave in front of the leading face of the g device such that it disturbs sea turtles off the sea/channel floor bottom and is approved by GADNR/WRD.

The 2009 demonstration project showed how dredging in the summer months will lead to an increase in sea turtle mortality, including valuable nesting females. We expect similar results will occur if hopper dredging resumes in the summer months. We recognize the importance of maintaining Georgia's deep-water ports for commerce. However, the Corps has successfully maintained these channels for the last 22 years using winter dredging windows to assist in the recovery of protected species.

The GEWA[35] also affords protection to Georgia's endangered North Atlantic Right Whales through regulation[36]. Any activities which are intended to harass, capture, kill or otherwise directly cause the death of any protected animal species are prohibited, except as specifically authorized by law or regulation adopted by the Board of Natural Resources[37]. Georgia also has a Cooperative Agreement with NMFS under

[35] O.C.G.A. 27-3-130
[36] Georgia Regulation 391-4-10.-09(1)(b)
[37] Georgia Regulation 391-4-10-.06(a)(1)

ESA Section 6, dating back to 1990 and is one of the oldest in existence with NMFS. This agreement extends into Florida and offshore federal waters. The agreement mandates Georgia review federal actions that have the potential to impact right whales and provide comments/and or recommendations aimed at minimizing or eliminating impacts to right whales. The agreement further tasks Georgia with taking management steps to reduce or eliminate injury or mortality to right whales caused by ship collisions and to protect habitats essential to the survival of right whales.

The 2020 SARBO proposes to mitigate right whale collision risk with adaptive measures that require vessels to temporarily reduce their speed when whales are sighted within a specified distance of vessels. Adaptive measures like this are less protective than static seasonal speed reductions because: 1) detection probability from aerial platforms is only approximately 50%[38], 2) survey teams can only fly 2-3 days per week on average because of weather and other constraints, and 3) telemetry data show that individual whales can move 40-60 miles in a day[39]. The following alternative measures, which if adopted by the Corps, would allow the Brunswick Harbor Modification and O&M project to proceed in a manner that is consistent to the maximum extent practicable[40] with Georgia's GEWA:

- Dredges and other project vessels 26 feet in length or greater shall operate at 10 knots or less within the Southeast Seasonal Management Area (SMA) from 15 November to 15 April;
- Dredges and other project vessels 26 feet in length or greater shall operate at 10 knots or less within the Mid-Atlantic SMA from 1 November to 30 April;
- Vessels may operate at speeds greater than 10 knots when necessary to maintain safe steerage and navigation; and
- Automatic Information Systems (AIS) shall be properly installed and operational on all dredges and project vessels 26 feet in length or greater.

The Study for which the federal consistency determination[41] was developed includes the entire limit of the maintained federal channel, extending approximately 11 miles offshore and includes areas outside State of Georgia waters[42]. The GCMP enforceable policies listed above are applicable to all areas of the project. The alternative measures listed above, which if adopted by the Corps to allow the Brunswick Harbor Modification and O&M project to proceed in a manner that is consistent to the maximum extent practicable, would also be applicable to those areas of the proposed project outside of State of Georgia waters. This means that hopper dredges working in the outer harbor channel would be restricted to the colder water dredge window if these alternative measures are adopted by the Corps'.

[38] Hain et al. 1999
[39] Andrews 2015
[40] 15 CFR 930.43(a)(3)
[41] Brunswick Harbor Modifications Study, Glynn County, GA, Draft Integrated Feasibility Report and Environmental Assessment and Draft FONSI, June 2020, Appendix J
[42] 15 CFR 930.33(c)

While more than 90 days have passed since we received your federal consistency determination, the Final Integrated Feasibility Report and other coordinations have not yet been completed. You are urged to modify the proposed project to incorporate the alternative measures outlined and submit a revised federal consistency determination. We welcome continued discussion to resolve these matters so that the project can move forward in an environmentally responsible manner. Please contact Mark Dodd at (912) 506-7260 with GADNR/WRD Wildlife Conservation Program if you have technical questions regarding Georgia wildlife or Kelie Moore at (912) 262-2334 if you have questions.

Sincerely,

Doug Haymans
Director

DH/km

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Final Report

Project Title: Assessment of the demographic recovery criteria for the Northern Recovery Unit of loggerhead turtles (*Caretta caretta*) using genetic mark-recapture including implementation of high priority recovery actions.

Grant Number: NA16NMF4720076

Project Duration: July 1, 2016 – June 30, 2020

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Georgia Department of Natural Resources
South Carolina Department of Natural Resources

Project Summary

The Northwest Atlantic Ocean Distinct Population Segment of loggerhead turtle (*Caretta caretta*), listed as threatened under the U.S. Endangered Species Act, is one of the two largest nesting aggregations globally. It is therefore critical to species conservation at regional and global scales. The Northern Recovery Unit (NRU) represents a geographically and genetically distinct subpopulation and encompasses the northernmost range of nesting in the U.S.

The proposed research addressed critical recovery actions necessary to assess the status of NRU loggerhead turtles and will estimate important demographic variables required for population modeling and prioritization of recovery actions. Recovery action objectives included: 1) Estimate nesting female population size, clutch frequency and remigration intervals, 2) Estimate adult female recruitment and survival and compare among females using three major foraging areas, 3) Develop demographic and scenario planning models to forecast population-level responses to conservation and delisting scenarios, 4) Compare phenology, nest site fidelity, clutch size, and clutch frequency of neophyte and remigrant females, 5) Evaluate the effects of foraging area choice on nesting phenology, clutch size, clutch frequency, and remigration interval, 6) Reassess the southern boundary of the NRU by including northeast Florida, and 7) Develop an optimal subsampling protocol for efficient long-term monitoring.

High priority recovery actions addressed include: a) Refine geographic boundaries of recovery units [111, priority 2], b) Monitor trends in nesting [122, priority 1], c) Incorporate standardized nesting survey protocols on additional beaches to fully represent recovery units [123, priority 2], d) Conduct periodic censuses for the recovery units to obtain total nest counts and geographic distribution of nesting [125, priority 2], e) Estimate indices of abundance and determine trends [132, priority 2], f) Determine and monitor clutch frequency [153, priority 2], g) Determine and monitor remigration interval [154, priority 2], and h) Determine age-specific survival probabilities [1614, priority 2].

Project Description

Goals and Objectives

1) Estimate loggerhead nesting female population size, clutch frequency and remigration intervals to assess population recovery status.
2) Estimate adult female annual survival and recruitment and compare estimated survival of females utilizing the three known major foraging areas used by NRU females.
3) Develop demographic and scenario planning models to forecast population-level responses to conservation activities under management control and possible delisting scenarios.
4) Compare phenology, nest site fidelity, clutch size, and clutch frequency of neophyte and remigrant nesting females.

5) Evaluate effects of female foraging area choice on nesting phenology, clutch size, clutch frequency, and remigration interval.
6) Reassess the southern boundary of the NRU by characterizing nest site fidelity and mitochondrial DNA haplotype frequencies through the addition of sampling sites in Nassau, Duval, and St. Johns counties, Florida.
7) Explore the effects of spatial and temporal subsampling on the accuracy and precision of reproductive parameter estimates to maximize efficiency in developing a long-term sampling design.

1) Estimate loggerhead nesting female population size, clutch frequency, and remigration intervals to assess population recovery status.

The Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle (NMFS & USFWS 2008) relies on nest counts and demographic information including clutch frequency and remigration intervals to assess the status of recovery efforts. For the NRU to be considered recovered, there must be statistical confidence that the population has increased by 2% a year for 50 years resulting in a total of 14,000 nests on NRU beaches. Further, the recovery plan recognizes that annual variability in nest counts can be a result of changes in adult female abundance or in clutch frequency and remigration intervals. As such, the recovery plan stipulates that an increase in nests must be shown to correspond with increases in the number of nesting females as estimated from the number of nests, clutch frequency and remigration intervals. Robust estimates of these parameters are required for consideration of delisting. To date, clutch frequency, and remigration intervals have been estimated using conventional flipper tagging studies. These studies generally fail to produce robust estimates of demographic parameter due to the small geographic scope of sampling (5-15 km). Data collected during the first 3 years of our genetic mark-recapture study show that estimates of clutch frequency based on traditional tagging projects are highly biased (Shamblin et al. 2017). The current project included a population-wide near census of loggerhead nests from 2016-2018 to estimate adult female abundance, clutch frequency and remigration intervals.

Accounting for variation in remigration intervals is important for assessing trends in nesting data. Given the observed remigration intervals for Georgia nesting females, we expect that most individuals that remigrate will do so within five years. Therefore following completion of the 2015 sample assignments, we will have generated robust remigration data for only a single nesting cohort. Although the frequency distributions are roughly similar across the three Georgia cohorts examined, there was sufficient variation present to warrant examination of additional nesting cohorts to capture NRU dynamics. For example, there are strong differences in nest site fidelity for North Carolina nesting females relative to those nesting in Georgia and South Carolina (Shamblin et al. 2017), and other reproductive parameters may also vary. Examination of additional remigration cohorts will help determine if the remigration patterns observed for Georgia nesting females are applicable across the entire NRU. Examining additional nesting cohorts will ensure robust remigration interval estimates at the NRU scale.

This project addressed several priority 1 and 2 actions including: 1) Monitor trends in nesting [122, priority 1], 2) Incorporate standardized nesting survey protocols on additional beaches to fully represent recovery units [123, priority 2], 3) conduct periodic censuses for the recovery units to obtain total nest counts and geographic distribution of nesting [125, priority 2], 4) Determine and monitor clutch frequency [153, priority 2], and 5) Determine and monitor remigration interval [154, priority 2].

2) *Estimate adult female annual survival and recruitment and compare estimated survival of females utilizing the three major foraging areas known to be used by NRU females.*

Robust estimates of adult female annual survival and recruitment are critical parameters for models predicting population growth rates and species recovery. The recovery plan identifies determining age-specific survival rates for all recovery units as critical for recovery [1614]. Annual survival estimates for Northwest Atlantic nesting loggerheads vary greatly, ranging from 0.41 (Sasso et al. 2011) based on archival satellite tags applied at Juno Beach to 0.86 based on physical flipper tagging on the nesting beach at Cape San Blas (Lamont et al. 2014). This variation may reflect true survival probability differences among subpopulations or could be an artifact of different methodological approaches. NRU female annual survival was estimated at 0.85 based on physical flipper tagging on Bald Head Island, North Carolina (Monk et al. 2011). The robustness of this estimate is impeded by a large proportion of nesting females never being recaptured (84%), presumably due to low site fidelity relative to the scale of tagging effort (Monk et al. 2011). Applying age structure to survival estimation in the models provides a means of incorporating a transient effect on these individuals to reduce the downward bias in survival (Monk et al. 2011). However, if these females are truly being lost from the breeding population rather than just moving elsewhere, incorporating age structure may positively bias survival estimates. Data from our project suggest that local scale transience may only account for a portion of the low recapture rates previously documented at the scale of individual tagging beaches. Despite extensive coverage of NRU nesting beaches through clutch sampling, a large proportion of Georgia nesters from 2008 (25%), 2009 (27%), and 2010 (36%) have not been detected in subsequent nesting seasons. This does not appear to be the result of a spatial edge effect because 32% of 2010 South Carolina nesting females and 52% of 2010 North Carolina nesting females also have not been detected in subsequent seasons. Observed remigration intervals of greater than five years were rare for Georgia turtles going back to 2008. Remigration data are only available from 2010 onwards for South Carolina and North Carolina, but it is unlikely that a large proportion of unaccounted females will remigrate after five years given that observed remigration intervals for the 2015-nesting cohort show declining contributions from 4-year and 5-year remigrants. Therefore the large proportion of females that have not been detected remigrating may indicate considerably faster population turnover than previously thought and is cause for concern. Estimating annual survival in systems with unobserved states requires a minimum of four years of data because survival and transition probabilities are confounded in the final primary period of a study. However, given the large proportion of females remigrating at three of more years, annual survival estimates generated from 2013 and 2014 data will be preliminary in nature. Direct estimates of recruitment and annual survival from three additional years of sampling would yield considerably more robust estimates of survival and recruitment. Incorporation of stable isotope analyses will permit assessment of annual survival of females based on the major foraging areas they use to test for differences in mortality among foraging regions. The presence of differential mortality could lead to a greater understanding of effects of anthropogenic threats and habitat quality on population recovery.

This objective addresses the priority recovery actions: Determine age-specific survival probabilities [1614, priority 2] and Determine female reproductive lifespan [155, priority 3].

3) Develop demographic and scenario planning models to forecast population-level responses to conservation activities under management control and possible delisting scenarios

Demographic and scenario/decision based models are critical for assessing threats to loggerhead turtle population recovery and to determine priorities for conservation. The main purposes of such models are to help agencies discern the relative efficacy of actions under their control, to assess the relative contributions of stressors so that broader scope (state, national, international) conservation strategies may be devised, and to identify key uncertainties in sea turtle demography to which targeted information gathering would yield more effective conservation delivery. As the loggerhead population recovers, a population model will be important for assessing potential changes in population status under different delisting protection and management scenarios.

This objective addresses the priority recovery actions related to collection of demographic information for model building including: determine age-specific survival probabilities [1614, priority 2] for population modeling. The recovery plan does not list the development of population models as a priority action directly; however, the importance of population models is implied through the high priority recovery actions related to collection of demographic data for population modeling.

4) Compare phenology, nest site fidelity, clutch size, and clutch frequency of neophyte and remigrant nesting females.

The first six years of the genetic capture-recapture project have uncovered tremendous individual variation in nest site fidelity, observed clutch frequency, and remigration intervals. At least some of this variation may reflect previous nesting experience. The mechanisms underlying fine scale nesting beach selection are poorly understood, but there is a general hypothesis that new recruits to the breeding population may return to their natal region and nest on several different beaches prior to selecting one to which they exhibit higher site fidelity (Miller 1997, Miller et al. 2003). It has been difficult to directly test this hypothesis of relatively lower site fidelity of recent recruits because it is impossible to confidently classify unmarked females arriving on individual tagging beaches as true neophytes. Through the genetic capture-recapture project, we have documented several "false neophytes" that arrived at tagging beaches without tags or tag scars but were identified as remigrants based on genetic analysis. Continuation of sampling for 2016-2018 would permit classification of females as remigrants or neophytes for three additional years. Recruit versus remigrant assignments would permit testing neophyte nest site fidelity in an intra-seasonal behavioral context (small or large beach extent) but also in a spatially explicit context when these recruits do remigrate (site specificity between years).

Identifying differences in reproductive output between neophytes and remigrants is not explicitly listed as a recovery priority, however addressing potential differences is critical in relation to other priority actions that will affect population recovery: Determine and monitor clutch frequency [153, priority 2], Determine and monitor remigration interval [154, priority 2].

5) *Evaluate effects of female foraging area choice on nesting phenology, clutch size, clutch frequency, and remigration interval.*

Foraging habitat choice may have significant effects on important adult female demographic parameters, which could translate to substantial differences in lifetime reproductive output. Differences in demographic parameters by foraging areas could help identify and assess the magnitude of anthropogenic threats and habitat quality by site. This information could be used to develop management strategies for population recovery. Satellite telemetry studies of NRU nesting females have demonstrated that the Mid-Atlantic Bight (MAB), South Atlantic Bight (SAB), and Subtropical Northwest Atlantic (SNWA) areas serve as important foraging habitats for this subpopulation (Griffin et al. 2013). These studies indicate that the MAB likely supports the largest proportion of NRU females (Griffin et al. 2013), but sample sizes have been small overall, and the sample of telemetered turtles may be biased based on nesting phenology as many of these females were fitted with transmitters very early in the nesting season to address inter-nesting habitat questions. Studies coupling satellite telemetry and stable isotope analyses have demonstrated that it is feasible to assign nesting loggerheads to the four major foraging areas used by Northwest Atlantic loggerhead nesting females: MAB, SAB, SNWA, and the Southwest Florida shelf (SWFL) (Ceriani et al. 2012, 2015; Pajuelo et al. 2012). Ceriani et al. (2015) found that clutch size and remigration intervals varied significantly among females foraging in the MAB, SNWA, and SWFL foraging areas. Wassaw Island nesting females that foraged in the SAB laid significantly smaller clutches than MAB or SNWA females (Vander Zanden et al. 2014). MAB-foraging females nesting on Wassaw Island had significantly shorter remigration intervals than SNWA-foraging Wassaw females (Vander Zanden et al. 2014), the opposite pattern from that observed for Melbourne Beach nesting females (Ceriani et al. 2015). This discrepancy may reflect subpopulation level differences among females utilizing the same foraging areas or could represent an artifact of small sample size for SNWA females in the Wassaw study. Foraging ground assignments from a larger and more diverse sample of females nesting on beaches across the NRU and northeastern Florida are needed to better assess the carry-over effects of different foraging habitat utilization.

Identifying differences in reproductive parameters for females using different foraging areas is not explicitly listed as a recovery priority, however addressing potential differences is critical in relation to other priority actions that will affect recovery: Determine and monitor clutch frequency [153, priority 2], Determine and monitor remigration interval [154, priority 2]. The Recovery Plan recognized the need to assess the "effects on survival probabilities and reproductive output" of oceanic foraging behavior (NMFS and USFWS 2008). Although initial stable isotope analysis that suggested the possibility of oceanic foraging was misinterpreted (Reich et al. 2010), subsequent studies have demonstrated significant size differences in females foraging in different regions and these differences appear to have consequences for reproductive output (Vander Zanden et al. 2014, Ceriani et al. 2015). Therefore testing for potential differences in reproductive output for females representing the major foraging areas through more robust sample sizes remains important for assessing recovery. Any differences in survival across foraging areas may help identify and target anthropogenic threats in specific regions.

6) *Reassess the southern boundary of the NRU by characterizing nest site fidelity and mitochondrial DNA haplotype frequencies through the addition of sampling sites in Nassau, Duval, and St. Johns counties, Florida.*

The recovery plan identifies refining the geographic boundaries of recovery units as a priority 2 action for recovery [111]. It is important to define Recovery Unit boundaries correctly in order to obtain accurate population status assessments, generate threats assessments, and apply recovery actions. Recovery unit boundaries for Northwest Atlantic loggerheads have been determined primarily based on mitochondrial DNA haplotype frequencies. Sample sizes from northeastern Florida were limited in initial mitochondrial DNA analyses (Encalada et al. 1998), prompting the Recovery team to choose the Florida-Georgia border as the southern boundary of the NRU (USFWS and NMFS, 2008). However, subsequent analysis suggested that Amelia Island likely formed part of the NRU under several different management scenarios tested (Shamblin et al. 2011a). Status of Duval, St. Johns, Flagler, and northern Volusia County nesting populations was uncertain. Combined haplotype frequencies from this region were significantly different from the NRU and central eastern Florida, providing some support for recognition of a distinct northeastern Florida nesting population (Shamblin et al. 2011a). However, haplotype frequencies from samples collected during 10-day windows in northern Volusia County in 1998 and 2006 were significantly different from one another, suggesting that northeastern Florida may represent a broad transition zone between the NRU and central eastern Florida populations (Shamblin et al. 2011a). The apparent inter-annual variation in haplotype frequencies also may have resulted from intra-annual variation due to staggered nesting phenology by females arriving from different foraging sites. Near-census clutch sampling in this region will provide more robust haplotype frequency estimates as well as providing nest site fidelity data with which to compare for more northern rookeries. If nest site fidelity is comparable to that found for Georgia and South Carolina females, it may suggest sufficiently local recruitment to recognize a northeastern Florida Recovery Unit. Integration of stable isotope and demographic data will also permit robust testing for temporal variation. If temporal variation occurs, these data will facilitate explicit testing of whether it is being driven by differential foraging aggregation cohort representation annually or whether foraging area use affects phenology and drives intra-seasonal variation in haplotype frequencies.

In addition to addressing recovery action 111 (Refining geographic boundaries of recovery units), the integration of stable isotope and mtDNA data will provide preliminary estimates of genetic structure on the foraging grounds [112, priority 2].

7) *Explore the effects of spatial and temporal subsampling on the accuracy and precision of reproductive parameter estimates to maximize efficiency in developing a long-term sampling design.*

Long-term near census genetic sampling on a Recovery Unit scale will not be feasible in perpetuity. In order to prepare for efficient long-term monitoring, data are needed on the effects of spatial and/or temporal subsampling on the accuracy and precision of parameter estimates. Analyses based on spatial and temporal subsamples of the 2010 through 2017 NRU dataset will address whether reduced sampling schemes can still produce robust parameter estimates, and if so, how best to optimize sampling design to maximize efficiency. For example, the additional nest monitoring and sampling conducted on several islands by South Carolina Department of Natural Resources for this project requires extra personnel and logistical expenses. If eliminating the data from these islands does not result in compromised data quality at the state or NRU level, this additional effort could be eliminated in the future. Additional spatial configurations focused on index nesting beaches identified as loggerhead terrestrial critical habitat will be considered. Although any temporal reduction in sampling would certainly preclude robust estimation of clutch frequencies through violations of model assumptions, reducing sampling to two or three inter-nesting intervals each season would still provide a robust design capture-recapture framework and may possibly generate robust data on nesting female population size, remigration intervals, annual survival, and recruitment. These sampling designs would reduce nest sampling by approximately 30% to 60% and cut genetic analysis costs. Temporal sampling schemes focused on the peak 28 and 42 days of nesting will be considered using previous years' data and compared with parameter estimates generated from the complete data set to determine any differences in parameter estimates and their variances.

Optimizing a long-term, genetic capture-recapture protocol is not explicitly included as a recovery action. However, this objective addresses generation of robust parameter estimates related to recovery actions that impact monitoring and modeling of population recovery: Maintain and/or adopt standardized criteria for on-the-ground nesting surveys [121, priority 2], Determine and monitor remigration interval [154, priority 2], and Determine age-specific survival probabilities [1614, priority 2].

b. Methods

This research provided a near census of reproductive females in the NRU. Genetic mark-recapture is the least biased approach for estimating reproductive parameters for all monitored nesting beaches within the NRU. These data are needed to reduce uncertainty in population estimates for loggerhead turtles (Richards *et al.* 2011). A number of elements combined to provide a unique opportunity to conduct near-saturation genetic identification of reproductive females of the NRU, a goal that is logistically impossible using conventional tagging and monitoring approaches. Those elements included: 1) a comprehensive network of robust nest monitoring programs in northeastern Florida, Georgia, South Carolina, and North Carolina, 2) moderate nesting densities that allow comprehensive sample collections from nests and individual genotyping throughout the NRU, 3) the application of a novel genetic approach using maternal genomic DNA from egg shells to produce individual identification using multi-locus genotypes for nesting females, and 4) the ability to assign nests within and among years to individual, genetically tagged females.

We developed a panel of novel nuclear microsatellite markers for loggerhead turtles that were suitable for population level studies and individual genetic identification (Shamblin *et al.* 2007, Shamblin *et al.* 2009). Due to the logistical constraints of collecting tissue samples by intercepting nesting females on the beach at night, methods were developed to isolate maternal nuclear and mitochondrial DNA from loggerhead turtle egg shells (Shamblin *et al.* 2011b). This genetic tagging and mark-recapture approach yielded data on a geographic scale never before possible. This in turn enabled estimates of clutch frequency and nest-site fidelity with a level of accuracy that is unprecedented in previous monitoring efforts.

We genetically tagged NRU females by collecting a single egg from each nest on monitored beaches for the entire NRU as well as participating northeastern Florida beaches (Nassau, Duval, and St. Johns counties). Nest monitoring and egg collection was conducted by volunteers and collaborating agencies coordinated by the state resource agency coordinators (principal investigators). Each maternal DNA sample was genotyped at 16 nuclear microsatellite loci in three multiplex PCR reactions, and resulting multi-locus genotypes were used to assign clutches to individual nesting females. Samples matching at a minimum of ten loci with no more than two single allele mismatches were considered to represent the same individual. The combined microsatellite panel provided a non-exclusion probability of 5×10^{-28} and the ten least informative markers provided a non-exclusion probability of sibling identity of 1×10^{-5}, producing highly robust identification of individual nesting females in a matching context even in the presence of low levels of allele dropout and paternal genetic material present in the eggs.

Annual nesting female population size, intra-seasonal clutch frequency (residence time), and remigration intervals (based on state transition probabilities) were estimated using an multistate open robust design (Kendall and Bjorkland 2001) as implemented in program MARK (White and Burnham 1999). Recruitment was estimated based on the proportion of individual females assigned as neophytes following six years of saturation sampling. Reproductive parameters were compared between neophytes and remigrants by treating these as separate groups in program MARK. Nest site fidelity metrics were compared for these groups by assessing mean nesting extent, the distance between northernmost and southernmost observed clutches by each female.

A subset of NRU females were assigned to major foraging area using stable isotope analysis of yolk samples by Simona Ceriani of FWC based on methods previously described (Ceriani et al 2012, 2015). Stable isotope analyses were performed following genotyping to produce foraging area assignments for approximately 200, 300, 300, and 300 individual females for each of the 2015-2018 nesting seasons. Yolk sampling in North Carolina (Bald Head Island) and South Carolina (South/Sand islands, Kiawah Island, and Hilton Head Island) complemented previous stable isotope sampling (2012 and 2013). Additionally, Cape Romain National Wildlife Refuge samples were added given the importance of these beaches for the subpopulation. These foraging area assignments were used to group individuals by foraging aggregation for comparisons of reproductive parameters.

To reassess the southern boundary of the NRU, we sequenced the mitochondrial control region of unique northeastern Florida females to assess haplotype frequencies spatially in Nassau, Duval, and St. Johns counties. In the absence of direct natal site fidelity data, relatedness analysis may reveal connectivity with Georgia populations or isolation as a distinct subpopulation. Nest site fidelity data was also considered a proxy to examine to the relative connectivity between Georgia and northeastern Florida nesting populations. The combination of haplotype frequency, nest site fidelity, and relatedness data were used to assess whether there was sufficient support to recognize a northeastern Florida management unit or if this region represents a southern extension of the NRU.

Finally, the proposed project included a public outreach component by providing real-time nesting and genetic data to the public. Nesting data and genotypes were uploaded to an online database management system hosted on the website www.seaturtle.org . This database system is used to manage all loggerhead sea turtle nesting activity in Georgia, South Carolina and North Carolina. Genotype assignments were added to individual nest data collected by collaborators. Genotyping generally took approximately 2 months following receipt of the samples. Collaborators had full access to all genotype data when loaded into the database management system. Summary information on genotyping are available in real time to the public at the following website http://www.seaturtle.org/nestdb/genetics.shtml?program=3&beach=&year=2015&species= . The summary genetic data also include the number of samples genotyped, number of nests and individual females identified, and estimates of demographic parameters including clutch frequency, interesting period, and site fidelity.

The population-modeling component of the project including the calculation of adult female survival estimates is included in Appendix A.

RESULTS

Objective 1. Estimate loggerhead nesting female population size, clutch frequency and remigration intervals to assess population recovery status.

During the 2016-2018 nesting seasons, the nest monitoring networks north of Florida documented 25,390 loggerhead turtle nests. We assigned 24,806 (97.7%) of these to individual females (Table 1.1). We found a significant correlation between the annual number of nests and the annual number of identified females nesting on NRU beaches from 2010-2018 ($r = 0.99$, $df = 7$, $p < 0.0001$). In MSORD models to estimate annual abundance and clutch frequency, time dependent models were generally better supported than those with fewer parameters (via fixed detection probabilities across secondary periods or through linear or quadratic smoothing functions on the probabilities of entry and persistence). As with previous years, annual abundance estimates were approximately 3-5% greater than the number of empirically assigned females, suggesting reasonably high annual detection probabilities across the study area (Table 1.2).

Among 2,581 females that nested during 2008-2010, 1,811 (70%) were detected remigrating at least once over the period 2009-2018. Patterns displayed by NRU females that nested in 2010 and subsequently remigrated over the study period were similar to those from Georgia in 2008 and 2009 (Tables 1.3, 1.4, 1.5). The mean observed remigration interval by these females combined over this period (4,142 remigrations) was 2.84 (± 1.20) years. Two-year and three-year cycles dominated the observed remigration patterns (Fig. 1.1).

Table 1.1 Northern Recovery Unit loggerhead turtle clutch and individual female summary data. For comparative purposes, these data exclude Georgia-only samples from 2008 and 2009 and Florida-only females from 2016-2018. Each female was therefore treated as new in the 2010 cohort.

	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
Clutches recorded	5,770	6,966	7,946	8,752	3,834	8,689	11,287	8,493	5,610	67,347
Clutches assigned	5,587	6,844	7,790	8,575	3,753	8,516	11,084	8,322	5,400	65,781
Females identified	1,770	1,972	2,389	2,475	1,041	2,380	3,127	2,244	1,463	10,545
% new females	100	98.7	82.4	48.4	51.6	32.1	38.8	33.9	35.7	

Table 1.2. Female abundance and clutch frequency estimates for Northern Recovery Unit loggerhead turtles. Females and OCF (observed clutch frequencies) were based on observed detections. Estimated abundance and ECF (estimated clutch frequency) were derived using an open robust design framework to correct for detection. p* indicates the estimated annual detection probability- the probability of detecting a female at least once during a nesting season, conditional on her presence in that year's nesting cohort.

	Females	Estimated Abundance	OCF	ECF	p*
2016	3127	3225 (3184 - 3267)	3.45 (3.40 - 3.50)	4.63 (4.14 - 5.13)	0.97
2017	2244	2327 (2304 - 2349)	3.54 (3.48 - 3.60)	5.13 (5.04 - 5.31)	0.96
2018	1463	1537 (1515 - 1559)	3.38 (3.31 - 3.45)	4.73 (4.58 - 4.87)	0.95

Table 1.3. Observed remigration intervals from 2009-2018 (n = 1,076) for 428 female loggerhead turtles that nested in Georgia in 2008.

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1 year	3	1	2	2	8	0	2	12	8	0
2 years	NA	68	1	47	93	30	43	33	60	33
3 years	NA	NA	184	1	10	24	50	72	14	22
4 years	NA	NA	NA	106	0	4	13	22	6	5
5 years	NA	NA	NA	NA	45	0	0	9	7	5
6 years	NA	NA	NA	NA	NA	4	0	0	0	2
7 years	NA	NA	NA	NA	NA	NA	5	0	0	3
8 years	NA	NA	NA	NA	NA	NA	NA	7	3	0
9 years	NA	NA	NA	NA	NA	NA	NA	NA	6	0
10 years	NA	NA	NA	NA	NA	NA	NA	NA	NA	1

Table 1.4. Observed remigration intervals (n = 631) for 269 females that nested in Georgia in 2009 (excluding three 2008 Georgia remigrants).

	2010	2011	2012	2013	2014	2015	2016	2017	2018
1 year	1	0	2	2	1	0	10	2	2
2 years	NA	69	1	49	23	39	22	55	11
3 years	NA	NA	133	0	4	64	28	6	15
4 years	NA	NA	NA	36	0	1	17	3	4
5 years	NA	NA	NA	NA	9	0	0	0	1
6 years	NA	NA	NA	NA	NA	4	0	0	1
7 years	NA	NA	NA	NA	NA	NA	6	0	0
8 years	NA	NA	NA	NA	NA	NA	NA	6	0
9 years	NA	NA	NA	NA	NA	NA	NA	NA	4

Table 1.5. Observed remigration intervals (n = 2,435) for 1,186 NRU females that nested in 2010 (excluding 2008 and 2009 Georgia remigrants).

	2011	2012	2013	2014	2015	2016	2017	2018
1 year	25	5	29	6	2	40	12	2
2 years	NA	332	0	101	152	95	172	106
3 years	NA	NA	529	0	117	277	26	46
4 years	NA	NA	NA	109	0	13	34	4
5 years	NA	NA	NA	NA	90	1	4	7
6 years	NA	NA	NA	NA	NA	43	0	3
7 years	NA	NA	NA	NA	NA	NA	26	0
8 years	NA	NA	NA	NA	NA	NA	NA	27

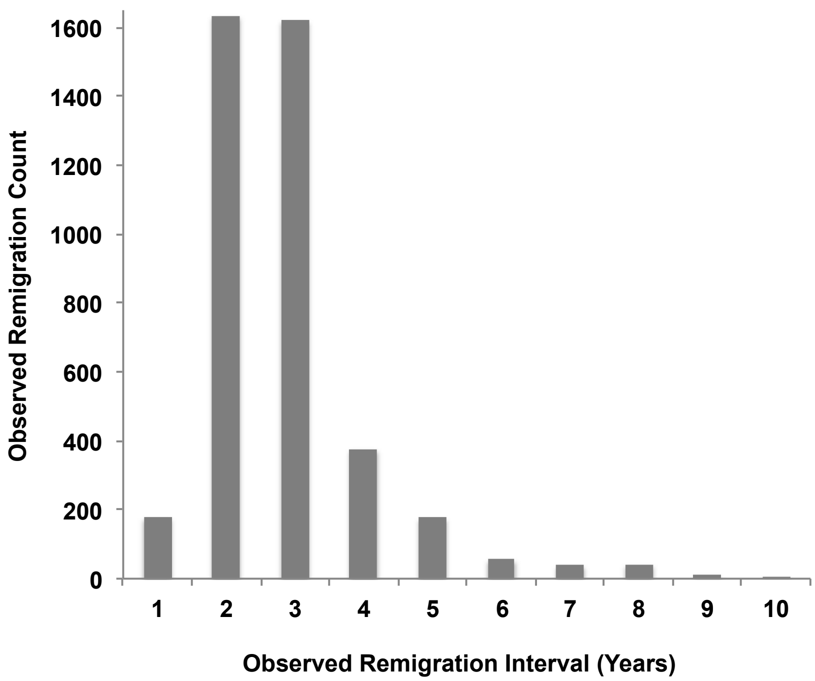

Fig. 1.1 Observed remigration intervals for 4,142 detected remigrations by 1,811 individual female Northern Recovery Unit loggerhead turtles that originally nested in 2008-2010 and remigrated through the 2018 nesting season.

Objective 2. Estimate adult female annual survival and recruitment and compare estimated survival of females utilizing the three known major foraging areas used by NRU females.

Apparent turnover was high, particularly in the first three years of the project, with 29% to 32% of the females identified from 2010-2012 never subsequently detected (Table 2.1). A smaller percentage of females in the 2013-2015 cohorts (15-22%) were not subsequently detected through 2019 (Table 2.1). Considering the 2010 cohort, approximately 4-6% of females that comprised each annual remigration cohort beginning with the 2012 season were not subsequently detected. Conversely, between 29-42% of the females comprising each annual nesting cohort from 2010-2015 were last detected nesting during the 2019 season.

Adult female survival estimates are found in the demographic modeling section of the report (Appendix A). With respect to comparing survival among foraging groups, the majority of SAB and SNWA females had nesting histories too short-term to generate annual survival estimates for them separately as foraging groups. Only 37 MAB females and 12 SNWA females sampled for stable isotopes during 2015-2018 had a known nesting history prior to 2015.

Females new to the genetics database comprised approximately 34 – 39% of each annual nesting cohort from 2016 – 2018 (Table 1.1). This proportion initially rapidly declined following initiation of saturation sampling in 2010 but has remained fairly stable since 2015 (Table 1.1). Parentage analyses suggested that only a minority of these apparent neophytes (19 – 28% per year) were candidate daughters of established females with previous nesting histories (Table 2.2). Visual checking of genotypes indicated that these parentage matches undoubtedly included some categorical assignment errors as well (eg. sister-sister pairs or half-sibling pairs rather than mother-daughter pairs), though it was not clear how common these categorical mis-assignments were.

Among females that nested during 2016-2018, 579 potential daughter recruits were assigned to 512 candidate mothers. Most females were assigned to a single mother-daughter pair, making it impossible to infer which was the mother and which the daughter given the short sampling window relative to loggerhead generation times. Females with multiple assigned offspring provided additional context on spatial and temporal distributions of potential recruitment. Assigned daughters often nested on the same island as their mother or on adjacent beaches, but in some cases some daughters nested up to 100 km away from their mother's last known nesting sites (Figs. 2.1, 2.2).

Parentage assignments for females with nesting histories prior to initiation of NRU genetic tagging (based on physical tags) provided additional context on spatial and temporal variation in recruitment. Among seven females originally tagged on Bald Head Island during the 1990's that nested long enough to be genetically tagged, only one had any assigned daughters. This female, CC004966, was tagged in 1997 and was last detected nesting in 2016. Her first potential daughter (CC009002) was initially genetically tagged at Fort Fisher in 2015 and was detected via physical tags on Bald Head Island in 2020. Her second potential daughter (CC009956) was detected laying a single clutch on South Island, South Carolina in 2016. Among 18 females initially tagged on Bald Head Island between 2000 and 2005 that nested long enough to be fingerprinted, three had assigned daughters. CC012847 was initially tagged in 2001 and last detected in 2006 and had three assigned daughters. CC004971 was initially tagged in 2005 and last detected in 2018. She had a single assigned daughter. Finally, CC003304 was initially tagged in 2003 and last detected in 2018. She had five assigned daughters. Among 17 females initially tagged on Cumberland, Little Cumberland, or Jekyll Island between 1980 and 1994, eight had assigned daughters. Among 33 females tagged on these islands between 1995 and 1999, only five had assigned daughters by 2018.

Integration of additional sources of data should further elucidate recruitment patterns. The strongest inference is with mother-daughter pairs, but these females comprise a small proportion of the overall dataset thus far due to the short timeseries for the study. Full-sibling relationships provide the next strongest inference of relatedness following mother-daughter pairs. A female initially captured by the South Carolina DNR in-water trawl survey project as a large juvenile in the Charleston shipping channel in 2006 was recaptured nesting on Bald Head Island in 2020. This female does not have a mother in the genetics database, suggesting that she died or was reproductively senescent before the genetic tagging project was initiated. However, the recaptured turtle does have at least four full siblings that have also initiated nesting since 2015. Four of these females are nesting in the Cape Fear region of North Carolina, but the fifth (CC007996) nested in the Charleston area (Fig 2.3). Given that all females shared the same sire, it is likely that all hatched the same year. If that assumption is valid, recruitment from the same hatch-year cohort ranges over a minimum of five years. Recruitment of this magnitude suggests a much higher survival rate than those typically considered for the population at large. However, it is unclear whether this high reproductive fitness is consistent across the population or there is significant variability in survival between individual females or nests.

Table 2.1 Apparent turnover and remigration cycles for nesting cohorts of Northern Recovery Unit loggerhead turtles, expressed as the proportion of each annual cohort that were last detected across subsequent nesting seasons.

	Nesting cohort					
Last detected	2010	2011	2012	2013	2014	2015
2010	28.8%	NA	NA	NA	NA	NA
2011	0.2%	31.8%	NA	NA	NA	NA
2012	4.1%	0.5%	30.8%	NA	NA	NA
2013	5.0%	3.5%	0.3%	17.1%	NA	NA
2014	4.6%	2.0%	1.3%	0.2%	21.7%	NA
2015	4.0%	4.9%	3.5%	2.4%	0.1%	14.8%
2016	5.8%	5.4%	6.9%	8.5%	5.9%	0.7%
2017	7.0%	7.7%	8.6%	9.7%	14.1%	13.3%
2018	9.3%	9.4%	10.1%	10.4%	8.8%	16.1%
2019	28.7%	29.5%	28.8%	41.6%	31.0%	39.6%

Table 2.2. Neophyte composition for annual cohorts of Northern Recovery Unit loggerhead turtles that nested 2016-2018 (inclusive of all Georgia data pre-2010). Females nesting exclusively in Florida were excluded from this table given initiation of sampling in only 2016. Neophyte daughters were the apparent neophytes that could not be excluded as belonging to mother-daughter pairs in parentage analyses including all recorded NRU (and northeastern Florida) females sampled through 2018. % Potential daughters is the proportion of apparent neophytes that could not be excluded as daughters of other nesting females.

	2016	2017	2018
Apparent neophytes	1199	749	519
% Apparent neophytes	38.6	33.6	35.6
Neophyte daughters	334	142	98
% Potential daughters	27.9	19.0	18.9

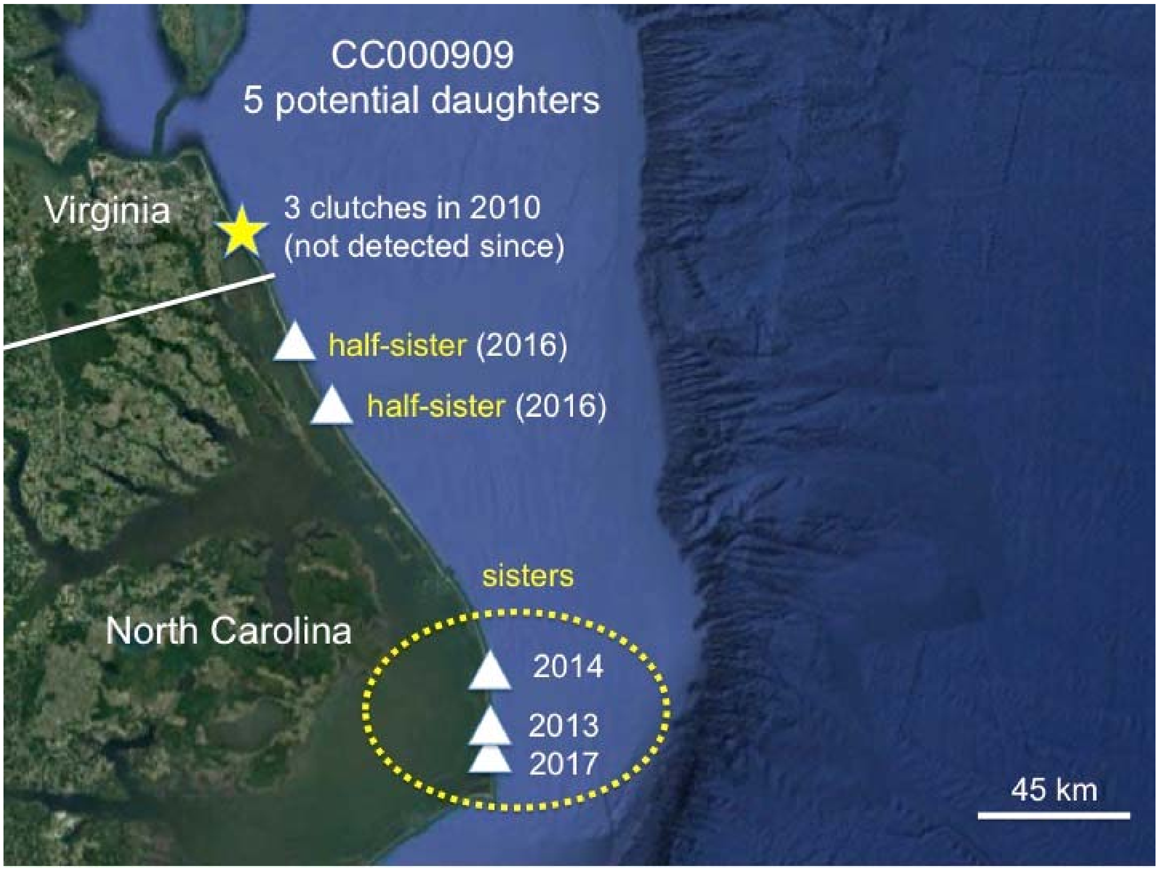

Fig. 2.1. Nesting distributions of Northern Recovery Unit loggerhead turtle female CC000909 (last detected nesting in 2010) and her five potential daughters that recruited during 2013-2017.

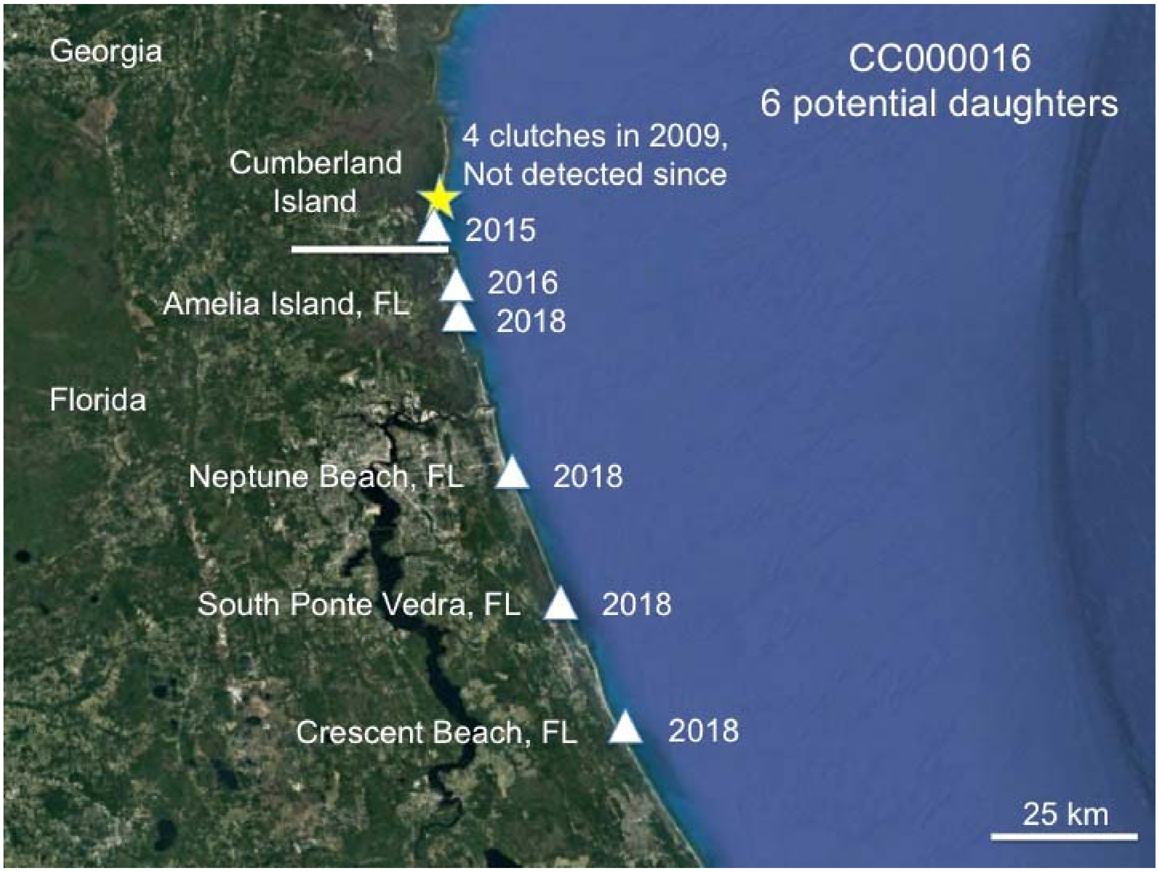

Fig. 2.2. Nesting distributions of female loggerhead turtle CC000016 (last detected nesting in 2009) and her six assigned daughters that recruited during 2015-2018. All offspring were assigned as half-siblings. Only one of these females was included in recruitment analyses due to recent initiation of sampling in northeastern Florida, but these data do provide context on the spatial scale of recruitment.

Figure 2.3. Spatial and temporal recruitment pattern of five full sister (shared sire) Northern Recovery Unit loggerhead turtles whose mother is not present in the DNA database.

Objective 3. Develop demographic and scenario planning models to forecast population-level responses to conservation activities under management control and possible delisting scenarios.

The population-modeling component of the project including the calculation of adult female survival estimates can be found in Appendix A.

Objective 4. Compare phenology, nest site fidelity, clutch size, and clutch frequency of neophyte and remigrant nesting females.

Remigrant females initiated nesting significantly earlier than apparent neophytes in each of the three years, with the mean day of year of their first detected clutches falling approximately a full inter-nesting interval earlier (Table 4.1). However, both groups ended nesting for the season at approximately the same time, with no significant difference in the mean day of year for the last recorded clutch for females by group across years (Table 4.1). This resulted in nesting cohorts that were nearly exclusively represented by remigrants in the first inter-nesting interval (14 days; 25 April-8 May) of each season, and still strongly skewed towards remigrants in the second inter-nesting interval compared to each year overall (Table 4.2; 9 May-22 May). Proportional detections of each group peaked in midseason, with approximately 80% of remigrants that nested in a given year detected during the 3rd, 4th, and 5th secondary periods (Fig. 4.1). By contrast, peak detections for apparent neophytes were shifted slightly later, occurring in the 4th, 5th, and 6th secondary periods, and represented approximately 50-60% of these females per secondary period (Fig. 4.1).

Nest site fidelity as expressed by nesting extent, the greatest distance between clutches assigned to each female within a year, was highly variable among individuals regardless of nesting experience, ranging from 0.01 km to 894 km. Nevertheless, NSF was significantly weaker for apparent neophytes than for remigrants in all three nesting cohorts (Table 4.3). Approximately 50-55% of remigrants deposited all of their detected clutches within 5 km, whereas only 17-25% of apparent neophytes exhibited this degree of NSF (Fig. 4.2).

Estimated egg counts were highly variable overall. Several on the low end of the spectrum likely represented disturbance during the nesting process that resulted in two partial clutches. However, these were not always apparent based on nesting histories and available comments for each nesting activity. We therefore made no attempt to correct for these and calculated means based on reported data. Remigrants had significantly higher clutch counts than apparent neophytes (Table 4.4), but the difference was small and possibly not biologically relevant.

Remigrants were detected laying significantly more clutches than apparent neophytes (Table 4.5). Apparent neophytes were left skewed in their observed clutch frequency distribution compared to neophytes, with most females detected laying a single clutch (Fig 4.3.). Robust design analyses in program MARK that accounted for detection also indicated significantly greater estimated clutch frequencies for remigrants relative to neophytes (Table 4.6). Detection probabilities across secondary periods were markedly lower for apparent neophytes relative to remigrants, leading to broader credible intervals for apparent neophyte ECF. ECFs suggested lower nest production in 2018 relative to 2016 and 2017, despite similar detection across years.

Table 4.1. Nesting phenology of apparent neophyte (Neo) and remigrant (Rem) Northern Recovery Unit loggerhead turtles. Initiation of nesting is expressed as the mean (± standard deviation) day of year (DoY) for the first detected clutch of each female by group. Cessation of nesting is expressed as the mean day of year for the last detected clutch of each female by group. Sample sizes vary from secondary period analyses (Table 4.2, Fig 4.1) due to exclusion of females with unknown lay dates ("wild" nests) here. Comparisons indicate Mann-Whitney U statistic and p value.

	2016	2017	2018
Neo N	1186	741	512
Rem N	1879	1460	932
Neo DoY First Nest	164.6 (± 16.3)	161.7 (± 17.5)	167.7 (± 16.9)
Rem DoY First Nest	151.5 (± 11.8)	144.0 (± 13.5)	151.5 (± 11.6)
First Nest Comparison U	1696100	878750	381670
First Nest Comparison p	< 0.0001	< 0.0001	< 0.0001
Neo DoY Last Nest	191.2 (± 19.0)	190.2 (± 19.4)	192.2 (± 18.5)
Rem DoY Last Nest	193.2 (± 14.6)	190.5 (± 15.9)	191.8 (± 14.6)
Last Nest Comparison U	1075300	556800	250090
Last Nest Comparison p	0.1029	0.2600	0.1291

Table 4.2. Apparent neophyte (Neo) and remigrant (Rem) Northern Recovery Unit loggerhead turtles detected in the first two inter-nesting intervals of each nesting season compared to the overall group composition for the year.

	2016		
	24 Apr - 7 May	8 May - 21 May	year
Neo	1	153	1199
Rem	31	938	1905
Rem %	96.9	86	61.4
	2017		
	25 Apr - 8 May	9 May - 22 May	year
Neo	8	154	749
Rem	252	1019	1479
Rem %	96.9	86.9	66.4
	2018		
	25 Apr - 8 May	9 May - 22 May	year
Neo	0	58	519
Rem	15	761	940
Rem %	100	92.9	64.4

Table 4.3. Nest site fidelity of apparent neophyte (Neo) and remigrant (Rem) Northern Recovery Unit loggerhead turtles. NE is the mean nesting extent (± standard deviation)- the distance (km) between the most distant recorded clutches for each female within nesting seasons. Comparisons indicate Mann-Whitney U statistic and p value.

	2016	2017	2018
Neo N	907	567	367
Rem N	1823	1409	883
Neo NE	62.49 (± 102.26)	66.45 (± 115.08)	87.12 (± 142.25)
Rem NE	23.76 (± 57.54)	22.57 (± 56.33)	27.34 (± 65.43)
U	1120800	552510	239630
p	< 0.0001	< 0.0001	< 0.0001

Table 4.4. Clutch size (estimated egg count) data for apparent neophyte (Neo) and remigrant (Rem) Northern Recovery Unit loggerhead turtles. Comparisons indicate Mann-Whitney U statistic and p value.

	2016	2017	2018
Neo clutch N	2958	1667	1233
Rem clutch N	7113	5248	3501
Neo mean eggs	102.1 (± 21.2)	104.0 (± 21.2)	98.3 (± 22.1)
Rem mean eggs	113.0 (± 22.9)	114.2 (± 22.1)	111.9 (± 24.0)
U	7340900	3116900	1428200
p	p < 0.0001	p < 0.0001	p < 0.0001

Table 4.5. Mean (± standard deviation) observed clutch frequencies (OCF) for apparent neophyte (Neo) and remigrant (Rem) Northern Recovery Unit loggerhead turtles during 2016-2018. Comparisons indicate Mann-Whitney U statistic and p value.

	2016	2017	2018
Neo N	1199	753	521
Rem N	1906	1479	940
Neo OCF	2.75 (± 1.36)	2.08 (± 1.42)	2.63 (± 1.41)
Rem OCF	4.08 (± 1.31)	4.17 (± 1.36)	4.03 (± 1.31)
U	560720	273910	117060
p	< 0.00001	< 0.00001	< 0.00001

Table 4.6 Estimated clutch frequencies (ECF) based on robust design analyses in program MARK. Variation in detection across secondary periods (p) is expressed as a range, given time dependency supported for all top models. *Indicates mean ECF and 95% credible intervals based on unconditional standard errors from model averaging given low weight of the top model.

	Apparent Neophytes		
	ECF	top model	top model p
2016	3.99 (3.82 - 4.16)	$pent_t\ phi_{tsm}\ p_t$	1: 0.40, 2-5: 0.68 - 0.74, 6: 0.55, 7: 0.22
2017	3.91 (3.70 - 4.12)	$pent_t\ phi_{quadt}\ p_t$	1-5: 0.60 - 0.77, 6: 0.58, 7: 0.39
2018	3.69 (2.98 - 4.39)*	$pent_t\ phi_{quadt}\ p_t$	1: 0.15, 2-5: 0.70-0.79, 6: 0.51, 7: 0.16
	Remigrants		
	ECF	top model	top model p
2016	4.95 (4.86 - 5.04)	$pent_t\ phi_{quadtsm}\ p_t$	1-6: ≥ 0.82, 7: 0.55
2017	5.23 (5.12 - 5.34)	$pent_t\ phi_{tsm}\ p_t$	1-5: ≥ 0.82, 6: 0.55 7: 0.19
2018	4.73 (4.59 - 4.88)	$pent_t\ phi_{tsm}\ p_t$	1-5: ≥ 0.77, 6: 0.51 9: 0.16

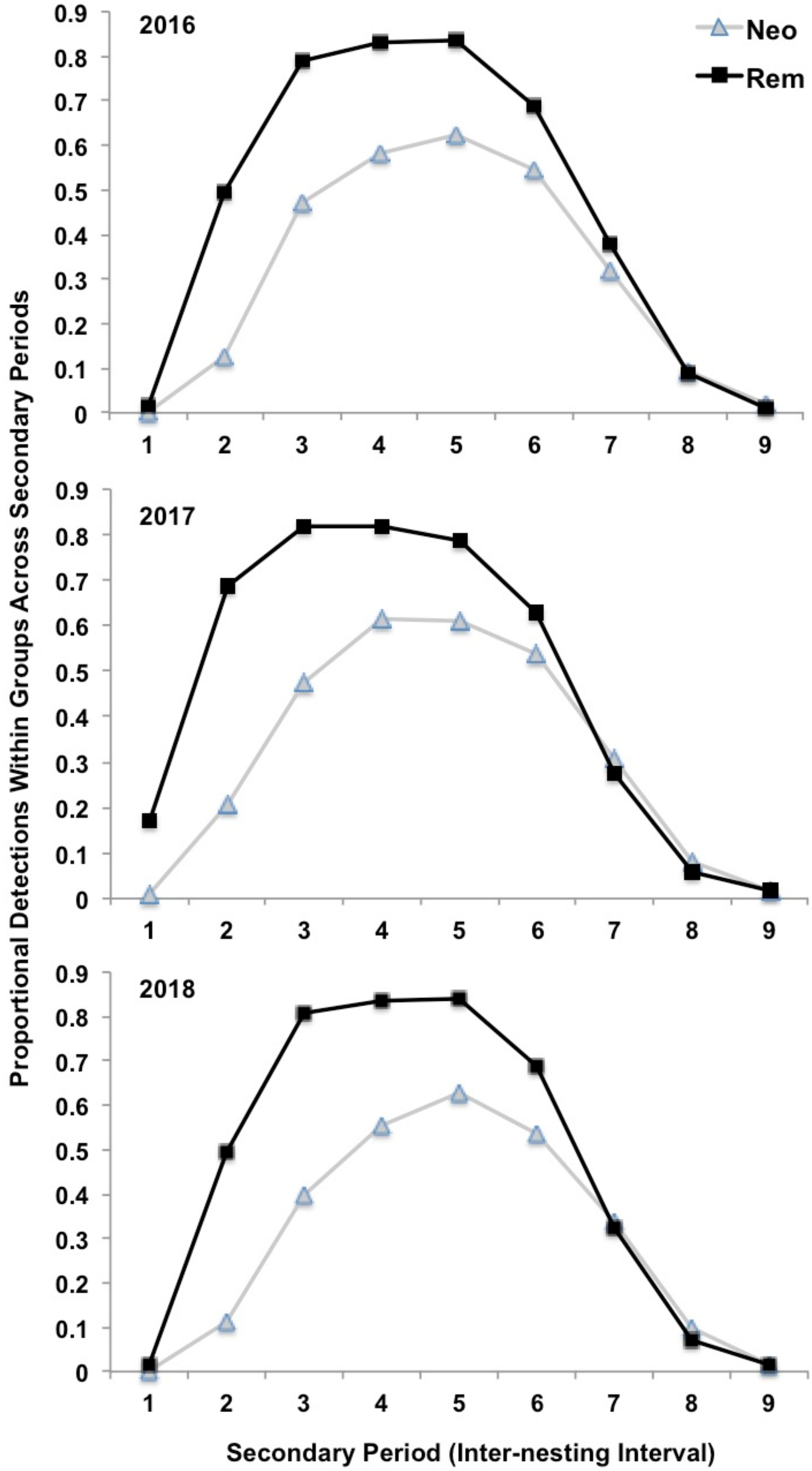

Fig. 4.1. Temporal distribution of nesting detections by apparent neophyte (Neo) and remigrant (Rem) Northern Recovery Unit loggerhead turtles, expressed as the proportion of each group detected nesting in each secondary period (inter-nesting interval) for 2016-

2018. Period 1 begins on 25 April (24 April in leap year 2016). Period 9 ends on 29 August (28 August in leap year 2016).

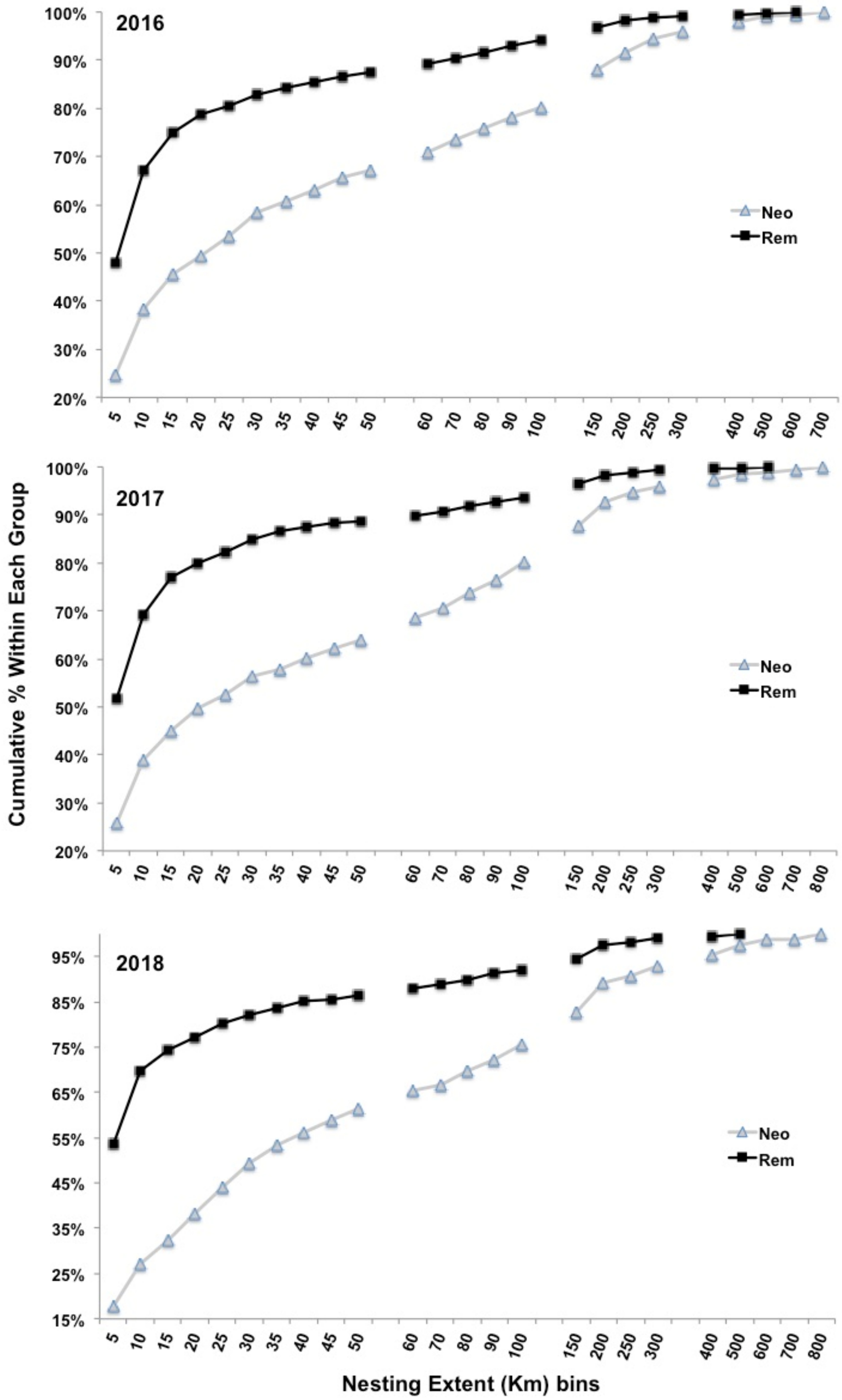

Fig 4.2. Nest site fidelity for apparent neophyte (Neo) and remigrant (Rem) Northern Recovery Unit loggerhead turtles, expressed as the proportion of each group that distributed all of their detected nests within nesting extent bins. These proportions are

cumulative across the x-axis. Nesting extent is the distance between the most widely separated recorded clutches for each female within a nesting season.

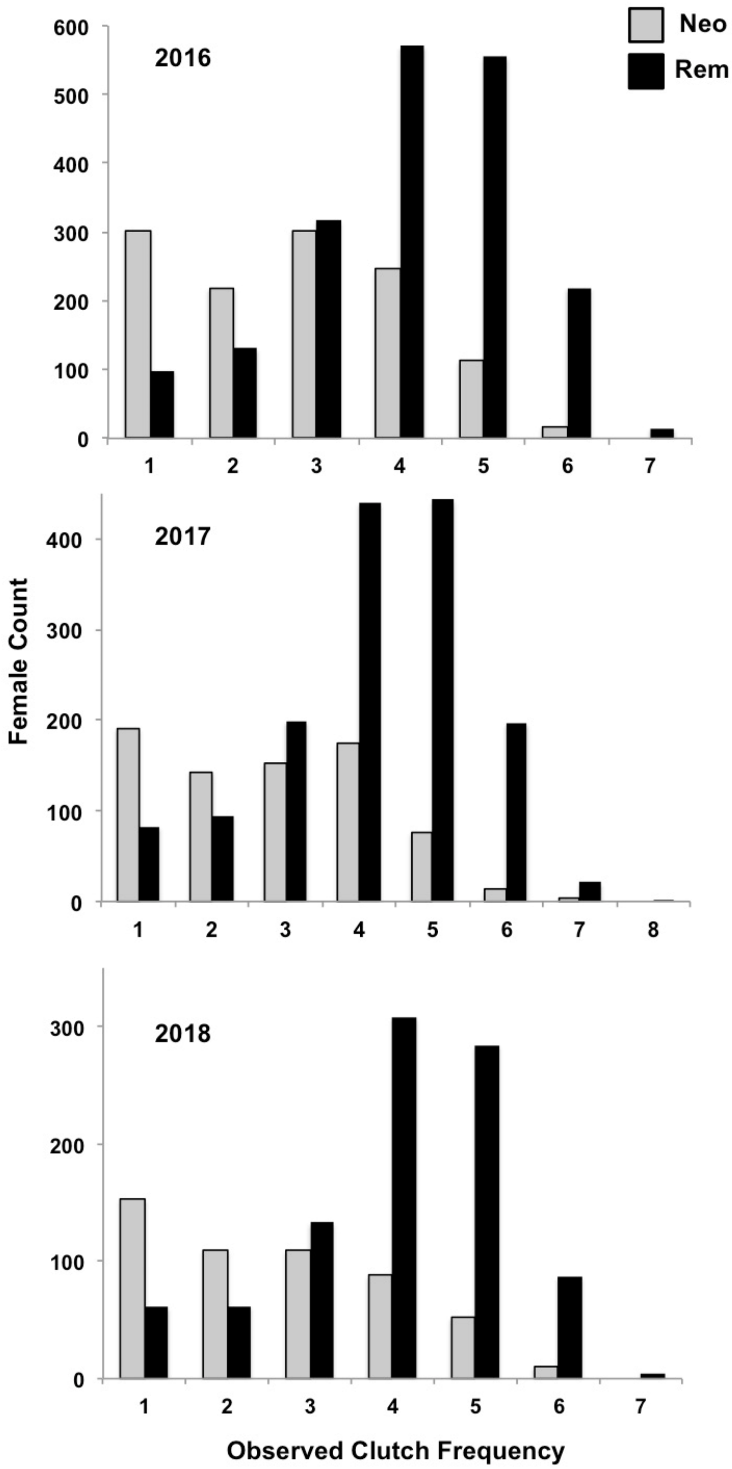

Fig. 4.3. Observed clutch frequency for apparent neophyte (Neo) and remigrant (Rem) Northern Recovery Unit loggerhead turtles.

Objective 5. Evaluate effects of female foraging area choice on nesting phenology, clutch size, clutch frequency, and remigration interval.

Approximately 80% of sampled females were assignable to a foraging area based on a threshold probability of 0.8. Among these, 87.2% were assigned to the Mid-Atlantic Bight, 8.7% to the South Atlantic Bight, and 4% to the Subtropical Northwest Atlantic (Table 5.1). South Atlantic Bight assignments were highly variable among nesting sites, comprising the largest proportion on Kiawah Island (12.7%) and lowest in northeastern Florida (4.4%) and Bald Head Island (2.7%). Subtropical Northwest Atlantic assignments were also highly variable among nesting beaches, being highest in northeastern Florida (12.5%) and lowest at Cape Romain (0.9%). Considering only females that nested north of Florida, 87.9% were assigned to the Mid-Atlantic Bight, 9.3% to the South Atlantic Bight, and 2.8% to the Subtropical Northwest Atlantic.

St. Johns County, Florida females were excluded from phenology, clutch frequency, and remigration interval analyses due to the short temporal window (2016-2018) and the high likelihood of incomplete nesting histories for the majority of females (see Objective 6 results). There were no significant differences in date of first detected clutches by foraging site (2016: Kruskal-Wallis $\chi^2 = 1.52$, df = 2, p = 0.467; 2017: Kruskal-Wallis $\chi^2 = 5.90$, df = 2, p = 0.052; 2018: Kruskal-Wallis $\chi^2 = 1.77$, df = 2, p = 0.413; Table 5.2). However, the first clutches of SNWA females did tend to be later than MAB and SAB. This may reflect the longer migration from more distant foraging grounds or missed Florida clutches prior to observed nesting histories. There was significant variation in corrected clutch frequencies (combined 2016-2018 data) among foraging site groups (Kruskal-Wallis $\chi^2 = 8.49$, df = 2, p = 0.014; Table 5.3). This difference was driven by significantly lower corrected clutch frequencies for MAB v SAB females (z = -2.68, p = 0.007), whereas other comparisons were not significant (MAB vs. SNWA: z = -1.26, p = 0.206; SAB vs. SNWA: z = 0.24, p = 0.809). When only known remigrant MAB and SAB females were compared (apparent neophytes excluded), the results only approached significance (W = 13212, p = 0.053). There was significant variation in observed remigration intervals among foraging site groups (Kruskal-Wallis $\chi^2 = 6.83$, df = 2, p = 0.033; Fig 5.2). This differentiation was driven by significantly longer observed remigration intervals for MAB vs. SAB females (z = 2.49, p = 0.013), whereas the other pairwise comparisons were not significant (MAB vs. SNWA: z = 0.903, p = 0.366; SAB vs. SNWA: z = -0.531, p = 0.599).

Table 5.1. Foraging ground assignments for individual female loggerhead turtles (where assignment probabilities exceeded a threshold of 0.80) based on stable isotope analyses of yolks. MAB, Mid-Atlantic Bight; SAB, South Atlantic Bight; SNWA, Subtropical Northwest Atlantic. Beach codes are explained in Figure 5.1.

State	Beaches	MAB	SAB	SNWATL	Total
Florida	SJC	113	6	17	136
South Carolina	HHI	205	24	14	243
South Carolina	KWH	174	26	4	204
South Carolina	ROM	194	17	2	213
South Carolina	YAW	156	16	2	174
North Carolina	BHI	69	2	3	74
Combined NRU + St. Johns		911	91	42	1044

Table 5.2. Nesting phenology (expressed as the day-of-year for the first observed clutch) for nesting loggerhead turtles assigned to foraging grounds in the Mid-Atlantic Bight (MAB), South Atlantic Bight (SAB), and Subtropical Northwest Atlantic (SNWA).

	2016	2017	2018
MAB	154.9 (± 12.4)	146.2 (± 14.4)	155.2 (± 15.0)
SAB	151.8 (± 9.9)	147.6 (± 12.1)	156.1 (± 13.4)
SNWA	155.3 (± 10.6)	157.9 (± 22.2)	162.3 (± 15.4)

Table 5.3. Observed clutch frequency (OCF) and corrected clutch frequency (CCF) for Northern Recovery Unit loggerhead turtles assigned to foraging grounds in the Mid-Atlantic Bight (MAB), South Atlantic Bight (SAB), and Subtropical Northwest Atlantic (SNWA). CCF were corrected by assuming inter-nesting interval gaps represented missed clutches.

		OCF	
	2016	2017	2018
MAB	3.88 (± 1.26)	3.95 (± 1.23)	3.95 (± 1.34)
SAB	4.43 (± 1.36)	4.43 (± 1.14)	3.61 (± 1.50)
SNWA	4.14 (± 1.68)	4.44 (± 1.94)	3.75 (± 1.04)
		CCF	
	2016	2017	2018
MAB	4.18 (± 1.28)	4.38 (± 1.27)	4.16 (± 1.37)
SAB	4.73 (± 1.39)	4.90 (± 1.03)	4.06 (± 1.47)
SNWA	4.43 (± 1.81)	4.67 (± 2.00)	4.38 (± 1.06)

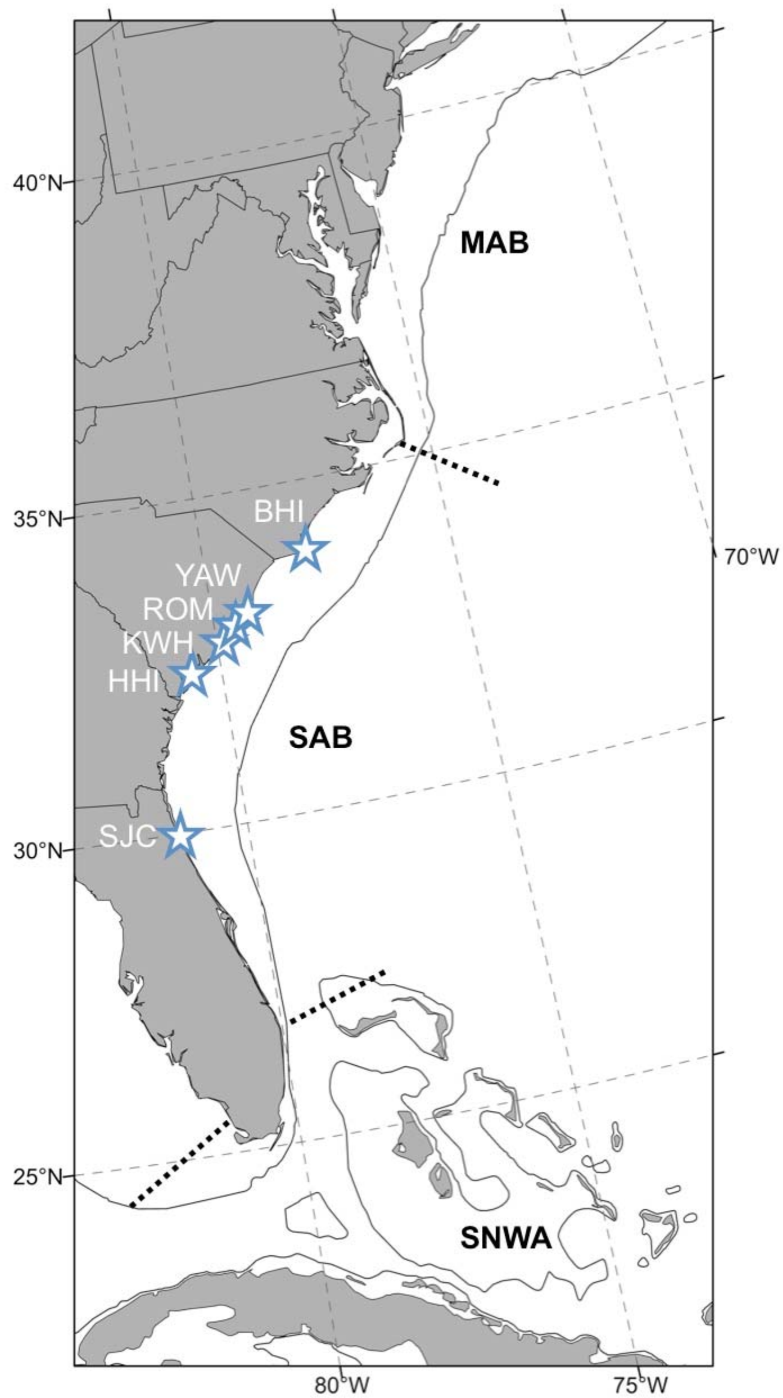

Fig. 5.1. Map of the three major foraging areas for Northern Recovery Unit loggerhead turtles and sampling locations for stable isotope samples. MAB: Mid-Atlantic Bight, SAB: South Atlantic Bight, SNWA: Subtropical Northwest Atlantic. SJC: St. Johns County, Florida; HHI: Hilton Head Island, South Carolina; KWH: Kiawah Island, South Carolina; ROM: Cape Romain National Wildlife Refuge (Cape and Lighthouse Islands), South Carolina; Tom Yawkey Reserve (South and Sand Islands), South Carolina; BHI: Bald Head Island, North Carolina.

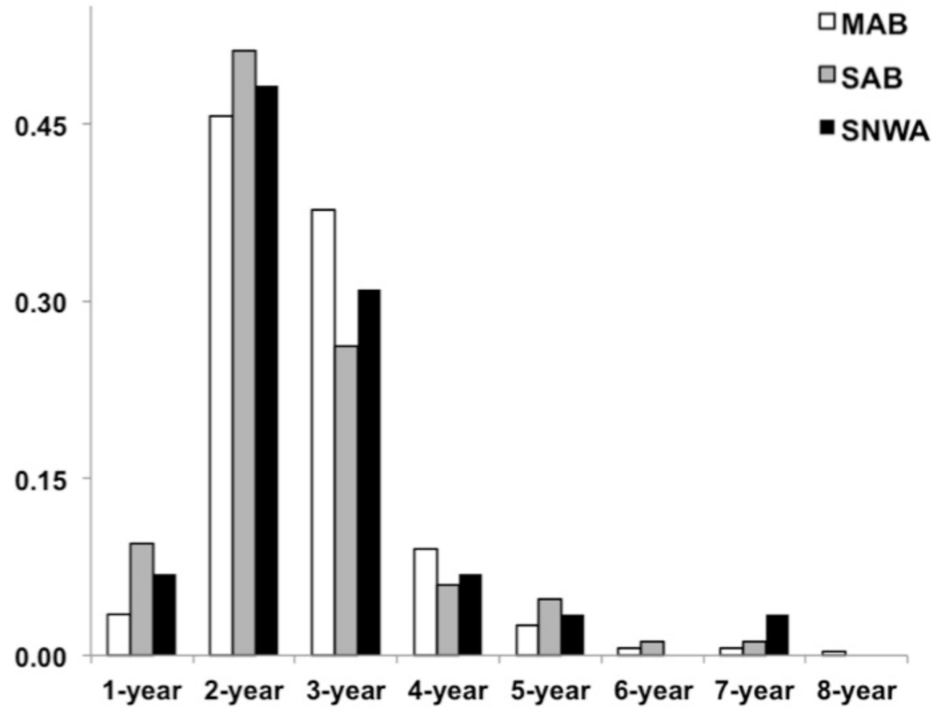

Fig. 5.2. Observed remigration intervals for loggerhead turtle females foraging in the Mid-Atlantic Bight (MAB), South Atlantic Bight (SAB), and Subtropical Northwest Atlantic (SNWA), expressed as the proportion of observations within each foraging group.

Objective 6. Reassess the southern boundary of the NRU by characterizing nest site fidelity and mitochondrial DNA haplotype frequencies through the addition of sampling sites in Nassau, Duval, and St. Johns counties, Florida.

A total of 981 individual females were identified based on clutch sampling from Nassau, Duval, and St. Johns County during 2016-2018 (Table 6.1). Ft. Clinch State Park and Anastasia State Park did not participate in sampling. Elsewhere, sampling efficiency was variable based on the ability of surveyors to locate clutches, being highest on Amelia Island and lowest at Ponte Vedra Beach. If nests were missed on deposition but located following hatchling emergence (undetected nests), a DNA sample was taken from inventory material (hatched eggs or dead hatchling tissue). DNA assignment efficiency was variable with undetected nests because it was often not possible to assign samples taken at inventory due to lack of matching maternal genotypes in the genetics database (Ponte Vedra Beach). As expected, the highest proportion of NRU remigrants was detected on Amelia Island, given proximity to the Georgia border. Most females that nested in Florida and north of Florida did so in multiple seasons and distributed nesting effort near the Georgia-Florida border. However, NRU remigrants and new females distributing their current year nesting effort north of the Florida border were identified throughout the three-county study area, even near the St. Johns-Flagler County border. Unexpectedly, several females displayed nesting dispersal between northeastern Florida and North Carolina within nesting seasons (Table 6.1, Figs. 6.1 through 6.4). One of these females (CC011280) nested in northeastern Florida, traveled approximately 700 km to NC, and then returned to nest within 30 km of her previous nesting site in northeastern Florida (Fig. 6.2).

OCF by site bin was highest near the Georgia border and declined southward (Table 6.2). The proportion of females within sites that were detected laying only a single clutch per season ranged from 11.3% on Amelia Island at the northern extent of Florida to 59.4% on the St. Johns County-Flagler County border (Table 6.2). Nest site fidelity was variable among females nesting in northeastern Florida, but there was no consistent latitudinal pattern (Table 6.3).

Mitochondrial control region sequencing yielded primarily CC-A1.1 and CC-A2.1 haplotypes (Table 6.4). However, sequencing of an expanded control region fragment did identify variants of both CC-A1 and CC-A2 that are more common elsewhere in Florida and the Greater Caribbean region. The expanded sampling effort also identified haplotypes more common among central eastern and southeastern Florida management units. The relative frequencies of CC-A1.1 and CC-A2.1 in latitudinal bins displayed a clinal trend from the Georgia border through the St. Johns County-Flagler County border (Fig. 6.5).

Table 6.1. Summary data for individual female loggerhead turtles identified nesting in northeastern Florida from 2016-2018. Site codes are explained in Figure 6.5 caption. Counts indicate individuals with nests in other states in previous years or the current year.

Site		Previous Years				Current Year		
	2016 N	GA	SC	NC	VA	GA	SC	NC
AML	83	24	8	1		36	5	
LTP	31	3		2		2	2	
JAX	32	2	2			4	2	
nSJC	43	3				3	2	
GTM	86	4	4			5	2	1
SPV	72	2		1		5	1	
sSJC	69	1	2	1			1	
	2017 N							
AML	68	17				27	2	1
LTP	9					2		
JAX	30	3	3	1		5	3	1
nSJC	39		2			3		1
GTM	77	7	5			7	3	2
SPV	54	2				3		3
sSJC	51	1		1		2		
	2018 N							
AML	53	11	3			9	4	
LTP	11	1				1	1	
JAX	23	4	2	1		3	1	1
nSJC	26	1	1			2	1	
GTM	51	1	1		1	1	2	4
SPV	36	3	1			1	2	1
sSJC	60	1				1		

Table 6.2. Observed clutch frequencies for individual loggerhead turtles that nested in northeastern Florida during 2016-2018 (combined across years). % SC females indicates the proportion of all females in each site bin that were detected laying only a single clutch.

	% SC females	mean (± SD) OCF
AML	11.3	3.49 (± 1.45)
LTP	13.7	3.61 (± 1.48)
JAX	30.6	2.58 (± 1.40)
nSJC	40.4	2.26 (± 1.38)
GTM	35.5	2.33 (± 1.33)
SPV	44.2	2.10 (± 1.28)
sSJC	59.4	1.64 (± 0.92)

Table 6.3. Spatial summary statistics for individual loggerhead turtles that nested in northeastern Florida during 2016-2018 and were detected laying at least two clutches within years. Females were assigned to each site bin based on their median latitude nesting location. N represents the sample size for spatial analyses, with % females indicating the proportion of all females in each site bin that N represents.

	N	% females	mean NE	median NE
AML	175	89.3	53.82 (± 80.86)	27.38
LTP	24	70.6	28.83 (± 54.25)	9.42
JAX	55	67.1	86.81 (± 165.34)	32.47
nSJC	57	60.6	59.63 (± 109.68)	19.36
GTM	129	62.3	80.28 (± 171.19)	14.88
SPV	82	51.6	72.92 (± 162.20)	17.43
sSJC	42	36.5	46.16 (± 64.05)	22.73

Table 6.4. Mitochondrial DNA control region haplotypes for female loggerhead turtles that nested in northeastern Florida from 2016-2018. "CC-A" haplotype prefixes were omitted to save space.

Site	Year	Mitochondrial control region haplotype											
		1.1	1.2	1.3	1.4	2.1	2.3	2.4	2.5	3.1	8.1	10.1	14.1
AML	2016	78				2						1	
AML	2017	49				2							
AML	2018	13				1							
LTP	2016	28				2						1	
LTP	2017	8				1							
LTP	2018	2											
JAX	2016	26									1		1
JAX	2017	21				2							
JAX	2018	13				1				1	1		
nSJC	2016	38				2	1						
nSJC	2017	27	1			5				1			
nSJC	2018	14				4							
GTM	2016	70				8		1		1		1	1
GTM	2017	56			1	5							
GTM	2018	31				7							1
SPV	2016	57		1		9							
SPV	2017	38	1		1	7				1		1	
SPV	2018	19				4				1			
sSJC	2016	48				10			1				
sSJC	2017	31	1	1	1	8	1						
sSJC	2018	41	1			8						1	1

Table 6.5. Observed clutch frequencies for individual female loggerhead turtles carrying control region haplotype CC-A2.1, compared to observed clutch frequencies for each site overall. A2.1 % SC is the proportion of females carrying haplotype CC-A2.1 that were detected laying just a single clutch, compared to % SC, the overall proportion of females detected laying a single clutch at each site.

	% SC	overall OCF	A2.1 N	A2.1 % SC	A2.1 OCF
AML	11.3	3.49 (± 1.45)	5	60.0	1.80 (± 1.30)
LTP	13.7	3.61 (± 1.48)	3	100.0	1.00
JAX	30.6	2.58 (± 1.40)	3	66.7	2.33 (± 2.31)
nSJC	40.4	2.26 (± 1.38)	11	75.0	1.33 (± 0.65)
GMT	35.5	2.33 (± 1.33)	20	40.0	2.20 (± 1.24)
SPV	44.2	2.10 (± 1.28)	20	35.0	1.90 (± 0.85)
sSJC	59.4	1.64 (± 0.92)	26	69.0	1.35 (± 0.56)

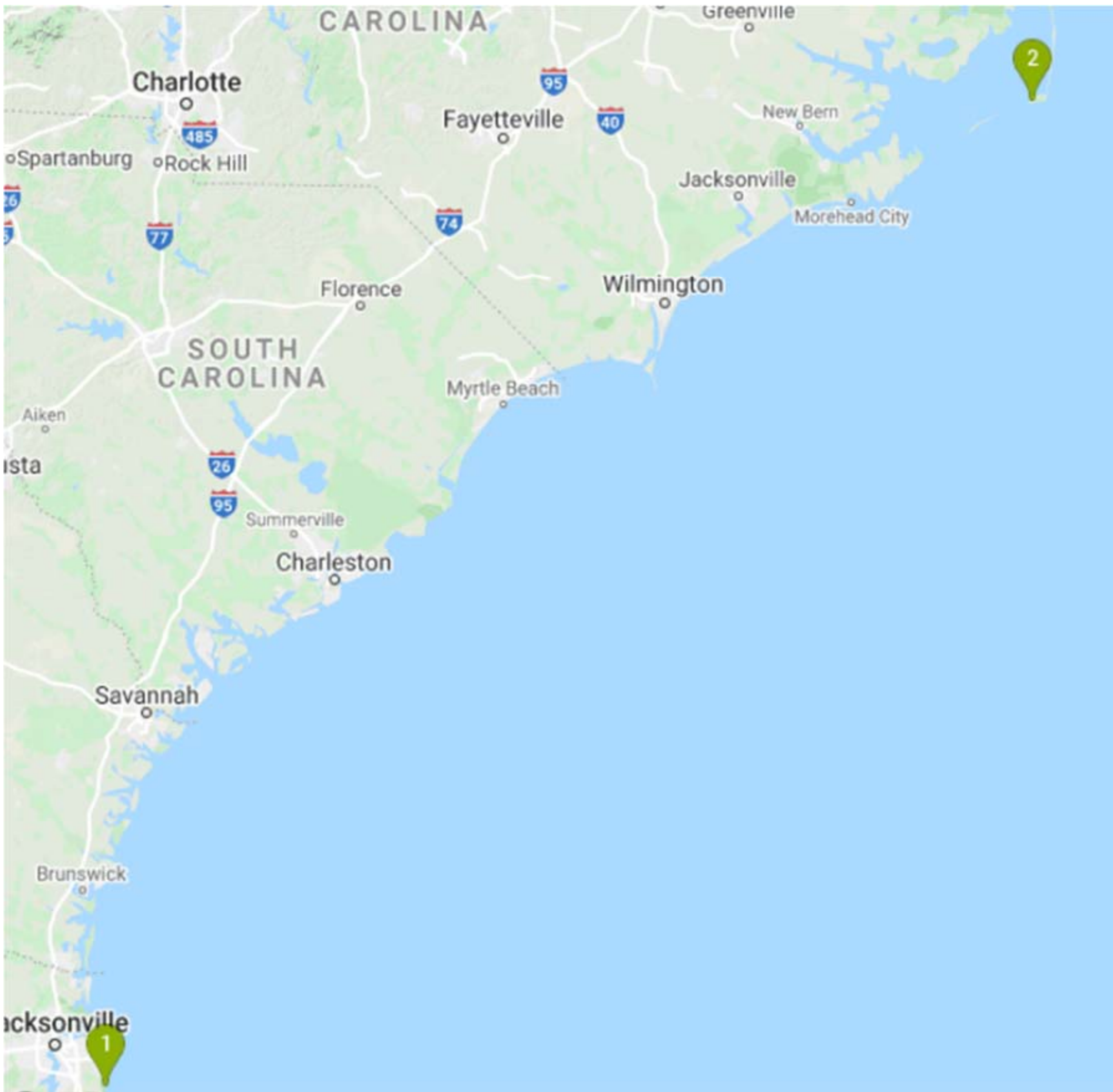

Fig. 6.1. Two nest detections for female loggerhead turtle CC009281 in 2016. She nested at Guana Tolomato Matanzas National Estuarine Research Reserve, St. Johns County, Florida on 3 July and Cape Hatteras National Seashore, North Carolina on 23 July. This represents nesting dispersal of at least 784 km.

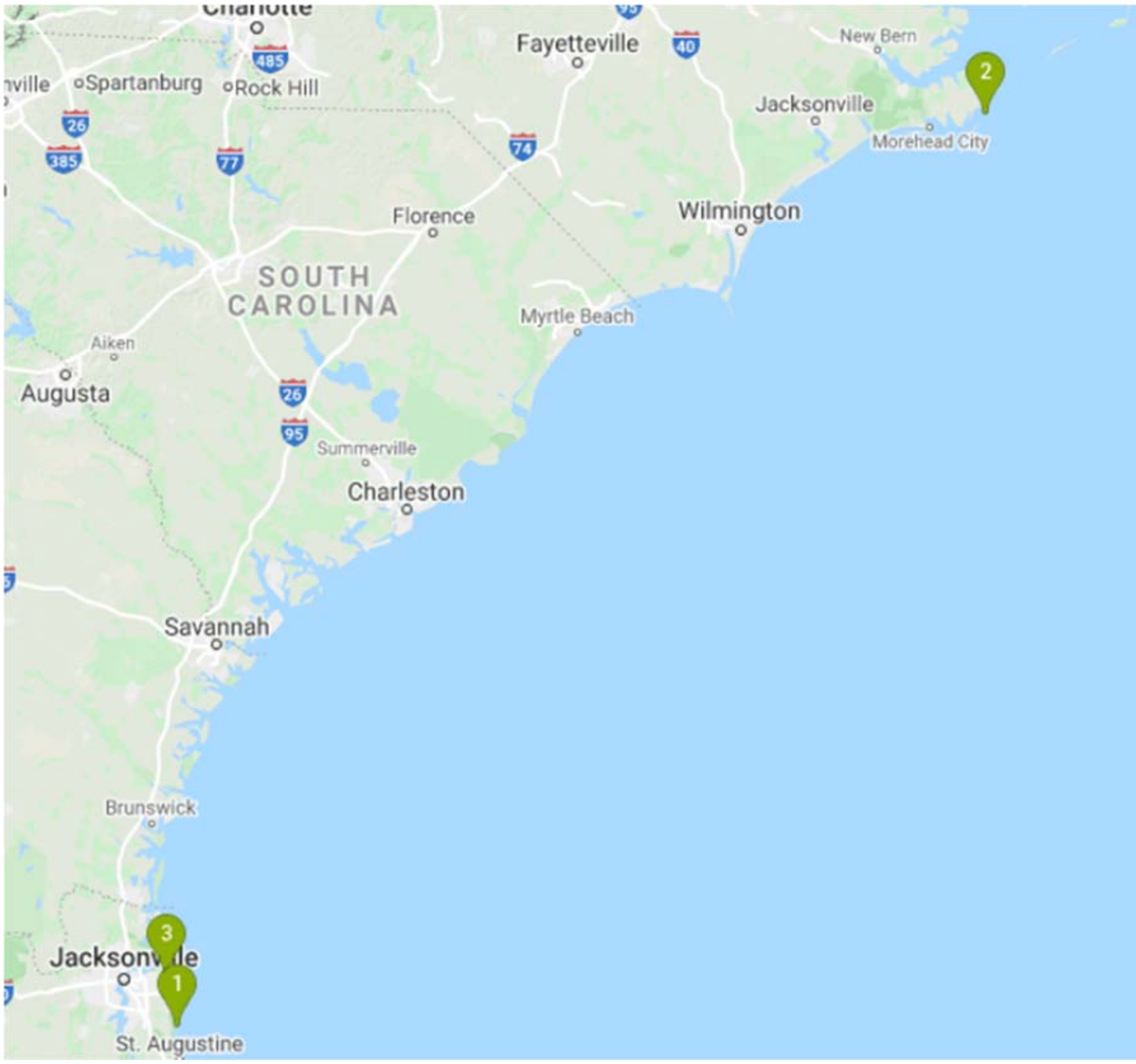

Fig. 6.2. Three nest detections for female loggerhead turtle CC011280 in 2018. This female nested at Guana Tolomato Matanzas National Estuarine Research Reserve, St. Johns County, Florida on 17 June; Cape Lookout National Seashore, North Carolina on 8 July; and Atlantic Beach, Florida on 30 July. This represents a nesting extent of 700 km.

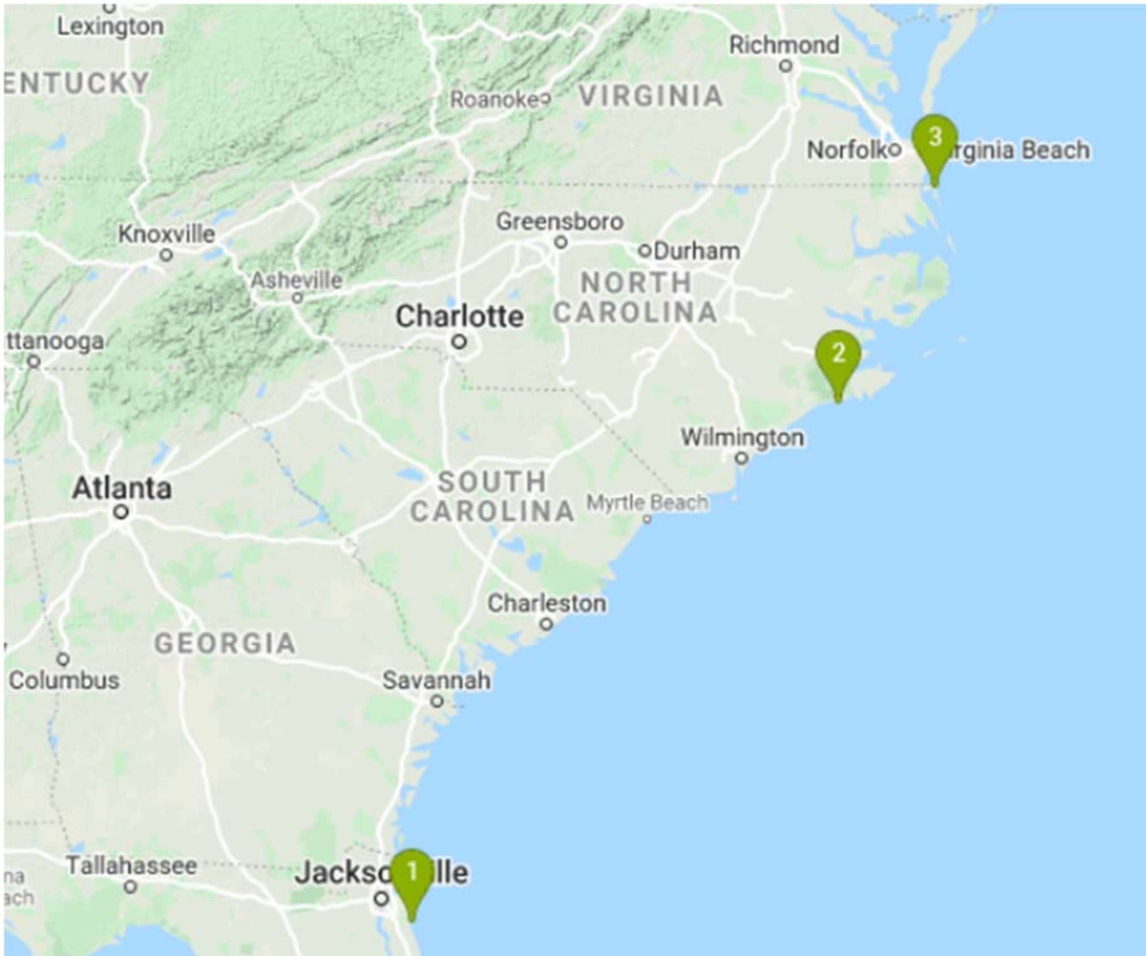

Fig. 6.3. Three nest detections for female loggerhead turtle CC011352 in 2018. This female nested at Guana Tolomato Matanzas National Estuarine Research Reserve, St. Johns County, Florida on 28 May; Indian Beach, North Carolina on 16 June; and the northern Outer Banks near the Virginia border on 7 July. This represents nesting dispersal of 878 km.

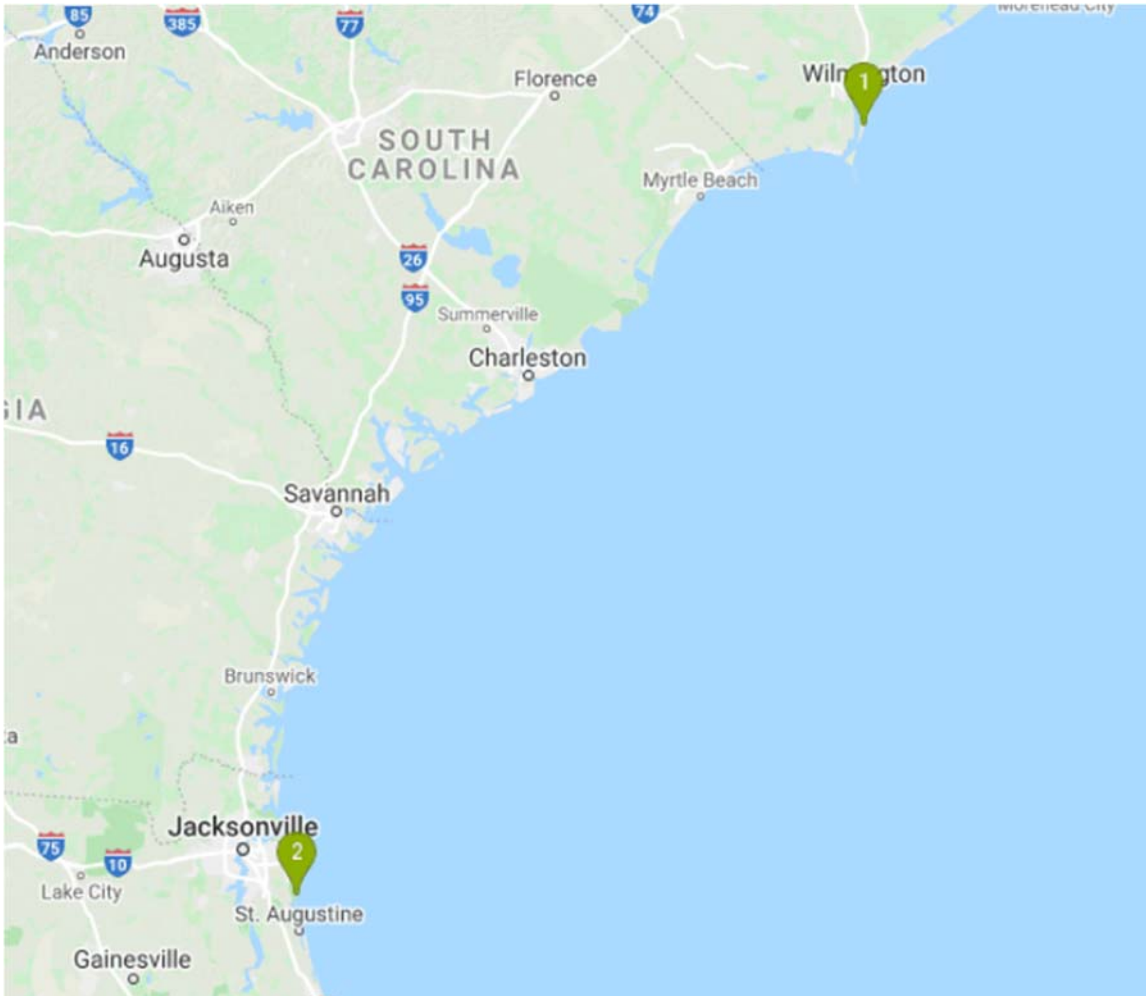

Figure 6.4. Two 2018 nest detections for female loggerhead turtle CC008256. She nested at Carolina Beach, North Carolina on 28 June and Guana Tolomato Matanzas National Estuarine Research Reserve, St. Johns County, Florida. This represents a nesting extent of at least 547 km. She had previously nested at Ft. Story Military Reservation, Virginia on 23 July 2014.

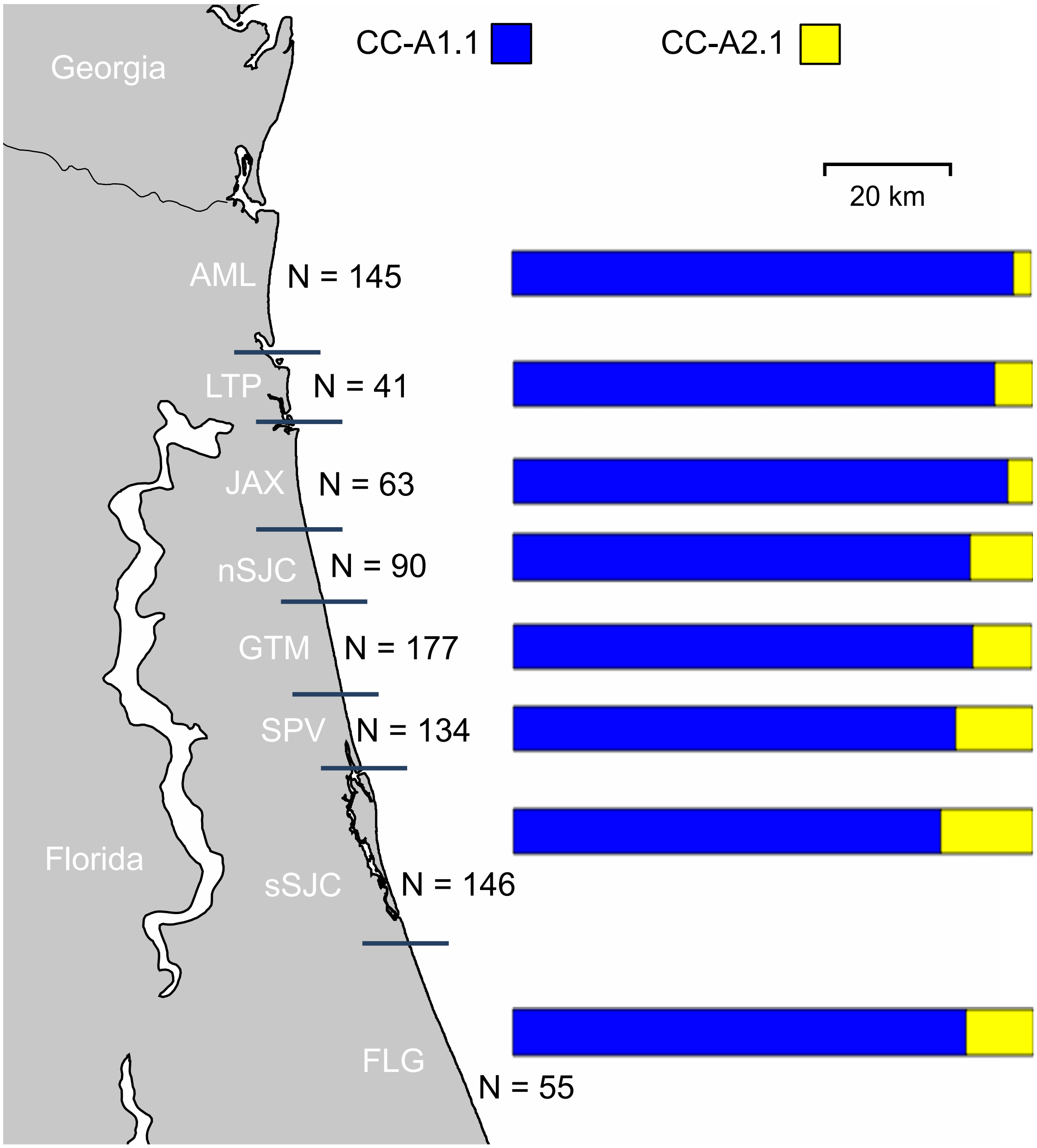

Fig. 6.5. Relative frequencies of mitochondrial control region haplotypes CC-A1.1 and CC-A2.1 for female loggerhead turtles that nested in northeastern Florida from 2016-2018. Females were assigned to a latitudinal bin based on their median nesting locations. Bin codes: AML, Amelia Island; LTP, Little Talbot Island State Park and Huguenot Park; JAX, southern Duval County beaches; nSJC, northern St. Johns County beaches (Mickler's Landing and Ponte Vedra), GTM, Guana Tolomato Matanzas National Estuarine Research Reserve and Guana River South; SPV, South Ponte Vedra and Vilano; sSJC, southern St. Johns County (St. Augustine Beach, Crescent Beach, Summer Haven). FLG are published data from Flagler County, collected 2007-2008 (Shamblin et al. 2011a) for comparison.

Objective 7. Explore the effects of spatial and temporal subsampling on the accuracy and precision of reproductive parameter estimates to maximize efficiency in developing a long-term sampling design.

Fulfilling this objective proved more challenging than expected based on how the data are stored in relational databases and exported from seaturtle.org. The database is currently designed to be inclusive for all data exported. For example, exporting nesting histories of females that nested in Georgia in 2016 yields all clutches laid by any female that nested in Georgia, but also all other clutches laid by these females in Florida, South Carolina, and North Carolina. Similarly, if data are exported for females that nested on index beaches of interest, all exported nesting histories would also include “offsite” clutches laid outside the boundaries of these index beaches. It was therefore not feasible to spatially subsample given the current structure of the database.

It is clear that any degree of temporal subsampling that focused on peak nesting would sacrifice the ability to estimate clutch frequency. Maintaining optimal robust design would require a minimum of three secondary capture periods, spanning approximately 6 weeks of the nesting season. It seems logical that these should focus on the peak nesting to capture as many females as possible. This sampling strategy would reduce clutch sampling by approximately 30% compared to full seasonal coverage. This would yield a small gain in cost savings given the loss of the ability to generate meaningful clutch frequency estimates. Conversely, focusing sampling at the beginning and end of each nesting season would minimize sampling but also increase the risk of missing a large proportion of females. Moreover, inter-nesting intervals appear to be somewhat variable over the study area and among females based on site fidelity. Having large temporal gaps between detections could further complicate inferences from program MARK.

CONCLUSIONS

Objective 1. Estimate loggerhead nesting female population size, clutch frequency and remigration intervals to assess population recovery status.

A recovery criterion for Northern Recovery Unit of loggerhead turtles is that the increase in the number of nests must be a result of corresponding increases in the number of nesting females. The genetic data collected in this study provides a unique opportunity to address this criterion. We found a significant correlation between the number of nests and the number of loggerhead females nesting on NRU beaches suggesting that nest counts provide an index to trends in adult female abundance.

Over the 9-year study period, 10,545 individual females were inferred based on genetic tags. Given that annual female abundance estimated from robust design analyses in program MARK suggested 3 to 5% of females across the region may have nested without being detected, the overall adult female population over the period could range from approximately 11,100 to 11,330 females. These adult female abundance estimates are roughly 3.7-fold greater than the median abundance estimated by Richards et al. (2011)

from nest counts from 2001-2010 and are 2.6-fold greater than the maximum estimate . Higher documented nest counts during our study relative to the 2000's account for a portion of this difference, as increasing numbers of nesting females were driving these increases in nesting. However, female abundance inferred directly from the genetic tagging was greater than expected based on estimated clutch frequencies and remigration intervals recorded at the subpopulation scale. For example, 11,287 clutches recorded in 2016 and an estimated clutch frequency of 4.63 nests per females that year should translate to approximately 2,438 females (2,200 to 2,726 based on the estimated clutch frequency credible intervals). Yet 3,127 females were assigned in 2016 based on genetic tags. This annual disparity is amplified over the study period. An overall count of 67,347 nests during 2010-2018, mean remigration interval of 2.84 years, and mean clutch frequency approximately 4.5 clutches per female should translate to approximately 4,700 females. Yet 10,545 females were inferred from genetic tagging, well over twice the first approximation estimate based on mean reproductive parameters. There are several non-exclusive explanations for this marked disparity that should be explored furtherincluding: 1) female abundance inferred from genetic tagging might be inflated due to assignment errors, 2) clutch frequency at the overall subpopulation scale may be overestimated, 3) discordance between inferred female abundance and observed clutch frequencies could be driven by greater dispersal between NRU and Florida nesting habitats than previously thought, and 4) population disequilibrium likely violates assumptions of abundance estimation.

Given that female abundance inferred from genetic tagging was considerably larger than that estimated from nest counts, could the genetic tagging estimate be inflated by assignment errors? The vast majority of females assigned DNA IDs were detected laying multiple clutches in their initial detection year. Direct matches across multiple detections provide strong inference of unique female identity because the markers are sufficiently powerful to easily distinguish among first order relatives like mothers-daughters and full sisters. The females with the lowest confidence are those assigned based on a single clutch observation. All such samples were assigned by re-extracting DNA from the sample and re-genotyping to verify, with direct matches assumed to confirm new maternal identity. During 2016, these "self" matches accounted for only 10% of identified females. Among these self-match assigned females, 25% were subsequently detected remigrating between 2017 and 2019. A small percentage of the inferred females each year could represent embryonic, rather than maternal, fingerprints due to swamping. However, given that these are always checked against other maternal consensus genotypes in the database through parentage analyses, any that do not match via parentage would still represent unique females in the database. Therefore, assignment error clearly cannot account for the strong disparity between abundance estimates based on genetic tagging and nest counts.

At the subpopulation scale, clutch frequencies for 2016-2018 were broadly congruent with those previously estimated using the same MSORD approach (Shamblin et al. 2017). However, as with previous analyses, there was some indication of annual variation in clutch frequency. This variation was not statistically significant among 2016-2018 comparisons given broad credible intervals, but it could be biologically important and warrants further investigation. Some variation in estimated clutch frequencies may arise from heterogeneity among nesting females. Given strong differences between apparent neophytes and remigrants in several reproductive parameters, as well as reduced detection of the apparent neophytes (Objective 4), clutch frequencies may be overestimated at the subpopulation scale.

Another potential explanation for detection of more females than expected given nest counts is demographic connectivity across nesting sites spanning the Florida border. Under this scenario, females nesting both within and south of the study area would be genetically tagged, but would provide incomplete nesting histories with respect to clutch frequency. Clutch sampling in northeastern Florida has revealed this type of dispersal (Objective 6). Genetic tagging has indicated that long-distance dispersal between North Carolina and Florida, previously documented via flipper tags (Stoneburner and Ehrhart 1981, Ehrhart et al. 2014), may be more common than previously appreciated. North Carolina females exhibit the highest proportion of single-clutch observations and the lowest detection probabilities across secondary periods, and this reduced detection cannot be accounted for by differences in survey effort among states (Shamblin et al. 2017). Therefore, the long-distance dispersal between Florida and North Carolina recorded for several females may be occurring at greater magnitude and even further south into Florida, beyond the boundaries of the genetic tagging study area. Historically, the challenge of quantifying dispersal between North Carolina and Florida was the small number of females tagged in North Carolina and low resighting effort in Florida. Genetic tagging via clutch sampling in high-density areas in Florida is not logistically feasible. However, with a genetic database of over 12,000 NRU females now available for comparison, it may be feasible to perform focused tagging (skin biopsies) of sufficient intensity during peak nesting to quantify dispersal in a meaningful way on high density beaches. Of 100 Melbourne Beach females currently in the database (collected in 2006), a single female was subsequently detected laying a single clutch on Kiawah Island, SC.

Finally, although converting nest counts into female abundance estimates using reproductive parameters is common practice for marine turtle monitoring globally, the NRU may be violating an important assumption that underpins this process. Typically, a single breeding proportion value (the reciprocal of the mean remigration interval in the present study) is applied to the average number of females nesting annually over an entire study period. As previously noted, an implicit assumption of this conversion process is that the population is stable over this period (Richards et al. 2011, Casale and Ceriani 2020). There is preliminary evidence that the NRU entered into the early stages of population growth during the study period (Bolten et al. 2019). The initial years of the genetic tagging project were marked by a high turnover rate, with 29% to 32% of each annual nesting cohort never subsequently detected (Objective 2). However, this proportion declined in later years, representing 15% to 22% of the 2013-2015 cohorts. Apparent recruitment in 2016-2018 was high, with 34-39% of each annual cohort being newly identified females. The impacts of violation of the assumption of population equilibrium in abundance estimation should be further explored.

Objective 2. Estimate adult female annual survival and recruitment and compare estimated survival of females utilizing the three known major foraging areas used by NRU females.

Apparent turnover for Northern Recovery Unit females was high, given that approximately one third of the females that nested during 2010-2012 were never subsequently detected. This proportion of females detected in only a single year was considerably lower for the 2013-2015 cohorts. This disparity cannot be explained by any difference in genetic tagging laboratory methodology or analytical approach over the study period. It is difficult to reconcile such high apparent turnover rates with increasing nest numbers and high apparent recruitment rates. Nonetheless, high turnover rates may partially explain the strong disparity between female abundance estimates based on mean reproductive parameters and the number of females directly assigned via genetic tagging.

Determining the cause of these high apparent turnover rates (real mortality, reproductive senescence, or nesting dispersal to Florida) is critical for elucidating population dynamics for the Northern Recovery Unit. Robust design modeling offers some flexibility in addressing variation in nest site fidelity for survival estimation. One approach is to produce artificial age structure by grouping females as transients or residents (Rivalan et al. 2005). Under this approach, real survival estimates are generated only for resident females, those present in the dataset during more than one secondary period. (Transients are essentially ignored). Alternatively, a similar artificial age structure can be applied to estimate survival separately for remigrants and apparent neophytes (Kendall et al. 2019). However, because 2010 marked the beginning of genetic tagging at the Northern Recovery Unit scale, it was not possible to confidently assign females as neophytes or remigrants prior to 2016.

Approximately 30-40% of each annual nesting cohort in 2016-2018 was new to the genetics database. Given observed remigration intervals, a small percentage of these may represent remigrants that were on the foraging grounds since the initiation of the genetic tagging project or went undetected in previous annual surveys. However, overall, these observations support high ongoing recruitment into the NRU nesting population.

Despite sampling most of the nesting range for nine years, it is clear that most females recorded do not have mothers or daughters in the database. This is not unexpected given long generation times as well as considerable variation in age at maturity and reproductive longevity (Avens et al. 2015). On the other hand, several females that were last detected nesting in the early years of the project do have assigned daughters that have recruited as nesting females in recent years. Matriarchs of many of the largest maternal families identified were recorded nesting within the last three years of the project. It's unclear whether this variation is due to temporal variation and the short sampling window or due to real differences in fitness among females. Given expected rates of multiple paternity (Lasala et al. 2013) and the low likelihood of re-mating of individuals across remigrations in such a large population, we would expect that more maternal relatives within generations would be related as half-siblings than full siblings. These half-sibling relationships can be difficult to distinguish from less related individuals with only 16 loci, particularly when family groups are small and no mother is present in the sample. Many relatedness inference programs that make use of triplets of individual genotypes (eg. COLONY, Wang and Santure 2009) provide the best confidence in assignments but are computationally intensive. A single run can take many days. The full NRU dataset is so large that COLONY now routinely crashes after a few days of computation. Mother-daughter inference will always be the highest confidence assignment, and that will only be possible to detect with some degree of continued sampling.

Objective 3. Develop demographic and scenario planning models to forecast population-level responses to conservation activities under management control and possible delisting scenarios

The population-modeling component of the project including the calculation of adult female survival estimates is found in Appendix A.

Objective 4. Compare phenology, nest site fidelity, clutch size, and clutch frequency of neophyte and remigrant nesting females.

Previous studies have suggested differences in several reproductive parameters between remigrant and neophyte females. For example, Tucker (2010) found that females arriving without tag scars laid fewer clutches than remigrants, and these apparent neophytes spread these clutches over larger beach extents. However, the difference in both observed (via tagging patrols) and estimated (via telemetry) clutch frequencies by experience groups was not statistically significant. This result can be attributed to the incorrect assignment of weak site fidelity remigrants nesting outside the physical tagging study area as neophytes, potentially obscuring real differences between groups. This study has documented the bias associated with assessing reproductive parameters when females are assigned to nesting experience groups based on traditional physical tagging beaches with relatively small geographic scope.

In the present analysis, significant differences were apparent in all reproductive parameters tested: clutch size, observed clutch frequency, estimated clutch frequency, and initiation of nesting. The proportion of remigrants in the first two inter-nesting intervals each year (through the third week of May) were strongly positively biased relative to the overall proportion of remigrants present in each annual cohort. These findings may have important implications for the use of telemetry to estimate clutch frequency. If the differences in phenology and clutch frequency between the groups are real, then clutch frequencies estimated from satellite transmitters applied on the nesting beach may be positively biased relative to the overall nesting population. Studies that have employed telemetry to assess clutch frequency have noted considerable individual variation: central western Florida loggerheads, two to eight clutches (Tucker 2010); Chagos Archipelago green turtles, two to nine clutches (Esteban et al. 2017); Ascension Island green turtles, two to eight clutches (Weber et al. 2013). Tucker (2010) argued that transmitters were distributed over the first quarter of the nesting season, and therefore represented some of the later arriving females. The fact that a single female laid only two clutches suggests that some neophytes were indeed included in the sample of females fitted with satellite tags, but these may still have been under-represented relative to their overall proportion in the population if similar staggered phenology occurs there as detected for the NRU loggerhead females. While we concur with these investigators that clutch frequencies generated from telemetry are far more realistic than those estimated from tagging patrols, these telemetry-based estimates may be positively biased, leading to underestimation of female abundance.

An important next step will be incorporating nesting experience into clutch frequency estimation by treating apparent neophytes remigrants as different groups within the same analysis. Our approach of running them separately simplified analyses and provided a first approximation of differences, but running both groups together would be more appropriate for informing detection. Nonetheless, availability constraints (eg. Florida nesting) would be the most likely explanation for apparent differences in detection between the groups, given consistent monitoring for each experience group on any particular study beach and during any particular secondary period (inter-nesting interval).

Objective 5. Evaluate effects of female foraging area choice on nesting phenology, clutch size, clutch frequency, and remigration interval.

Foraging area use for females that nested in 2016-2018 was largely consistent with that reported for NRU females sampled in 2012 and 2013 (Pfaller et al. 2020). Although sample sizes for SAB and SNWA females were small relative to MAB females, there was no apparent difference in the initiation of nesting dates among the three groups. This suggests that sampling of NRU females, either via telemetry or tissue/clutch sampling, should not be biased for foraging area choice by timing of sampling.

The finding of significantly higher corrected clutch frequencies for SAB vs. MAB females contrasts with previous analyses of Wassaw Island females that did not indicate differences (Vander Zanden et al. 2013). This apparent differentiation may have resulted from a recruitment pulse for MAB females or due to incomplete nesting histories by weak site fidelity MAB females. These hypotheses are not mutually exclusive, and the lack of differentiation in corrected clutch frequencies for remigrant MAB and SAB females could indicate a combination of both. Previous analyses indicated significantly shorter mean remigration intervals for MAB females than SNWA females nesting on Wassaw Island (Vander Zanden et al. 2013, but the SNWA sample for remigration analyses included only two females. We found no evidence of a difference between remigration cycles for these two foraging groups with a larger SNWA sample, suggesting that the longer remigration intervals previously reported may have reflected detection issues due to offsite nesting or missed nesting events on Wassaw Island.

The finding of significantly shorter remigration cycles for SAB than MAB females in the present study also contrasts with previous analyses that did not detect differentiation between the two groups (Vander Zanden et al. 2013). Detection issues due to offsite nesting may have also played a role in the apparent difference between studies. If shorter remigration cycles for SAB females hold true with additional scrutiny, more investigation is warranted. Despite the smaller body size and clutch sizes for SAB females, previously attributed to lower productivity of SAB foraging habitats relative to the MAB (Vander Zanden et al. 2013), their lack of extensive seasonal migrations may allow for energy allocation towards increased breeding periodicity.

Objective 6. Reassess the southern boundary of the NRU by characterizing nest site fidelity and mitochondrial DNA haplotype frequencies through the addition of sampling sites in Nassau, Duval, and St. Johns counties, Florida.

The initial goal was to assess NSF for these females to better understand the scale and magnitude of connectivity across this region and across the Florida border into Georgia and beyond. However, variation in observed clutch frequencies for females nesting in the seven latitudinal bins in Florida made it clear that detection varied considerably across the region, declining with distance from the Georgia border. Observed clutch frequencies for Amelia Island, Little Talbot Island State Park, and Huguenot Park were consistent with those seen in Georgia, but OCF declined steadily southward from there. The most likely explanation is that an increasing proportion of females also nested south of the St. Johns/Flagler County border. This overall OCF pattern was echoed by CC-A2.1 females in each latitudinal bin, with OCFs of CC-A2.1 females nearly universally lower than the overall OCF. The clinal shift in the relative frequencies of CC-A1.1 and CC-A2.1 suggest a broad transitional zone between the NRU and central eastern Florida management unit, which is supported by the patterns of connectivity suggested by NSF analyses and inferred from the OCF differences across the region. Given the relatively low nesting densities across northeastern Florida and the stronger affinity to NRU than central eastern Florida management unit haplotype frequencies, this region may best be treated as a southern extension of the NRU for monitoring and management purposes.

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Appendix A.

An integrated population model for loggerhead sea turtles in the Northern Recovery Unit

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1 Introduction

Sea turtle populations are difficult to assess and monitor primarily because efficacious surveys are only feasible during nesting. Entire life stages are practically unobservable, and even mature females spend variable numbers of years at sea between breeding seasons. Females nest multiple times in a season, but distances between consecutive nests may be on the scale of tens of kilometers. The latter attribute has restricted the scope of inference of sea turtle tagging efforts on discrete beaches.

Previous efforts to estimate vital rates of the loggerhead Northern Recovery Unit (NRU) were limited either by data paucity (SEFSC, 2009) or by the analysis framework (Shamblin et al., 2017). With this effort, we make use of the two most comprehensive nesting datasets yet collected for the NRU. The first, nest survey and monitoring efforts organized by state wildlife agencies of Georgia, South Carolina and North Carolina, includes records for 102,096 nests over the period 1997 – 2019, including information on the number of eggs and hatchlings produced. The second is the genetic mark-recapture dataset of Shamblin et al. (2017) plus subsequent additions, which includes 77,960 detections of 11,477 individual females over the period 2008 – 2019.

Our approach is to use a Bayesian integrated population model (IPM; Besbeas et al. 2002; Kery and Schaub 2012) that links a matrix population model operating at the level of the NRU, to a multi-state mark-recapture model that allows nest detection probability to vary along the NRU coast (i.e., GA, SC, NC). Parameters are shared between the two model components, improving estimation and allowing prediction of the population trajectory into the future. Critical to the operation of the model is the incorporation of major changes to sea turtle management that occurred in the NRU, including the adoption of turtle excluder devices (TEDs) and nest protection. The model is allowed to alter appropriate population parameters (e.g., hatchling survival) in years corresponding to these management changes. Information from surveys of invertebrate prey in areas where non-breeding adults forage has also been incorporated.

Our objectives in building the loggerhead IPM were to: 1) improve estimation of population vital rates, and 2) allow prediction of future changes to the population, under various management scenarios. We now describe separately the mark-recapture and projection models, then their integration, and the process of model fitting. Subsequent sections explore sensitivities of the model, and describe how the parameterized projection model may be used as a decision support tool.

1.1 Year indices

Throughout the report, three year indexes are used: t for the entire projection period, tm for the period of mark-recapture data (2008 – 2019), and ts for the period of nest count data (1997 – 2019). The index $t(tm)$ indicates the values of t corresponding to the years covered by tm; $t(ts)$ is defined similarly.

2 Mark-recapture model

The mark-recapture portion of our model has the general form of a multistate Jolly-Seber model (Kery and Schaub, 2012; Kery and Royle, 2016), in which individuals are allowed to recruit into the breeding population over the course of the study. Non-breeding females may occupy one of a number of states corresponding to the number of years since last breeding. No attempt is made to account for male turtles, since they are never observed.

The mark-recapture model estimates a number of parameters jointly with the NRU-wide projection model; these are enumerated in chapter 4. They include survival, number of nests laid (clutch frequency), and annual, NRU-wide, per nest detection probability.

2.1 Input data

The data input to the mark-recapture model comprise nest records for individuals in the genetic mark-recapture dataset. The data were organized in two distinct matrices. The first, called here D^l, contains information about individual nests, including: 1) location $x \in (0, 1)$ along the scaled, 'linearized' coast (with the southern extreme being 0, the northern end 1); 2) clutch size c, and 3) emergence rate e, the ratio of hatchlings that emerged from the nest, to the number of eggs laid. There were 77,960 such nest records in all.

The second individual-based data matrix, called here D^n, tabulated the number of nests assigned to each individual $i \in 1, 2, \ldots, I$ in each year $tm \in 1, 2, \ldots, T_m$. The dimensions of D^n were I = 11,477 rows by T_m = 12 columns.

2.2 Coastal segments

Space is treated explicitly in two ways in the mark-recapture model; both rely on conceiving of the NRU coast as a linear feature. The first use of space was in constructing a nesting kernel for each female, from nest locations. The second spatial process was nest detection probability, which was applied at the level of the *coastal segment*.

We defined coastal segments by locating breaks in beach features that did not split logical beach units such as barrier islands, or jurisdictions of monitoring organizations. Coastal segments could contain several discrete beaches. Estuaries and inlets provided good natural boundaries (Table 2.1).

Table 2.1: Coastal segments used in the loggerhead sea turtle integrated population model. Geographic features represent the northern end of each segment; the southern end of segment 1 is the St. Mary's River (the border between Florida and Georgia). The sum of the total beach lengths of the segments is 1,065.5 km.

Number	Northern boundary	State	Total beach length (km)
1	St. Andrew Sound	GA	33.9
2	St. Simon's Sound	GA	15.0
3	Altamaha Sound	GA	24.6
4	Sapelo Sound	GA	31.0
5	St. Catherine's Sound	GA	16.6
6	Ossabaw Sound	GA	16.8
7	Wassaw Sound	GA	14.5
8	Savannah River	GA	11.9
9	Port Royal Sound	SC	29.3
10	St. Helena Sound	SC	45.0
11	North Edisto River	SC	32.0
12	Stono Inlet	SC	19.0
13	Charleston Harbor	SC	27.4
14	Dewees Inlet	SC	15.6
15	Bulls Bay	SC	15.4
16	Key Inlet	SC	5.2
17	Romaine River	SC	20.0
18	South Santee Inlet	SC	7.3
19	Winyah Bay	SC	11.3
20	North Inlet	SC	12.6
21	Pawley's Inlet	SC	7.2
22	Midway Inlet	SC	2.4
23	Murrells Inlet	SC	11.0
24	Little River Inlet	SC	57.5
25	Tubbs Inlet	NC	7.2
26	Shallotte Inlet	NC	22.7
27	Lockwoods Folly Inlet	NC	14.4
28	Cape Fear River	NC	23.1

Continued next page...

Table 2.1: Coastal segments continued.

Number	Northern boundary	State	Total beach length (km)
29	Carolina Beach Inlet	NC	34.3
30	Masonboro Inlet	NC	6.5
31	Mason Inlet	NC	7.7
32	Rich Inlet	NC	7.6
33	Howard's Channel	NC	5.9
34	New River Inlet	NC	41.8
35	Brown's Inlet	NC	12.3
36	Bear Inlet	NC	5.8
37	Bogue's Inlet	NC	5.6
38	Beaufort Inlet	NC	43.1
39	Ocracoke Inlet	NC	90.0
40	Oregon Inlet	NC	124.9
41	Rappahannock River	NC,VA	130.1

Coastal segments were defined as straight line segments connecting the boundary points; nests were then projected perpendicularly onto the nearest segment. We then treated the entire coast as a continuous linear feature of unit length, as though the coastal segments had been 'straightened' out, like a surveyor's chain.

2.3 Segment-level detection probability

Nest searching effort has not been constant through space or time on NRU beaches. Each segment $s \in \{1, 2, \dots, S = 41\}$ had an associated, time-varying nest detection probability, $p^d_{s,ts}$, with $ts \in \{1, 2, \dots, T_s = 23\}$ indexing the years of the nest survey data.

Nest searching effort data was available for all beach-year combinations in the nest survey data: effort has generally increased within segments during the period of nest monitoring (1997 – 2019), as has the number of segments receiving effort. Effort $f_{s,ts} \in [0, 1]$ was calculated as the ratio of km·days over which nest searching was conducted, to the total possible beach km·days during the breeding season. We used a restrictive model to relate detection probability to effort, to reflect field observations that nest detection probability should rise approximately linearly with effort, with slope near 1:

$$p^d_{s,ts} = p^{min}_s + (p^{\max} - p^{min}_s) \times \text{cdf}_\beta(f_{s,ts}, a^d, 1/a^d)$$

$$a^d \sim \text{Unif}(0.5, 2)$$

$$p^{max} \sim \text{Unif}(0.97, 1)$$

$$p_s^{min} \sim \text{Unif}(0, 0.05)$$

where cdf_β is the cumulative distribution function for the beta distribution. The curve's intercept is segment-dependent because some segments are monitored by volunteers who act independent of formal surveys; thus, some segments may have nests registered in the database even though $f_{s,ts} = 0$.

2.4 Nesting kernels

To translate the time-varying detection probabilities associated with coastal segments to individual detection probabilities for females, we used the notion of a nesting kernel. We redefined each nest's location as a proportion, where the value represented the relative distance from the southern end of the coast. Along the linearized coast, the nesting kernel is conceived of as a unimodal beta distribution that is fitted to the vector of observed nest locations for an individual female:

$$x \sim \text{Beta}(a_i^k, b_i^k)\ \forall x \in \mathbf{x}_i$$

We initially used vague Gamma distributions as priors for a_i^k and b_i^k, but found that estimates of individuals' kernels were unreasonably wide (implying that individuals' detection probabilities were unrealistically low; see $p_{i,t}^{avg}$ definition below). We therefore fit unimodal beta distributions to each individual's observed nest locations before fitting the population model, and passed the parameter values a^k_i and b^k_i as constants to the model. An alternative solution would involve the use of an additional level of hierarchy, with hyperparameters used to share information about kernel widths across individuals. We will continue to investigate this approach to kernel estimation.

We thus make a strong assumption about how an individual's nests are distributed: if nests are observed within two non-adjacent segments, our choice of a unimodal beta to describe the nesting kernel implies that the probability of the individual nesting between those two segments is high. However, some segments are known to have lower nesting densities (e.g., segment 24 containing Myrtle Beach), and survey effort is concomitantly lower as well. To provide information to the model regarding these differences in nest density, we produced a constant vector int of expected 'nesting intensity' in each segment s (Fig. 2.1). Each int_s was calculated by 1) dividing the observed number of nests d^{tot}_{ts} by the amount of effort $f_{s,ts}$ put toward surveys of the segment in those years; 2) taking the mean value of the result in each segment, over years 2015-2019; and then 3) normalizing the resulting vector by dividing it by the sum of its elements.

For each individual, we then assessed the amount of probability mass of its kernel corresponding to each coastal segment s, and multiplied that probability by the segment's nesting intensity int_s:

$$k_{i,s} = int_s \times \left[\text{cdf}_\beta(s, a_i^k, b_i^k) - \text{cdf}_\beta(s-1, a_i^k, b_i^k)\right].$$

The resulting values represented the probability the individual will nest in each coastal segment. Notice that all elements of this expression are constants in the model, since the nesting kernels are regarded as fixed.

In a given year t, the ith individual's per nest detection probability is the vector product

$$p_{i,t}^{avg} = k_{i,\cdot} \cdot p_{\cdot,t}^{d}$$

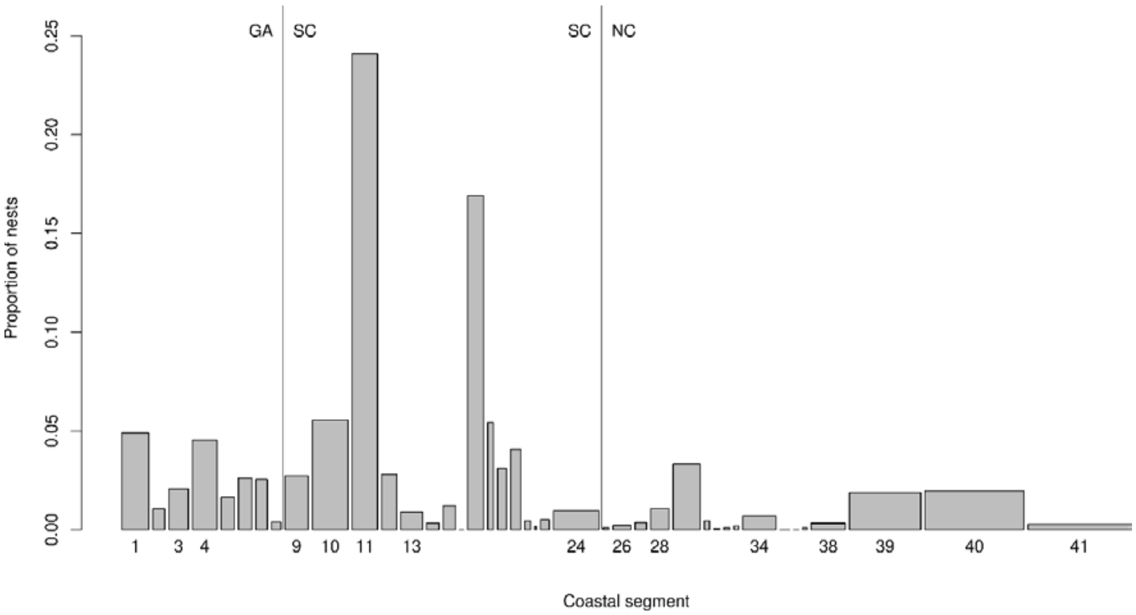

Figure 2.1: Calculated nesting intensity across coastal segments (Table 2.1), in the Northern Recovery Unit; used as data in integrated population model. Bar width is proportional to the amount of beach in the segment. Compare to Fig. 4.1.

where $p^{d}_{s,t}$ is fixed to 0 if no survey occurred in the segment that year. The number of nests observed for individual i in year t, that is the ith row and tth column of matrix D^n, was modeled as a binomial process:

$$d^{n}_{i,t} \sim \text{Binom}(p^{avg}_{i,t}, n_{i,t})$$

where n is the true number of nests, which is dependent on the state of the turtle in a given year (see section 2.6).

We thus assume that any coastal segment within the nesting kernel of a turtle will be chosen as a nest site, with probability corresponding to the overlap of the kernel with the segment, times a measure of the observed proportion of NRU nests laid within the segment, which we call nesting intensity.

2.5 Individual states, and transition matrix

Individuals' states were defined by the $I \times T$ matrix Z. Two states were used for initial entry into the breeding population, one for breeding, one for death, and 11 for remigration (Table 2.2).

Table 2.2: Possible individual states in the mark-recapture model.

Number	State
1	Juvenile
2	Non-breeder with unknown history
3	Non-breeder: 12 years since breeding
4	Non-breeder: 11 years since breeding
5	Non-breeder: 10 years since breeding
6	Non-breeder: 9 years since breeding
7	Non-breeder: 8 years since breeding
8	Non-breeder: 7 years since breeding
9	Non-breeder: 6 years since breeding
10	Non-breeder: 5 years since breeding
11	Non-breeder: 4 years since breeding
12	Non-breeder: 3 years since breeding
13	Non-breeder: 2 years since breeding
14	Breeder
15	Dead (absorbing state)

Individuals were initially assigned to one of three states in year $t = 1$:

1. juvenile ($z = 1$),
2. non-breeding adult with unknown history ($z = 2$), or
3. breeding adult ($z = 14$).

Individuals left state 1 to become breeders with probability r, and left state 2 to become breeders with probability v. Breeding females either bred again, died, or were moved into state 13. Breeders survived with probability φ_t^{br}.

The 15×15 transition matrix M for year tm of the genetic mark-recapture period is:

$$
M_{tm} = \begin{bmatrix}
1-r & 0 & 0 & 0 & \dots & 0 & 0 & r & 0 \\
0 & 1-v & 0 & 0 & \dots & 0 & 0 & v & 0 \\
0 & 0 & 0 & 0 & \dots & 0 & 0 & \phi^{nb} & 1-\phi^{nb} \\
0 & 0 & \phi^{nb}(1-p^{br}_{t,11}) & 0 & \dots & 0 & 0 & \phi^{nb}p^{br}_{t,11} & 1-\phi^{nb} \\
0 & 0 & 0 & \phi^{nb}(1-p^{br}_{t,10}) & \dots & 0 & 0 & \phi^{nb}p^{br}_{t,10} & 1-\phi^{nb} \\
0 & 0 & 0 & 0 & \dots & 0 & 0 & \phi^{nb}p^{br}_{t,9} & 1-\phi^{nb} \\
0 & 0 & 0 & 0 & \dots & 0 & 0 & \phi^{nb}p^{br}_{t,8} & 1-\phi^{nb} \\
0 & 0 & 0 & 0 & \dots & 0 & 0 & \phi^{nb}p^{br}_{t,7} & 1-\phi^{nb} \\
0 & 0 & 0 & 0 & \dots & 0 & 0 & \phi^{nb}p^{br}_{t,6} & 1-\phi^{nb} \\
0 & 0 & 0 & 0 & \dots & 0 & 0 & \phi^{nb}p^{br}_{t,5} & 1-\phi^{nb} \\
0 & 0 & 0 & 0 & \dots & 0 & 0 & \phi^{nb}p^{br}_{t,4} & 1-\phi^{nb} \\
0 & 0 & 0 & 0 & \dots & 0 & 0 & \phi^{nb}p^{br}_{t,3} & 1-\phi^{nb} \\
0 & 0 & 0 & 0 & \dots & \phi^{nb}(1-p^{br}_{t,2}) & 0 & \phi^{nb}p^{br}_{t,2} & 1-\phi^{nb} \\
0 & 0 & 0 & 0 & \dots & 0 & \phi^{br}_t(1-p^{br}_{t,1}) & \phi^{br}_t p^{br}_{t,1} & 1-\phi^{br}_t \\
0 & 0 & 0 & 0 & \dots & 0 & 0 & 0 & 1
\end{bmatrix}
$$

In the seven-column block elided from the above matrix, indicated by ellipses, all elements are zero except for the lower off-diagonal, which continues the sequence $\varphi^{nb}(1 - p^{br}_{t,i})$, $i \in \{11, 10, \dots, 3, 2\}$. Note that the model assumes that adult turtles that have not bred for 12 years (row 3 of matrix) either breed, or die.

The rows of each $\boldsymbol{M_t}$ sum to 1, and the state $z \in \{1, 2, \dots, 15\}$ of each individual $\boldsymbol{i}$ for year $t+1$ is given by:

$$z_{i,t+1} \sim \text{Categorical}(m_{z_{i,t}\cdot}) \tag{2.1}$$

where $m_{z_{i,t}\cdot}$ represents the $z_{i,t}$th row of $\boldsymbol{M_t}$.

Breeding season survival φ^{br}_t applies only to state 14 (the only observable state), to which also applies the first breeding probability value, $p^{br}_{t,1}$. Likewise, non-breeding survival applies to the unobserved states 4 – 13, to which apply the remainder of the breeding probability values. Using turtle detections only, then, breeding and non-breeding adult survival and the vector of remigration probabilities are confounded, and by itself, the model cannot estimate them without strong priors.

2.6 State-dependent fecundity

Turtles vary in the number of detected nests in a breeding season, and although some of this variation may be to detection probability, we also reasoned that turtles killed during the breeding season would on average have less time to lay nests and fewer clutches. We therefore made clutch frequency state-dependent. Clutch frequency was modeled as a mixture of Poisson distributions, with the parameter used corresponding to an individual's state in year $t + 1$. That is, turtles that would be dead in year $t + 1$ generated clutches in year t according to a potentially different Poisson distribution than those that would be alive in year $t + 1$. The Poisson parameter for surviving turtles, λ^{live} was constructed according to:

$$\lambda^{live} \sim \text{Pois}(sh_1^{live}, sh_2^{live})$$

$$sh_1^{live} \sim \text{Unif}(0,20)$$

$$sh_2^{live} \sim \text{Unif}(0, 20)\ .$$

The parameter for doomed turtles, λ^{die}, was constrained to be $\leq \lambda^{live}$:

$$\pi^{die} \sim \text{Unif}(0, 1)$$

$$\lambda^{die} = \pi^{die} \times \lambda^{live}\ .$$

An indicator of next year's state $w_t^{live} \in \{0, 1\}$ was then used to choose the proper parameter in the generation of clutch frequency n:

$$n_{i,t} \sim \text{Pois}(w_t^{live} \times \lambda^{live} + (1 - w_t^{live}) \times \lambda^{die})\ .$$

3 Matrix projection model

We used a projection model to control the stage-specific abundances within the loggerhead NRU population. This female-only matrix model is conceptually stage-based, with the following distinct life stages (SEFSC, 2009). Hatchlings are defined as hatched turtles less than one year of age; juvenile stages include pelagic, small benthic and large benthic; adults are divided into breeding and non-breeding females (Figure 3.1).

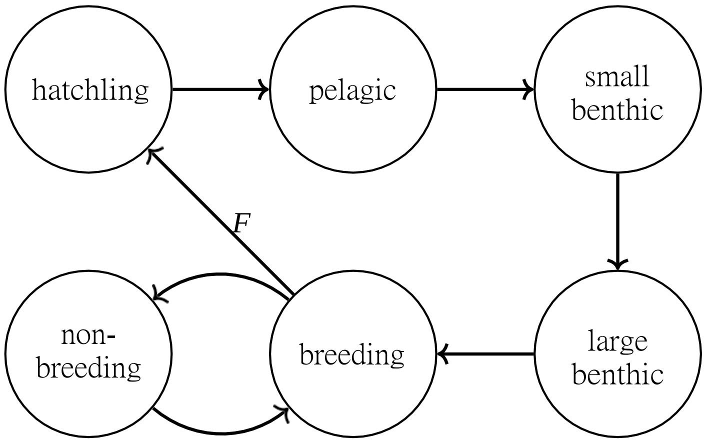

Figure 3.1: General sketch of loggerhead sea turtle life stages used in the population projection model. Per capita fecundity F determines the number of hatchlings.

To allow a better fit to the nest survey time series, life stages were expanded to into age-based sections of the projection matrix for pelagic, small benthic and large benthic juveniles. These age-based sections allow for the propagation of age-specific cohorts through time, a feature that is lacking from a purely stage-based model. For example, years with above-average hatchling production induce a 'pulse' of recruits that is preserved (though dampened) as it moves through life stages over time. The hatchling stage is equivalent to age, since the definition of a hatchling is simply a turtle of age ≤ 1 year.

The section of the matrix corresponding to adult females was divided into subsections for breeding and non-breeding turtles. Although absolute cohort ages are not preserved in the adult stages, the non-breeding section is year-based: cohorts of non-breeding turtles are divided each time step, with portions directed into the breeding stage, dying, or remaining in the non-breeding stage. In the latter case, turtles are moved into the class denoting one additional year spent in the non-breeding stage.

Fecundity rate F is a weighted average of rates F_s, which applies to turtles that will survive the breeding season, and F_d, which applies to those that will die before next year. The weights are simply the breeding survival rate and its complement, respectively.

3.1 Management epochs

Key to the inferential power of the integrated population model is the definition of five management epochs along the time period covered by the model (Table 3.1). The first epoch begins with the first year of the projection model. The second epoch begins in 1970, when organized nest protection efforts began on NRU beaches. Nest protection activity then increased steadily until 1988. The third epoch begins in 1989, when nest protection efforts doubled immediately. The fourth epoch begins in 1991, with the adoption of turtle excluder devices (TEDs) on shrimp trawlers: these TEDs were large enough to exclude small benthic juveniles and the majority of large benthic juveniles. The fifth and final epoch, which continues until the end of the projection period (i.e., until 2066) begins in 2003 with the adoption of TEDs large enough to exclude breeding adults from trawl nets.

Table 3.1: Definition of management epochs, in the matrix projection model, showing which survival parameters were free to change at the onset of each epoch. Survival of hatchlings, pelagic juveniles, and non-breeding adults was assumed to be constant across all epochs. Empty cells indicate that the value was fixed to that used during the previous epoch. *Note that nest survival ramps linearly up from φ^{nst}_1 to $0.5 \times \varphi^{nst}_2$ over Epoch 2.

		Survival Values			
Epoch	Years	Nest	Small Benthic	Large Benthic	Breeding Females
1	start – 1969	φ_1^{nst}	φ_1^{sml}	φ_1^{lrg}	φ_1^{br}
2	1970 – 1988	*			
3	1989 – 1990	φ_2^{nst}			
4	1991 – 2002		φ_2^{sml}	φ_2^{lrg}	
5	2003 – 2066				φ_2^{br}

The use of these management epochs allows the model to change in specific ways, to match historical events. This adds realism to the model, but also provides important patterns of freedom and constraint in survival parameters, which help the model fit the data time series while maintaining reasonable parameter values.

3.2 Prior distributions for survival parameters

SEFSC (2009) provide candidate distributions of annual survival probability for NRU loggerhead sea turtles, derived from reported studies. We used the distributions given there to establish uniform prior distributions for annual survival of hatchlings and juvenile turtles.

Table 3.2: Prior distributions for survival parameters. Ranges for hatchling and juvenile stages taken from SEFSC (2009).

Stage	Symbol	Distribution	Parameters
Nest	$\varphi^{nst}_1, \varphi^{nst}_2$	Uniform	0, 1
Hatchling	φ^{hat}	Uniform	0, 0.05
Pelagic	φ^{pel}	Uniform	0.59, 0.88
Small benthic	$\varphi^{sml}_1, \varphi^{sml}_2$	Uniform	0.74, 0.89
Large benthic	$\varphi^{lrg}_1, \varphi^{lrg}_2$	Uniform	0.74, 0.93
Non-breeding adult	φ^{nb}	Uniform	0, 1
Breeding adult	$\varphi^{br}_1, \varphi^{br}_2$	Uniform	0, 1

3.3 Stage duration and remigration model

Proposed ranges of stage duration in years for the three juvenile stages are provided by SEFSC (2009): pelagic (10,18), small benthic (9,12), large benthic (4,12). In order to allow the model to fit closely to the time series of NRU nest counts, we expanded the juvenile stages and the non-breeding adult stage into age-based compartments of the projection matrix.

For the juvenile stages, we used the maximum number of years for the stage given in SEFSC (2009) as the size of the square, age-based compartment. From the beginning of stage stg until the minimum stage duration value, turtles progressed to the next year within the stage at the rate $P^{stg} = \varphi^{stg}$. On reaching the age of minimum stage duration, turtles were sent to the next stage at a rate of G^{stg}_a, where $a \in \{1, 2, ..A\}$ tracked the number of years eligible to graduate, and persisted in the stage at the rate $P^{stg}_a = \varphi^{stg} - G^{stg}_a$. Graduation rate G^{stg}_a was modeled as a beta-binomial process, so that by the maximum allowable age, all turtles would be graduated from the stage.

$$G^{stg}_a = \phi^{stg} \times \mathrm{cdf}_B(a, p^{stg}_G, A)$$

where cdf_B is the cumulative distribution function for the binomial, and

$$p^{stg}_G \sim \mathrm{Beta}(sh^{stg}_1, sh^{stg}_2) .$$

with sh^{stg}_1, sh^{stg}_2 given vague Gamma priors. For large benthic turtles, the subsequent stage was breeding adult (rather than non-breeding).

The adult portion of the projection matrix resembled closely the transpose of the state transition matrix. After breeding, females left the breeding stage with probability $\varphi^{br}(1-p^{br}_1)$, or bred again at the rate $\varphi^{br}p^{br}_1$. Continued persistence in the non-breeding stage carried turtles 'backward' through the non-breeding compartment of the matrix, until they were forced to breed or die at the end of the sequence of p^{br} values.

Breeding probability was modeled as a beta-binomial, similar to the juvenile stages, but with one additional feature. The observed sequence of NRU nest totals oscillates fairly dramatically. To fit modeled nest numbers to these oscillations, we used a random effect of year t to alter the

p^{br} values. With $J = 11$ the number of years in the mark-recapture dataset minus 1:

$$p^{br}_{j,t} = \mathrm{cdf}_B(j-1, p^{\alpha}_t, J-1)\ \forall j \in \{1, 2, \ldots J\}$$

$$p^{\alpha}_t = \mathrm{logit}^{-1}(\mathrm{logit}(p^{br}_p) \times \alpha_t)$$

$$p^{br}_p \sim \mathrm{Beta}(sh^{br}_1, sh^{br}_2)\ .$$

$$\alpha_t \sim \mathrm{Norm}(0, \sigma)$$

sh^{br}_1, sh^{br}_2 vague Gammas and $\sigma \sim \mathrm{Unif}(0, 10)$.

Thus the average condition of p_{br} is represented by p^{br}_p, since this implies that $\alpha_t = 0$.

Given the age-based compartments within it, the projection matrix was therefore large (54×54), and the abundance vector correspondingly long. However, this proved necessary to fit the model to the highly variable series of nest counts.

3.4 Fecundity

The fecundity rate, as is typical in matrix projection models, appears in the top right corner of the projection matrix. Reflecting the use of a mixture of Poisson distributions to model clutch frequency in the mark-recapture model, fecundity in the projection model makes use of a weighted average of expected clutch frequencies for turtles surviving to year $t + 1$ and those dying in the current breeding season.

$$F_t = (\varphi^{br}_t \times \lambda^{live} + (1 - \varphi^{br}_t) \times \lambda^{die}) * \varphi^{nst}_t \times C/2 \times p^{em}$$

where C is the mean clutch frequency, divided by 2 to enforce an equal sex ratio among hatchlings, and p^{em} is the estimated emergence success of hatchlings. C is estimated using a negative binomial model fit to the observed clutch sizes in the mark-recapture dataset; p^{em} is derived from a zero-inflated Binomial model that also employs φ^{nst}, and is fit to the emergence information in the mark-recapture data.

4 Integrated model

Some parameters, including those for adult survival, breeding probability, clutch frequency, emergence success and nest survival, appear directly in both the mark-recapture and projection model. Several other features are used to link the two model components, in addition.

To make use of the nest count time series in conjunction with the projection model, we needed to model detection probability at the level of the NRU population. To get an overall detection probability p_t^{Avg} for the NRU each year, we found the weighted average of the coastal segments' detection probabilities, with the weights coming from a normalized sum k^{Tot} of all turtles' nesting kernels (a constant vector, since individuals' kernels were fixed in this version of the model):

$$p_t^{Avg} = k^{Tot} \cdot p^d_{\cdot,t} \, .$$

Then, total nest counts d^{tot}_{ts} were modeled as:

$$d^{tot}_{ts} \sim \text{Binom}(p^{Avg}_{t(ts)}, n^{tot}_{t(ts)})$$

where the subscript $t(ts)$ indicates the elements in the projection times series t that correspond to the survey times series ts. The value n^{tot}_t was derived directly from the abundance vector a_t:

$$n^{tot}_t = \text{round}(a_{54,t} * ((1 - \varphi^{br}_t)\lambda^{die} + \varphi^{br}_t \lambda^{live})$$

where element 54 of a_t holds the breeding female abundance.

As mentioned in section 2.4, individuals' nesting kernels were fixed in the mark-recapture component and entered the model as data. Because the individuals considered in each data shard differed, the normalized sum of their kernels k^{Tot} also differed among shards (Fig. 4.1).

4.1 Model fitting

We fit the model using JAGS (Plummer, 2017) called from R (R Core Team, 2020); however, the model is large and very time-consuming to update. Even with parallelization, running the model took too long for it to be of much use. We therefore used a method to split the data and re-join the parameter estimates known as Consensus MCMC (Scott et al., 2016). We split the mark-recapture data into ten 'shards' according to individuals, ran the same model on each set, then took weighted averages of the parameter values across the MCMC chains, with weights equal to 1/variance of the estimate. Using a burn-in of 5,000 iterations and 5,000 sample iterations, the time to complete a run using a single chain was approximately 20 hours. Results from the consensus MCMC run are reported in section 5.1.

In fact, estimates were largely similar across the shards, and in sections 5.2-5.3 below, estimates are obtained from a single representing 10% of individuals in the dataset. These runs used 3,000 burn-in and 2,000 sampling iterations.

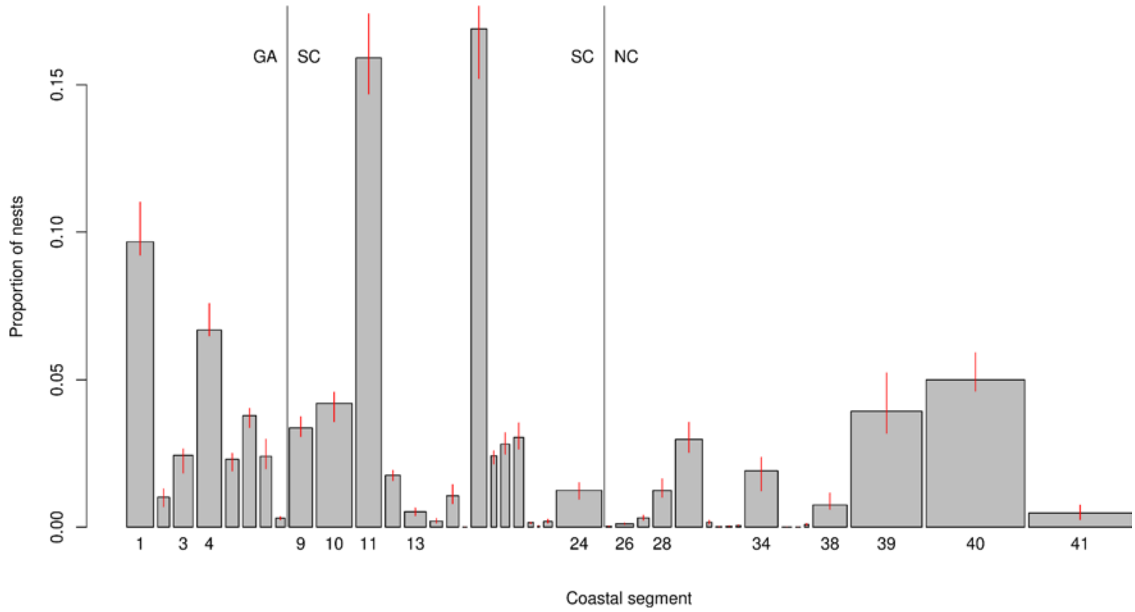

Figure 4.1: Median values of the normalized sum of individuals' nesting kernels, k^{Tot}, across the ten data shards used in the consensus MCMC model fitting procedure. Red bars indicate 2.5th and 97.5th percentiles. Compare to Fig. 2.1

Convergence of some parameters was slow, including those that were partially confounded, such as survival of juvenile stages. However, in examining trace plots, we observed that values of these parameters across MCMC chains was consistently confined to rather narrow ranges. We conclude, therefore, that extended MCMC runs would eventually converge around estimates similar to what we report. Future work will include confirming this proposition.

5 Results and model sensitivity

Although constraints have been placed on parameters and their interrelationships throughout the IPM, we expect estimates of latent parameters such as φ^{nb} to be highly dependent upon the values of other parameters, and on the functional forms for segment-level detection probability and probability of breeding in relation to remigration interval.

We therefore first report results from a model version with prior distributions as described above; then, from versions with constraints upon the curve relating segment-level detection probability to search effort. Finally, we demonstrate the use of the IPM as a management tool, by predicting the population-level effects of a future increase in mortality of breeding females.

5.1 Full model

The full, unconstrained model had a long 'burn-in' period of 20 years: the projection period began in 1947. We found this burn-in period to be sufficiently long to allow the projection model to stabilize within first epoch. All parameters that were free to change during the time series did so, and significantly (Table 5.1). Hatchling and pelagic juvenile estimates (> 0.049 and > 0.87) remained very close to the upper limit of their allowed ranges (0.05 and 0.88), indicating they provided constraints on the model behavior. Likewise, large and small benthic survival began, after TED implementation in 1991, to move to hover near the upper limit of their respective ranges. These patterns demonstrate that interpretation of estimates from these unobservable early stages should be done with care; however, the general pattern of increased survival of small and large benthic juveniles following 1991 can be safely interpreted: those changes allow the model to fit the nest count time series.

Breeding survival is predicted to have been quite low before adult TEDs were implemented; whereas in the present era, this value is estimated at $\widehat{\varphi}_2^{br} = 0.994$ (0.998, 0.999). Non-breeding survival is estimated to be lower, $\widehat{\varphi}^{nb} = 0.961$ (0.964, 0.966); overall adult survival is between these two values, and depends on the remigration interval. Estimated remigration intervals are in turn dependent upon detection probability (Fig. 5.1) and our assumptions regarding nesting kernels. Interpretation of breeding survival against non-breeding survival therefore requires some care.

Probability of breeding, across the range of years since breeding (Fig. 5.2), reveals an important aspect of the model: in an average year, most non-breeders return to breed before being away four years. However, there is variation among years ($\widehat{\sigma} = 0.43$ (0.34, 0.58)), and this variation shifts the breeding probability curve along the x-axis (shifts to the right are more extreme than to the left). Variation due to this random effect can be seen in the future uncertainty in breeding adult abundance (Fig. 5.3), nests (Fig. 5.4), hatchlings (Fig. 5.5), and juveniles (Figs. 5.6-5.8).

Table 5.1: Posterior estimates (point estimate and 95% Bayesian credible interval) from the full integrated population model, fit with consensus MCMC.

Parameter	Symbol	Median (2.5%, 97.5%)
Hatchling survival	φ^{hat}	0.050 (0.049, 0.050)
Pelagic juvenile survival	φ^{pel}	0.880 (0.879, 0.880)
Small benthic juvenile survival (– 1990)	φ_1^{sml}	0.751 (0.749, 0.771)
Small benthic juvenile survival (1991 –)	φ_2^{sml}	0.889 (0.889, 0.890)
Large benthic juvenile survival (– 1990)	φ_1^{lrg}	0.923 (0.918, 0.926)
Large benthic juvenile survival (1991 –)	φ_2^{lrg}	0.928 (0.928, 0.929)
Breeding adult survival (– 2002)	φ_1^{br}	0.851 (0.867, 0.869)
Breeding adult survival (2003 –)	φ_2^{br}	0.994 (0.998, 0.999)
Non-breeding adult survival	φ^{nb}	0.961 (0.964, 0.966)
Expected clutch frequency of surviving breeders	λ^{live}	2.82 (2.78, 2.86)
Expected clutch frequency of dying breeders	λ^{die}	2.61 (2.14, 2.84)

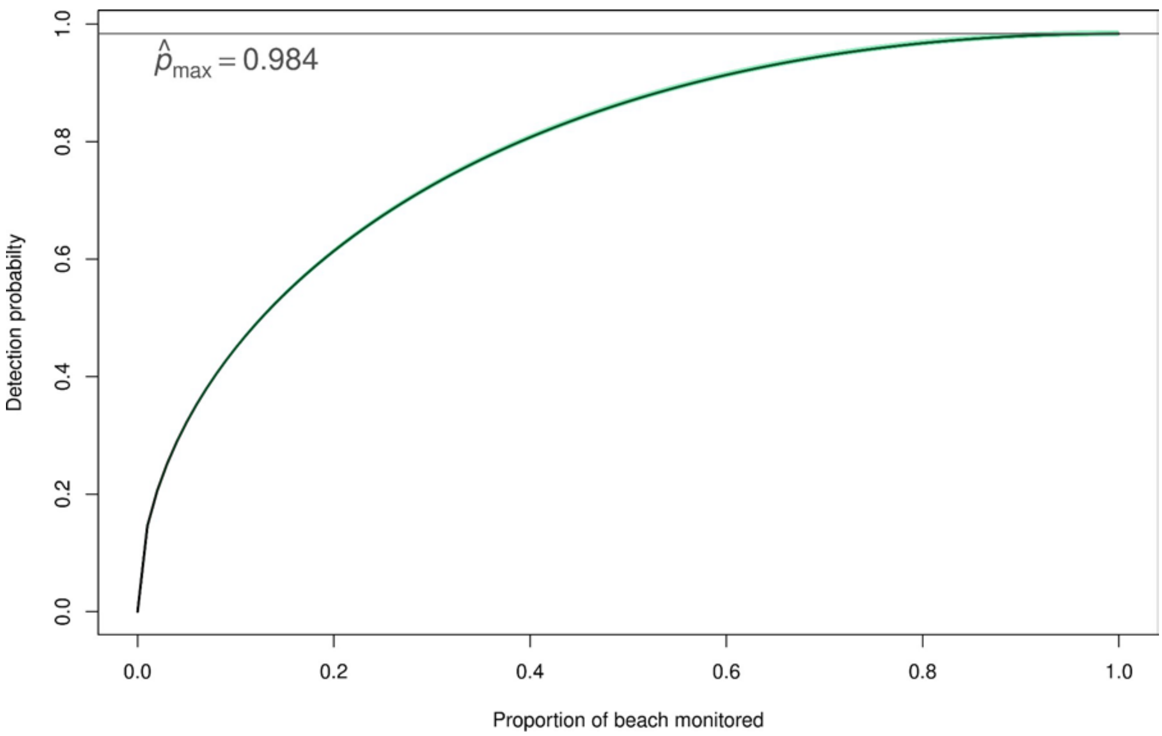

Figure 5.1: Relationship of coastal segment detection probability to nest survey effort, in the full integrated population model, for a segment in which no turtles are found when survey effort is zero. Note that segments were free to have non-zero y-intercepts (see section 2.3.)

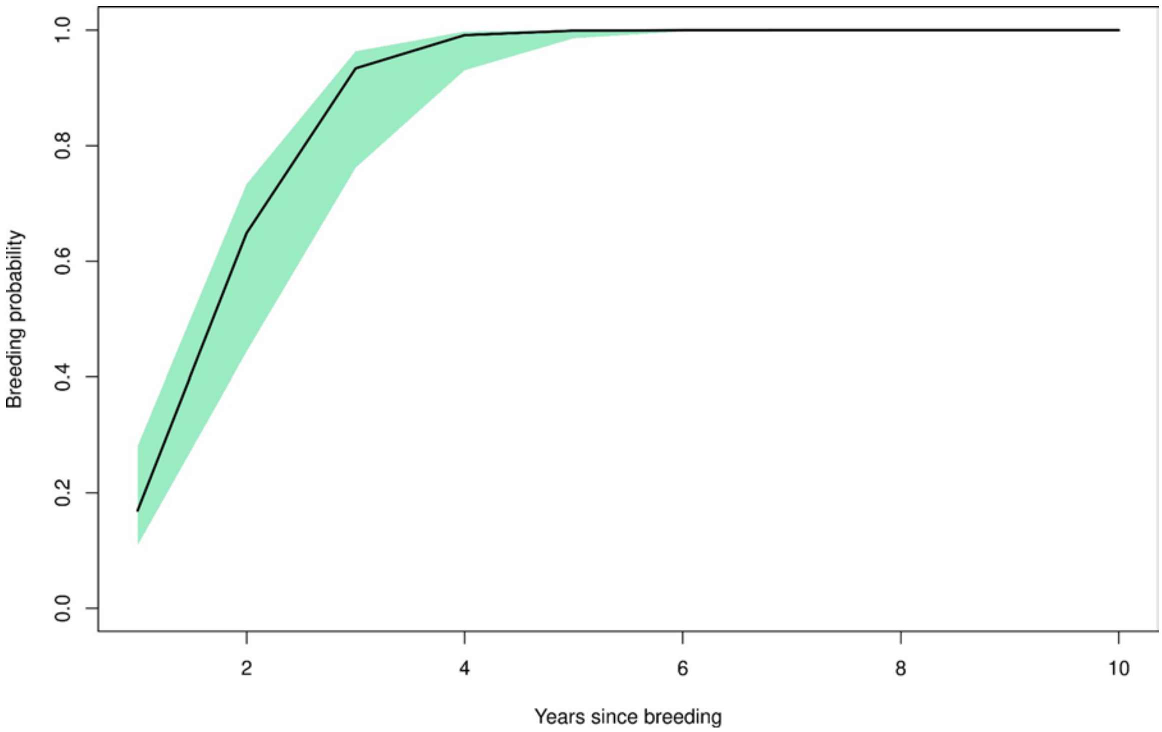

Figure 5.2: Predicted average relationship of probability of breeding, to years since breeding, for loggerhead sea turtles in the Northern Recovery Unit.

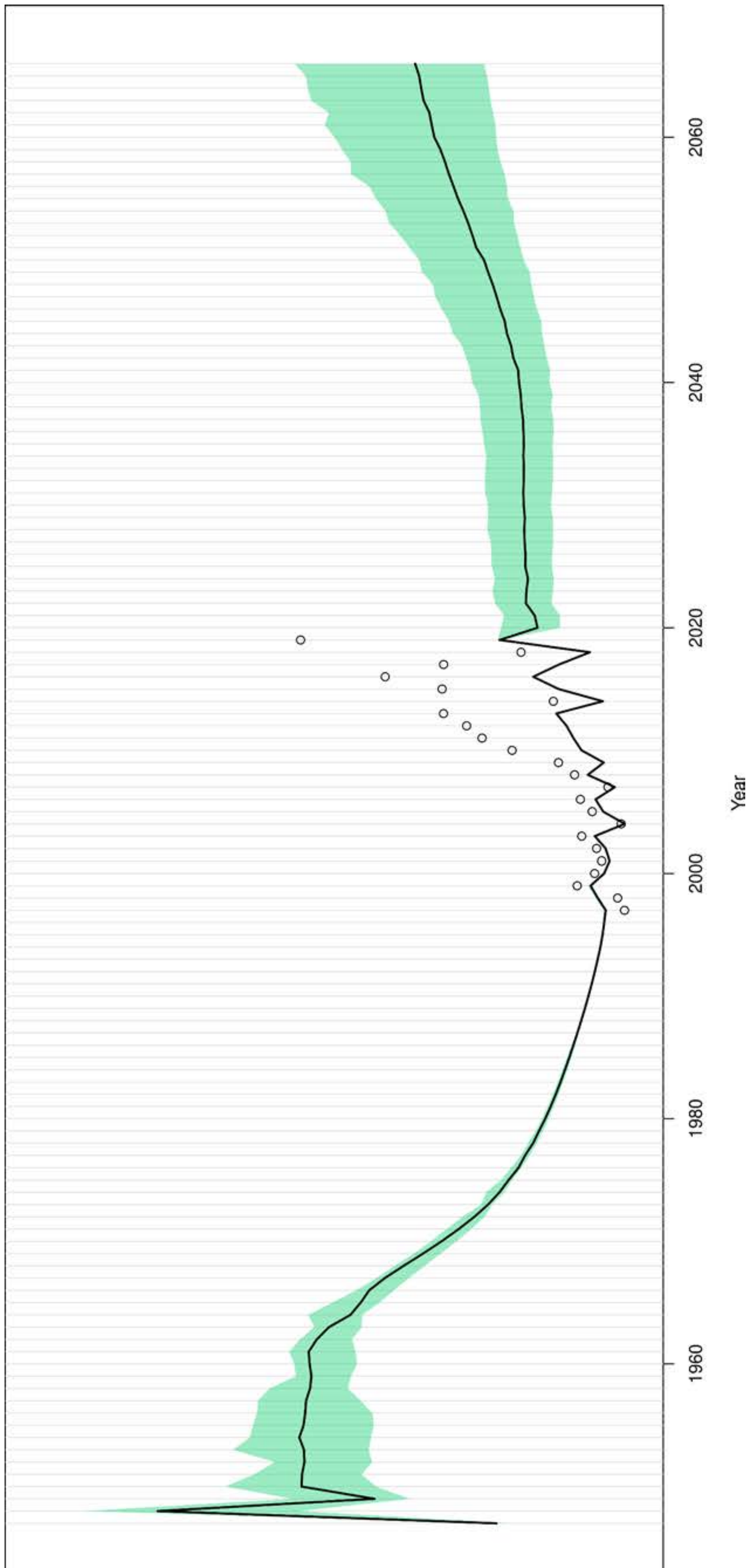

Figure 5.3: Predicted abundance of breeding adult female loggerhead sea turtles in the Northern Recovery Unit. Open circles show the raw NRU nest counts.

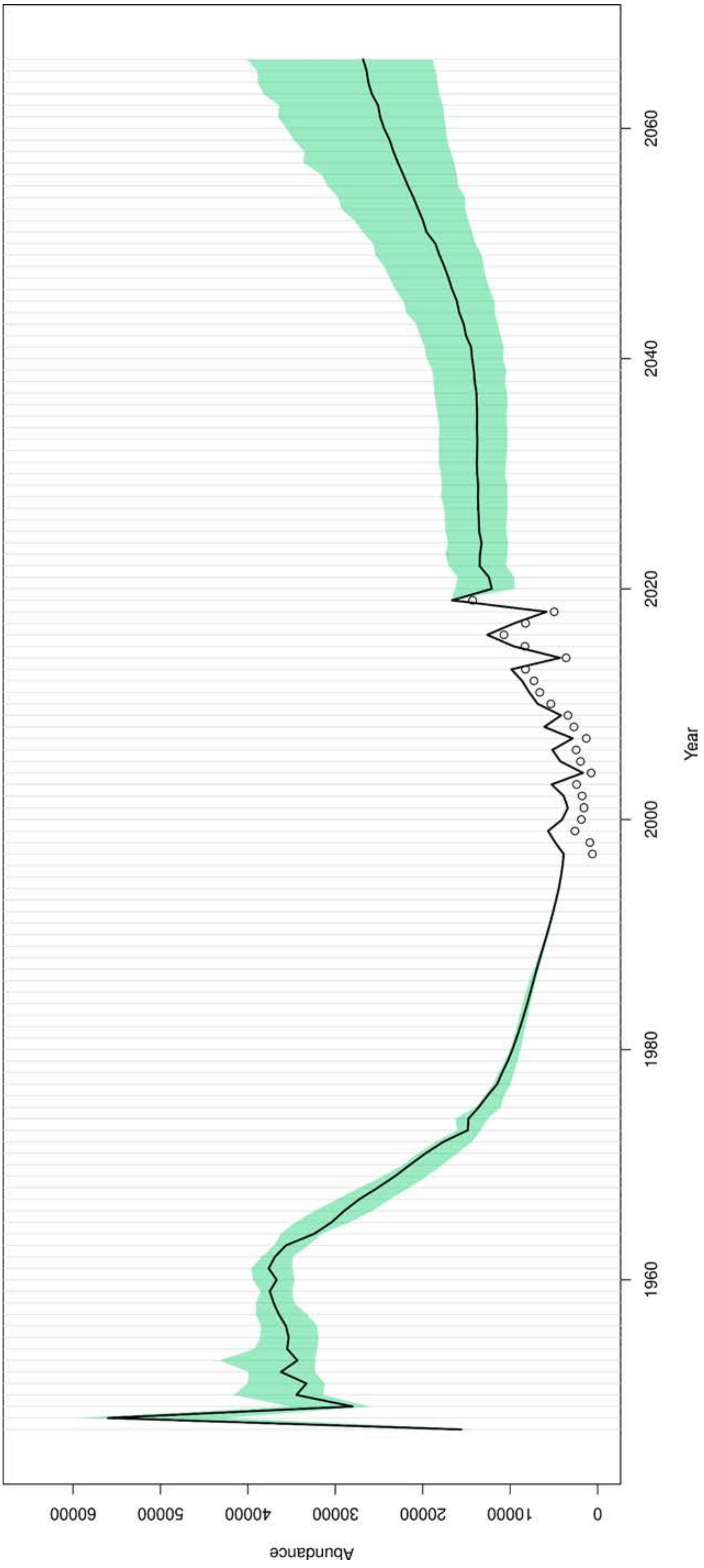

Figure 5.4: Predicted number of loggerhead sea turtle nests in the Northern Recovery Unit. Open circles show the raw NRU nest counts.

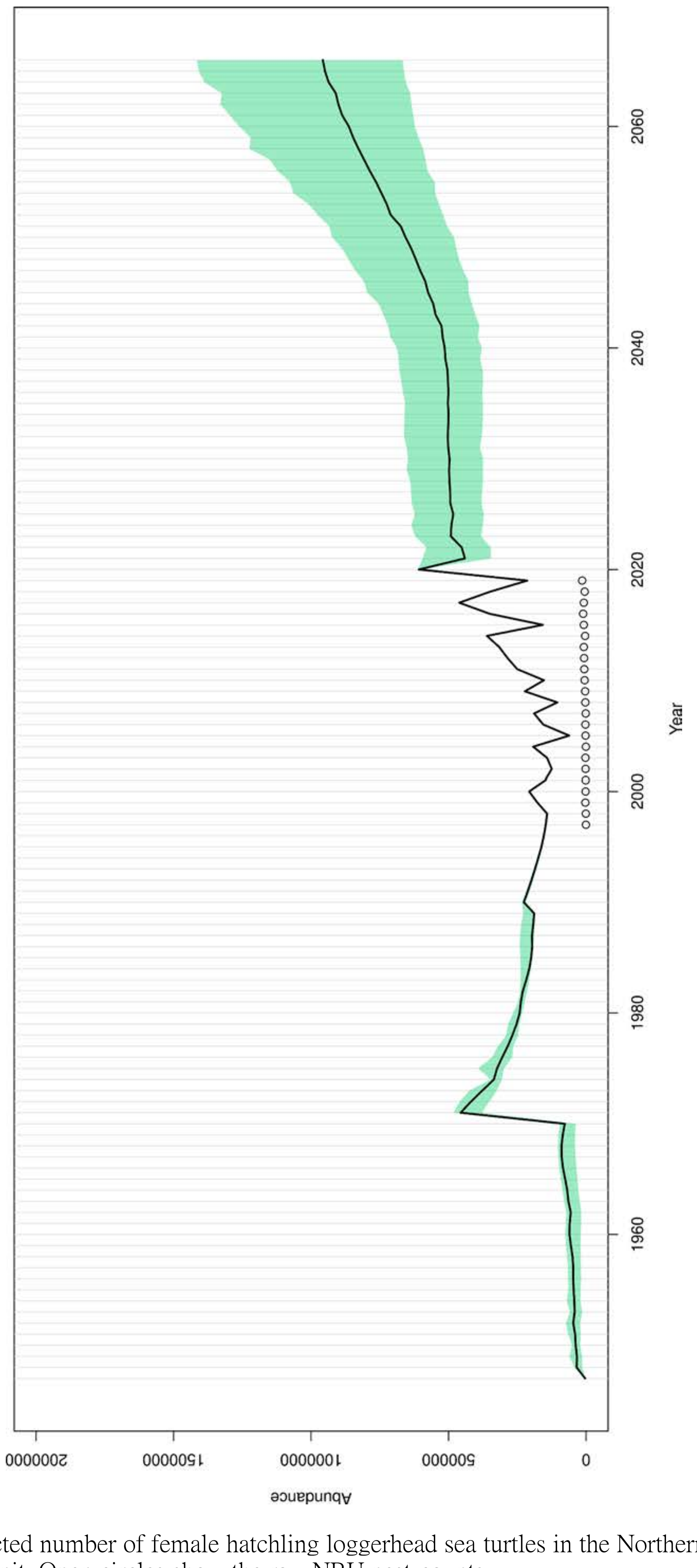

Figure 5.5: Predicted number of female hatchling loggerhead sea turtles in the Northern Recovery Unit. Open circles show the raw NRU nest counts.

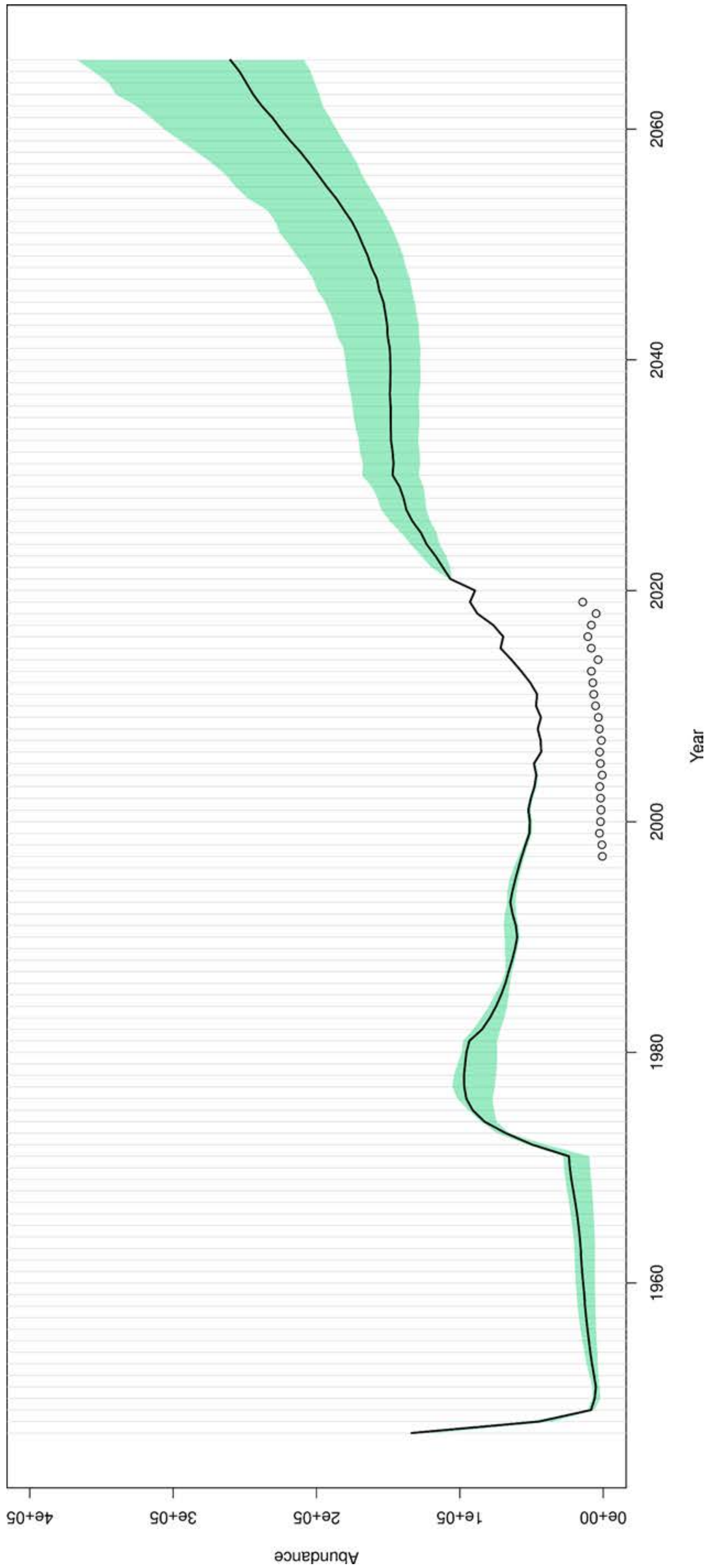

Figure 5.6: Predicted number of female pelagic juvenile loggerhead sea turtles in the Northern Recovery Unit. Open circles show the raw NRU nest counts.

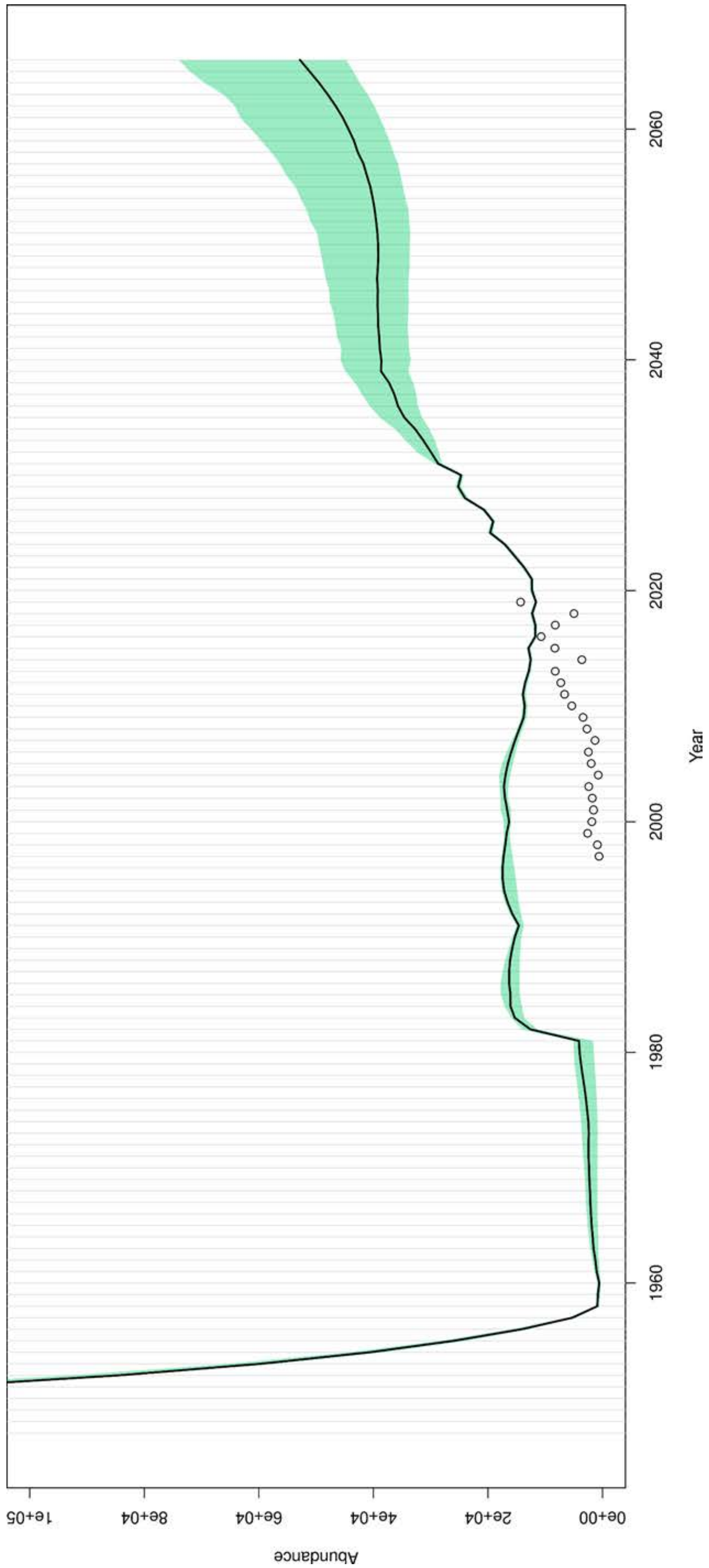

Figure 5.7: Predicted abundance of female small benthic loggerhead sea turtles in the Northern Recovery Unit. Open circles show the raw NRU nest counts.

Adult female abundance showed a distinct oscillation in the time series (Fig. 5.9), a pattern that is predicted to continue. These oscillations are clear in the the other life stages as well, and show that the population, despite improved adult survival in recent years, will have periods of vulnerability in which recruitment to the adult stage is low, and that these periods may themselves last decades.

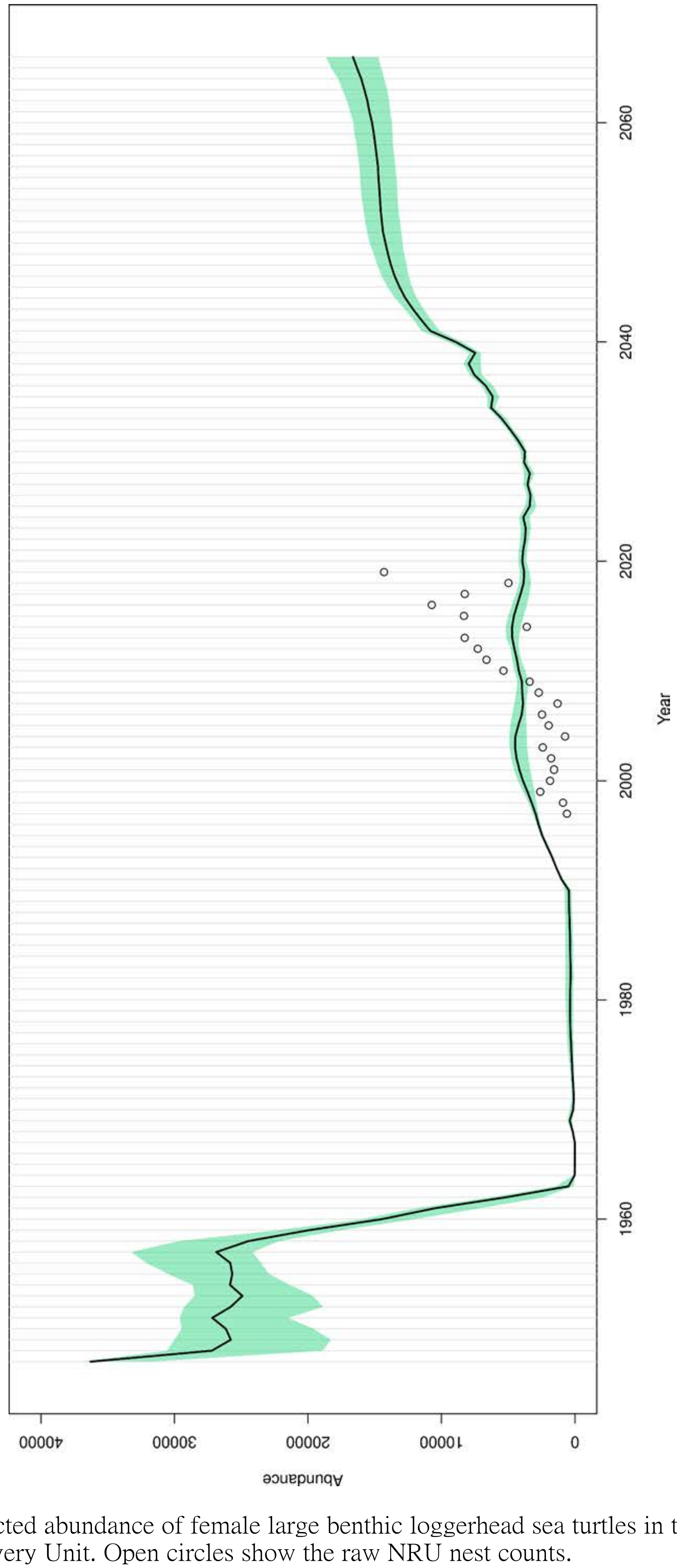

Figure 5.8: Predicted abundance of female large benthic loggerhead sea turtles in the Northern Recovery Unit. Open circles show the raw NRU nest counts.

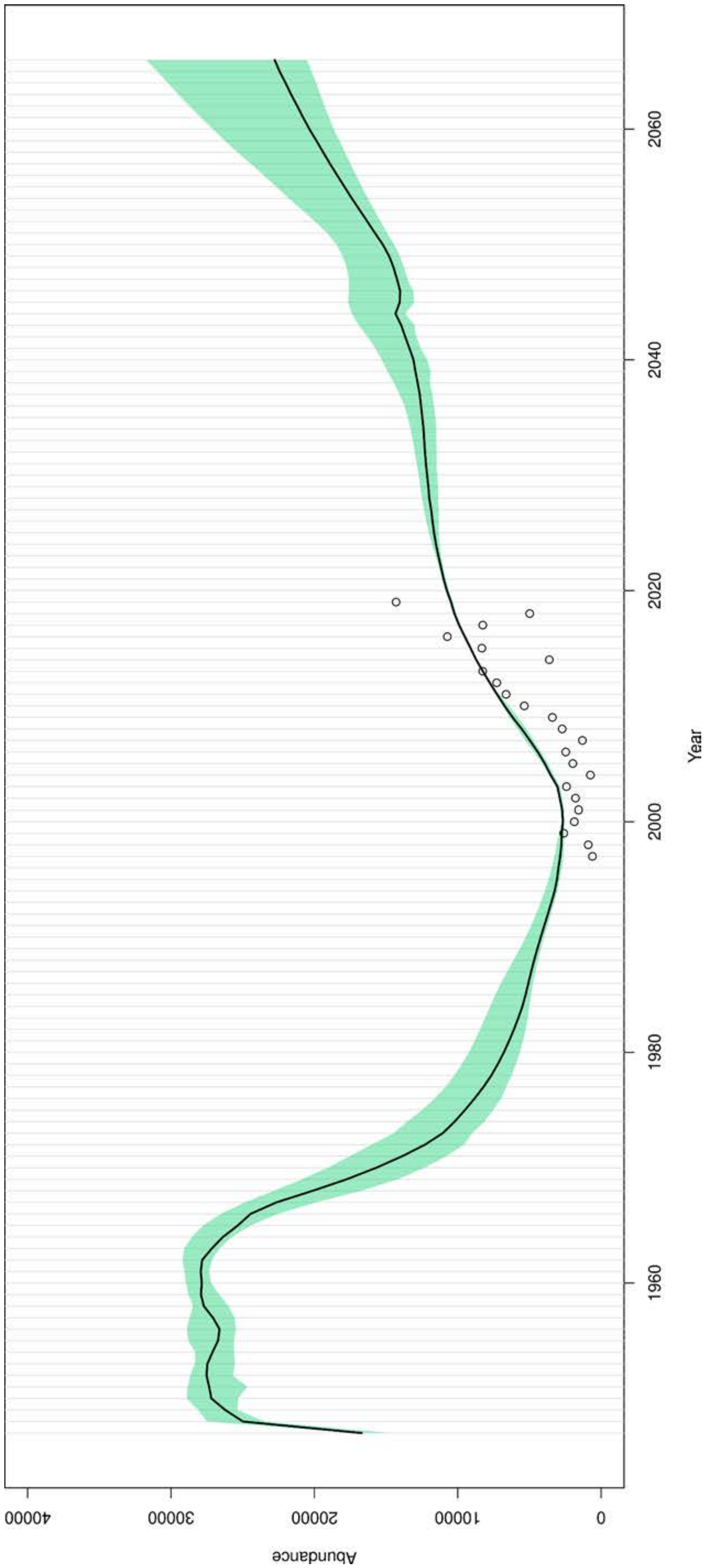

Figure 5.9: Predicted abundance of adult female loggerhead sea turtles in the Northern Recovery Unit. Open circles show the raw NRU nest counts.

5.2 Models with constrained detection curves

Detection is influential in many models such as ours that feature a state-space organization. We assessed estimates from three model versions (*HiDet*, *1to1*, *LoDet*), which differed only in the constraint placed upon the curve relating segment-level detection probability to nest survey effort (Figs. 5.10-5.12).

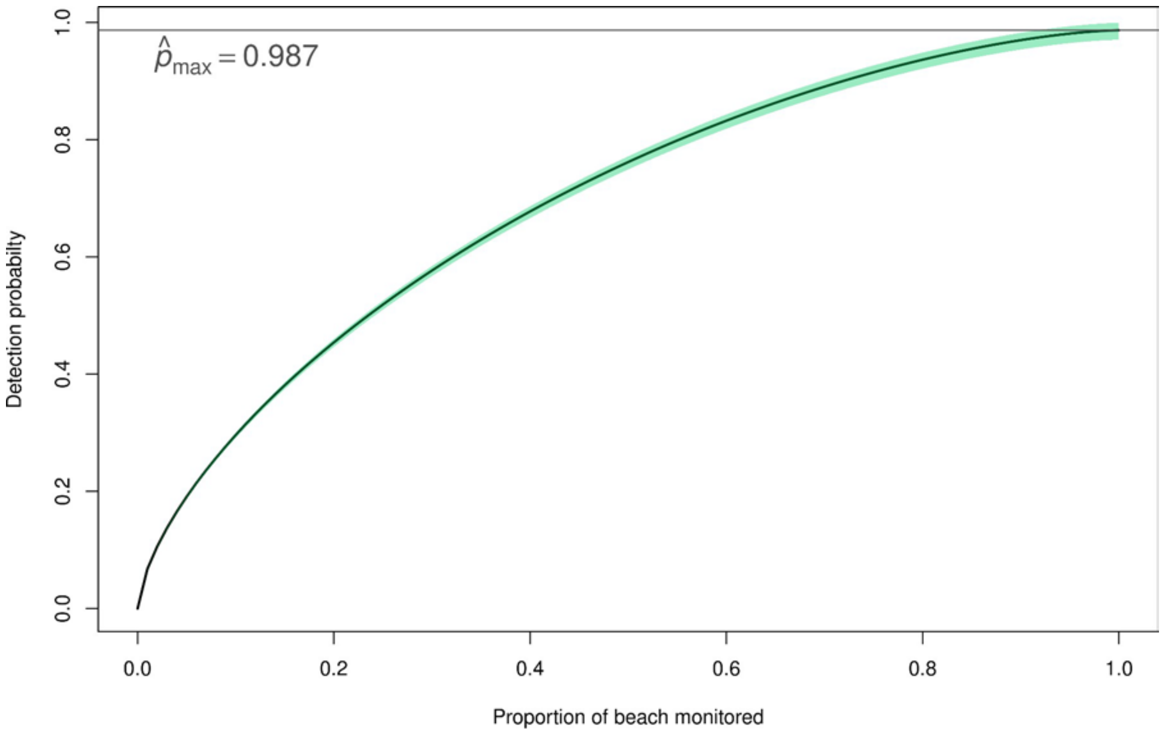

Figure 5.10: Relationship of coastal segment detection probability to nest survey effort, in the constrained model *HiDet*. Compare to the detection curve from the full IPM (Fig. 5.1.

Constraining the detection probability curve did alter estimates of important life history parameters (Table 5.2). Some estimates were considerably different. Expected clutch size, for instance, was lower when detection probability was constrained high, and the difference between λ^{live} and λ^{die} was small. In contrast, when detection was assumed to be lower, expected clutch size for surviving breeders λ^{live} was much higher, and λ^{die} lower and less precise.

The difference emphasizes how important an assessment of detection probability could be, in making inference and predictions about the NRU population. It may be that information already exists, that could aid in modeling the detection process; but some small additional effort during surveys to assess detection probability (e.g., some sort of double observer design) might provide considerable benefit to population modeling efforts.

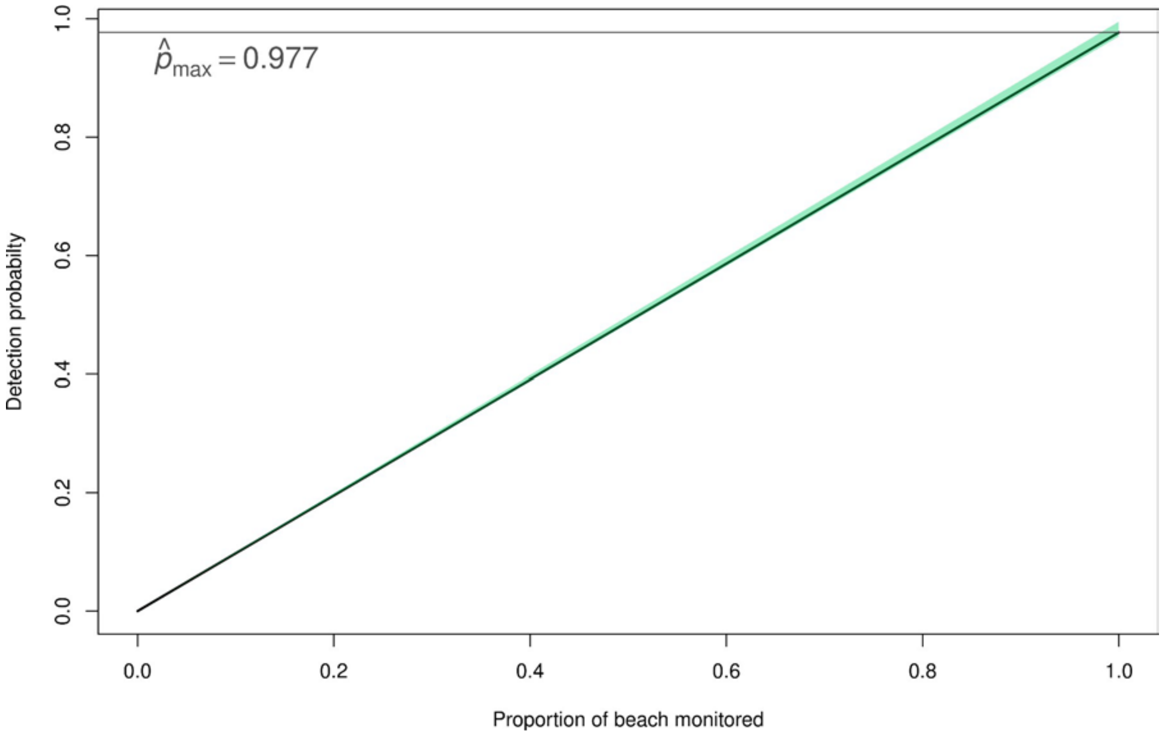

Figure 5.11: Relationship of coastal segment detection probability to nest survey effort, in the constrained model *1to1*.

Table 5.2: Posterior estimates (point estimate and 95% Bayesian credible interval) from two constrained models, *HiDet* and *LoDet* (estimates from the *1to1* model were intermediate).

Parameter	Symbol	*HiDet*	*LoDet*
Breeding adult survival (– 2002)	φ_1^{br}	0.903 (0.897, 0.812)	0.876 (0.847, 0.885)
Breeding adult survival (2003 –)	φ_2^{br}	0.990 (0.967, 1.00)	0.972 (0.983, 0.992)
Non-breeding adult survival	φ^{nb}	0.960 (0.949, 0.966)	0.960 (0.951, 0.992)
Expected clutch frequency of surviving breeders	λ^{live}	2.98 (2.89, 3.07)	3.98 (3.823, 4.097)
Expected clutch frequency of dying breeders	λ^{die}	2.82 (1.76, 3.02)	0.693 (0.016, 3.718)

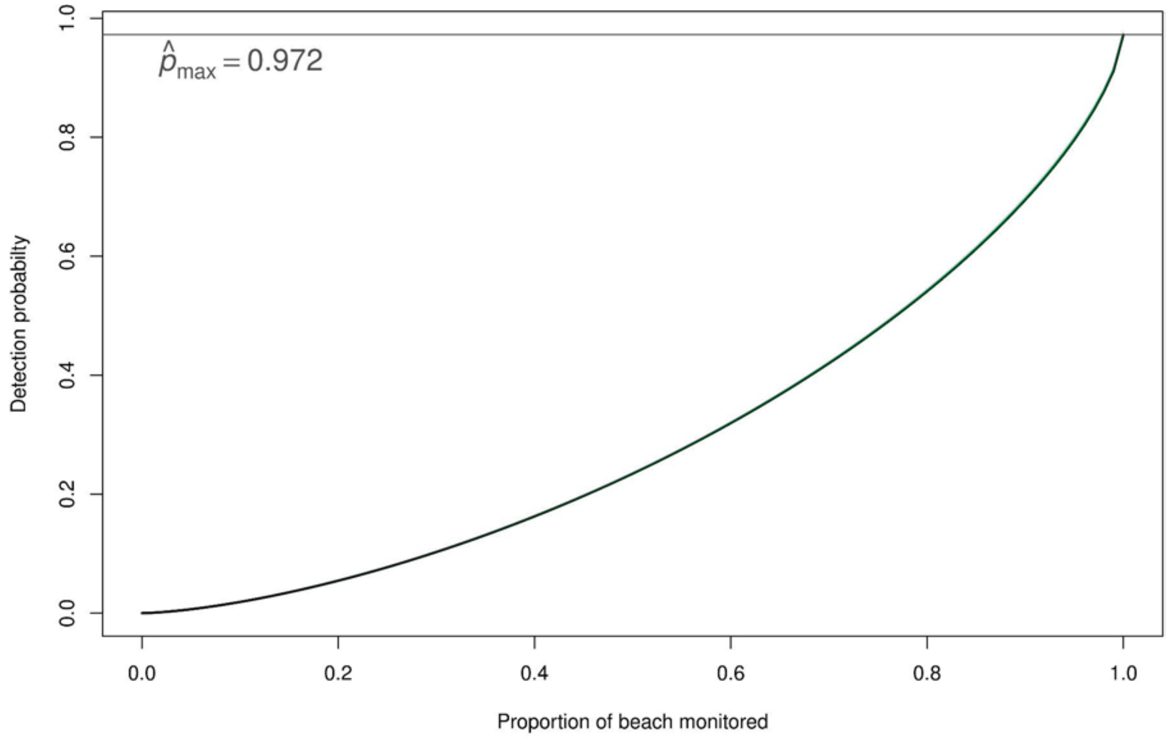

Figure 5.12: Relationship of coastal segment detection probability to nest survey effort, in the constrained model *LoDet*.

5.3 Example of assessment of planned management actions

To demonstrate how our model might be used to assess the consequences of management actions, we fit a model with a simple intervention that began in year 2021. We removed 500 breeding adult females from the population each year. The resulting female abundance trajectory shows a strong dip in the near term, but also a long-term change in the trajectory around which the population will oscillate.

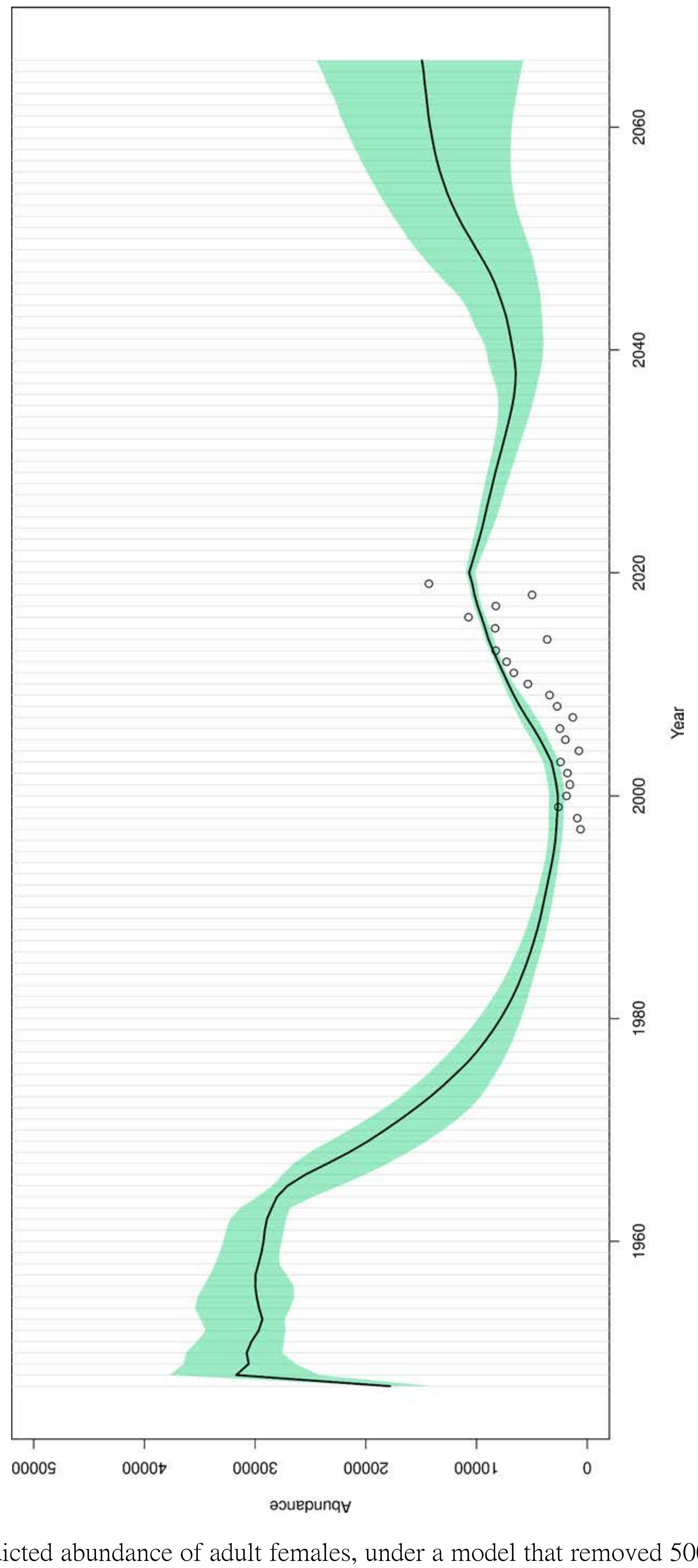

Figure 5.13: Predicted abundance of adult females, under a model that removed 500 adult females annually from the breeding population beginning in 2021. Open circles show the raw NRU nest counts.

6 Interpretation and management implications

Different model versions are in good agreement regarding the general population trajectory through the projection period. Although female abundance has increased since a low point around 2000, current adult abundance is approximately 1/3 to 1/2 the mean abundance in the 1960's.

Examination of the stage-based abundance time series (Figs. 5.4-5.9) reveal the qualitative explanation for the model's parameter estimates and forecast. Low fecundity began to be ameliorated by nest protection efforts in the NRU beginning in 1970. Simultaneously, however, high mortality of breeding females drastically reduced adult abundance and the per capita number of nests laid. The two counteracting influences on hatchling production resulted in a peak in pelagic juveniles, cresting just before 1980 then declining. Implementation of small TEDs in the late 1980's allowed this pulse to remain strong as it moved through the small and large benthic stages. The pulse began recruiting into the adult stage in the early 2000's. Simultaneous implementation of large TEDs boosted breeding season survival, resulting in better retention of females in the population and increased per capita nests laid. The result was the observed increase in NRU nests from 2008 to the present.

Following 2020, recruitment into the adult stage is predicted to decline as the tail end of the hatchling pulse of the late 1970's and early 1980's reaches maturity. In the absence of significant recruitment, adult abundance will decline according to the adult survival rate, which is predicted to be fairly high ($\widehat{\varphi}^{nb} = 0.961$ (0.964, 0.966)). Then in the 2040's, the next pulse of hatchling production from the 2000's and 2010's will begin to mature into the adult stage. The population will continue to oscillate in this way, with a period corresponding to the maturation interval, around an apparently positive long-term trajectory. The oscillations are predicted to dampen over time, if conditions remain static. Female abundance is projected to reach its 1970's mean by around 2050.

The steep decline of adult abundance throughout the 1980's and 90's brought the population close to extinction; nest protection efforts and the adoption of TEDs appear to have allowed a pulse of recruits to rescue the population, but slowing recruitment for the next two decades will make the population vulnerable once again to adult mortality. The large increase predicted to begin in the 2040's depends on low adult mortality and sustained high hatchling production in the 2020's. Therefore, our model predictions suggest that continuing protection of adults (with TEDs) and nest protection at current levels should be prioritized. Declines in reproductive output and survival may delay recovery or result in future population declines. Our model has great utility in the exploration of the effects of proposed management action, and we will continue to develop it for that purpose.

It is worth noting that the variance across years in breeding probability is estimated to be high, though changes to adult numbers take place over the course of decades. As an indicator of population status, then, nest counts alone would be difficult to interpret. Explaining this variance and better resolving remigration intervals would lead to improved survival and abundance estimates, since remigration, survival and detection probability are so tightly linked. Nest monitoring and genetic mark-recapture efforts should continue at current levels, in order to: 1) assess whether the predicted pattern of nest numbers and breeding females is borne out in the coming years, and 2) better resolve the probability of long remigration intervals.

Adult survival estimates and the remigration probability curve (Fig. 5.2) are interdependent. If adults are capable of delaying breeding in the NRU for 10 or more years, adult survival may be extremely high. However, additional questions would arise as to why turtles' remigration intervals vary so widely. To better resolve both adult survival and remigration patterns, continuing the genetic mark-recapture effort in the NRU should be a priority.

Table 6.1: Total number of segments in which NRU loggerhead turtles appear, in the genetic mark-recapture dataset.

Number of segments	Number of individuals
9	4
8	4
7	33
6	66
5	184
4	476
3	1167
2	2879
1	6666

6.1 Assumptions, caveats and future work

Several important assumptions are worth emphasizing, in interpreting the model results. Perhaps most importantly, we assume that the NRU population is closed, such that turtles hatched in the NRU do not emigrate to other populations either temporarily or permanently: the only way to exit the population is via mortality. Moreover, no turtles enter the the population through immigration, either temporary or permanent. The reasonableness of this closure assumption is unknown, but there are suggestions in the genetic mark-recapture data that suggest it may be violated. For example, of 11,479 individual turtles identified in the NRU during 2008-2019, 1,896 (16.5%) have only been observed once. And the large number of turtles' apparent nesting kernels clustered at the southern edge of the NRU territory implies a potential for exchange of turtles across that boundary (Fig. 4.1).

The only spatially-explicit component of the present model is detection probability, which is related to effort devoted to finding nests and identifying the females to which they belong. If other life history parameters vary spatially, such as breeding or nest survival, accounting for spatial pattern in those parameters could improve both understanding of the population and management decisions.

We did not attempt to group individuals according to the size of their nesting kernels, though this does vary (Table 6.1). If the size of the nesting kernel is related to age, for example, this would have implications for demographic modeling and prediction.

Several simple constraints could be added to the model to bring parameter estimates into closer agreement with general understanding about loggerhead life history and conservation in the NRU. For instance, it may be reasonable to require that adult breeding survival should always be less than or equal to non-breeding survival; and that changes in survival of small and large benthic juveniles from the pre-TED to the post-TED era should be similar (Table 5.1). Adding such constraints, as well as investigating alternative functional forms and distributional assumptions for model components such as individuals' intra-seasonal clutch number and nesting kernel, will be undertaken as we prepare this work for publication.

7 Acknowledgments

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Bed Leveler Evaluation Report

U.S. Army Corps of Engineers (USACE)

Savannah District

January 2015

Prepared by Mary E. Richards
Biologist
Savannah District, Planning Division

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Appendices

1.0 Introduction and Background

Brunswick Harbor is on the Atlantic coast in the State of Georgia. The harbor's entrance channel is authorized at a 38-foot depth, 500 foot width starting in the Atlantic Ocean, running northwest through the Brunswick Inlet ebb shoal, and then turning west into the inlet. The entrance channel is approximately 10 miles long, with Jekyll Island to the south and St. Simons Island to the north (Figure 1).

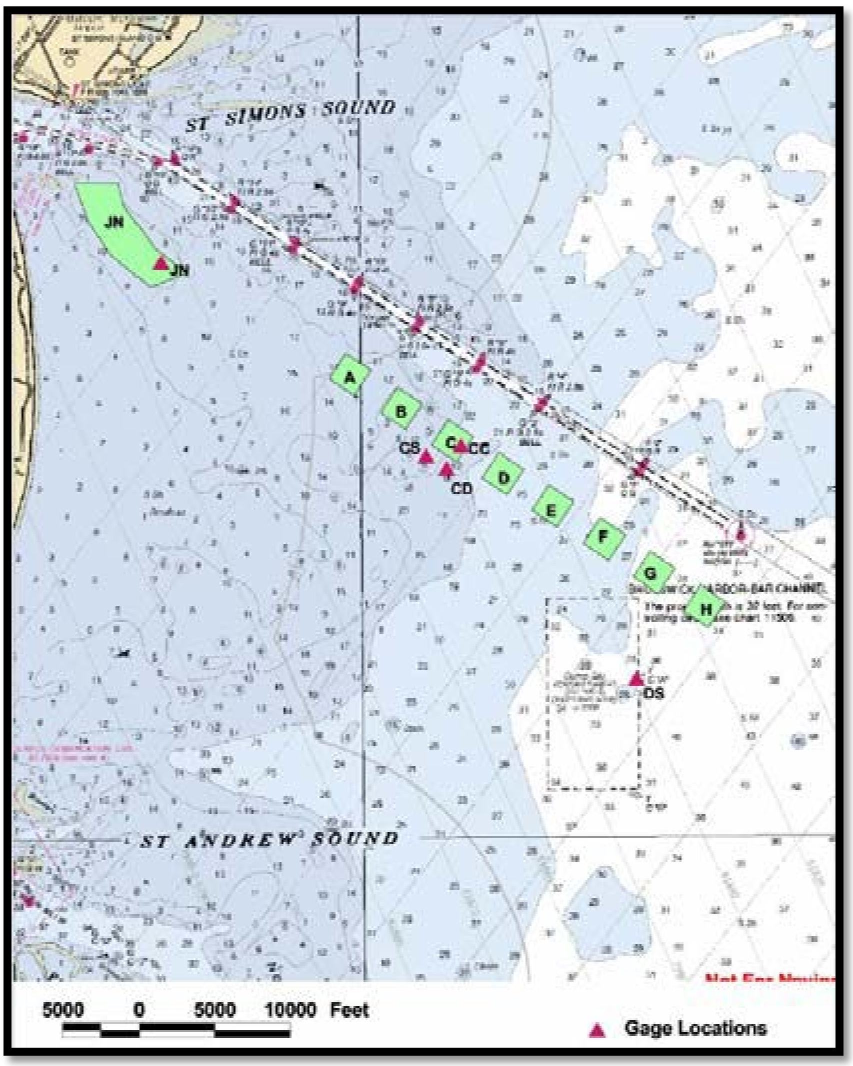

Figure 1. Brunswick Harbor entrance channel location.

The Brunswick Port is the 2nd busiest auto port in the nation and the Georgia Ports Authority (GPA) reported double-digit growth in total tonnage and a record number of auto and machinery units (roll-on/roll-off or ro/ro cargo) moved across the Brunswick docks in Fiscal Year (FY) 2014. However, in spite of its national ranking based on ro/ro units, the port is ranked 93 in the nation based on vessel trips and tonnages by commodity for ports and waterways of the U.S. These statistics are compiled and supplied to the U.S. Army Corps of Engineers (USACE) by the Waterborne Commerce of the United States (WCUS) Statistics Center. The data are used to analyze the feasibility of new projects and to set priorities for new investments, and the operation, rehabilitation and maintenance of existing projects. Based on this ranking, Brunswick Harbor has not received sufficient funding to maintain the entrance channel at its 38-foot authorized depth since its last deepening, which was completed in 2003. USACE received additional funds in FY 2011 through the American Recovery & Reinvestment Act that allowed it to better maintain channel depths that year.

In FY 2012, USACE performed dredging operations in Brunswick Harbor's entrance channel from January 27 through February 7. Water temperatures in the channel were unseasonably warm and the hopper dredge conducting the work had 6 incidental takes of sea turtles during that period while in "clean-up" operations. USACE South Atlantic Division (CESAD) determined that continued dredging in Brunswick at that time could impact other dredging projects in the Division and temporarily suspended the Brunswick dredging operations. Dredging resumed on March 22, and 3 sea turtles were taken in the one load dredged that day. Consequently, USACE terminated dredging operations for the year in the Brunswick Harbor entrance channel.

As part of the After Action report, the dredging contractor commented that if use of a bed leveler had been allowed, he could have significantly improved the channel bottom after suspension of hopper dredging activities. Bed levelers are sometimes used by the dredging company as an alternative to additional clean-up passes by a hopper dredge to level sediment on the channel floor after a hopper dredge has passed.

Some have proposed that use of a bed leveler in a channel with numerous trenches would reduce sea turtle take because the bed leveler would smooth out the channel floor to meet the contract requirements without requiring additional passes of a hopper dredge with its suction arm. A bed leveler is a long steel blade that is dragged along the channel to smooth out the bottom surface. The device moves sediments in the peaks down to the troughs. It does not use any suction and is operated to produce a sand wave in front of the blade to disturb sea turtles off the channel bottom and away from the blade itself. The device is suspended at a set elevation, so in situations with a deep trench, the bed leveler may pass over a resting turtle. In other situations, the sand wave in front of the device would disturb a resting sea turtle and cause them to rise into the water column above the leveler.

In FY 2012, the Savannah District proposed to perform a field study to evaluate the effectiveness of bed levelers used in concert with hopper dredges to minimize the take of sea turtles while maintaining entrance channels of deep-draft navigation projects.

The test included use of a closed-net trawler to assess sea turtle abundance and impacts of the bed leveler to sea turtles. This test and evaluation was the result of extensive coordination efforts between USACE, the Georgia Department of Natural Resources (GADNR), and the National Marine Fisheries Service (NMFS) to obtain the environmental approvals needed to use a bed leveler in FY 2013. The results of that evaluation can be found in the report titled "Bed Leveler Evaluation Report_Final_June 2013". In summary, the bed leveler proved effective that year at improving the channel bottom and no sea turtles were adversely impacted.

After coordinating the results of that evaluation with GADNR and NMFS, Savannah District proposed to repeat the evaluation in FY 2014 (request for approval in Appendix A) using the procedures and methods outlined in Section 2.0, which were similar to the ones used in the previous year's evaluation. The second test would be performed between Stations -15+000 to -39+000 and in the Cedar Hammock range (Stations 16+000 to 20+000). USACE received all environmental approvals by the end of December 2013 (Appendix B) and began the bed leveler evaluation on March 30th, 2014 with abundance trawling. Use of the bed leveler device began on April 3rd, 2014.

2.0 Evaluation Procedures and Methods

The dredging contract (which included bed leveler operations) was awarded to Great Lakes Dredge & Dock Company (GLDD). The bed leveler that GLDD used is pictured in the title page of this report. It consisted of a steel blade 32 feet long, 4 feet high, and weighed approximately 40,000 pounds. An 11.5-inch strip of steel was welded along the bottom length angling approximately 45° forward of the blade face. This was designed to better "catch" sediment peaks and subsequently aided in creating a sand wave intended to disturb sea turtles off the channel bottom and away from the bed leveler. All support structures were welded to the back of the blade.

Originally, the bed leveler that arrived on site had two secondary attachment points extending two feet on either side of the blade (Figure 2). These structures could potentially serve as "pinch points" for impinging sea turtles and the contractor was directed to modify the blade with metal plate additions so that no structures extended beyond the width of the blade face (Figure 3).

The blade was suspended from a 110-foot long, 60-foot wide barge and lowered to selected depths based on hydrographic surveys and adjusted constantly to compensate for tidal fluctuations. The vessel used to maneuver the barge was a 65-foot long, 3,000 horsepower offshore tug (Figure 4). The bow of the tug was secured to the back of the barge at all times, pushing it along the channel at 1-2 knots so the bed leveler suspended from the front would trail underneath the barge at a safe distance from the tug's propellers.

Figure 2. Secondary attachment points.

The trawler Margaret Webb conducted capture trawling to determine sea turtle abundance. They began this operation on March 30th. Also, in order to assess impacts to sea turtles from use of the bed leveler, capture trawling was conducted 24 hours a day, weather and maintenance permitting, whenever the bed leveler was being operated, April 3rd – April 15th, 2014. GLDD daily operation reports can be found in Appendix C.

Figure 3. GLDD personnel welding metal extensions to bed leveler blade face.


Figure 4. The tug vessel Mr. Chester maneuvering the barge/bed leveler.

3.0 Discussion

The NMFS Southeast Regional Office (SERO) no-jeopardy Biological Opinion (BO) issued for this evaluation authorized incidental take by injury or mortality of two sea turtles (loggerhead and/or Kemp's ridley), and incidental take by non-injurious closed-net trawling of 21 sea turtles (twelve loggerheads, seven Kemp's ridley, one green, and one leatherback). In addition, the Incidental Take Statement (ITS) authorized non-lethal take of two Atlantic sturgeon.

During the 13 days of the evaluation, 396 bed leveler tows were completed in the navigation channel. Seventeen live, healthy sea turtles were captured, tagged and released back into the channel. These included eight loggerheads, eight Kemp's ridley, and one leatherback (Table 1). Unlike the previous year's evaluation, no sturgeon or dead turtles were found. Trawl reports for all incidental captures can be found in Appendix D.

Table 1. Summary of Incidental Captures

Date	Tow #	Sea Turtle Species	Water Temperature (°C)	Straight Carapace Length (cm)
3/30/14	5	Loggerhead	16.2	64.1
3/31/14	25	Loggerhead	16.5	77.0
3/31/14	35	Kemp's Ridley	16.5	48.2
4/04/14	75	Loggerhead	17.2	57.5
4/05/14	106	Loggerhead	17.2	72.1
4/05/14	106	Kemp's Ridley	17.2	45.3
4/05/14	107	Kemp's Ridley	17.2	42.2
4/08/14	202	Kemp's Ridley	17.9	41.5
4/09/14	216	Kemp's Ridley	17.9	43.2
4/09/14	221	Loggerhead	17.9	72.3
4/09/14	226	Loggerhead	17.9	64.0
4/10/14	252	Kemp's Ridley	18.2	28.5
4/10/14	263	Kemp's Ridley	18.2	47.6
4/11/14	286	Leatherback	18.3	149.0
4/12/14	318	Loggerhead	18.4	72.5
4/12/14	318	Kemp's Ridley	18.4	49.0
4/13/14	346	Loggerhead	18.5	72.1

On April 10th, the seventh Kemp's ridley was captured, and a leatherback was captured the following day. In anticipation of exceeding the authorized take for those two species, Savannah District prepared a Section 7(a)(2) and 7(d) Endangered

Species Act Jeopardy Analysis on the impacts of continued operations to sea turtles. That analysis concluded that continued use of the bed leveler and closed-net trawler would not jeopardize any threatened or endangered species. USACE provided the analysis to NMFS on April 15th (Appendix E).

Sea turtle strandings are monitored yearly by the Sea Turtle Stranding and Salvage Network (STSSN) and the GADNR Sea Turtle Program. USACE coordinated with those conservation programs and found that there were no sea turtles strandings reported on beaches adjacent to the project area (Jekyll Island, St. Simons Island, Sea Island) with blunt force or crushing injuries presumed to be related to bed leveling activities during or following the evaluation. Documented strandings before, during, and after the evaluation are listed in Appendix F.

One of the purposes of this evaluation was to compare sea turtle takes attributed to a hopper dredge to those that could be attributed to a bed leveler for a given dredging season covering the same reaches of the channel. In the FY 2013 evaluation, there were no sea turtle takes by the hopper dredge or bed leveler, so no comparison could be made. However, during the FY 2014 evaluation, two loggerheads were taken by the hopper dredge Terrapin Island (Table 2), while none were taken by the bed leveler.

Table 2. Brunswick Harbor Dredging Statistics for FY 2013 & 2014

Fiscal Year	# of Loads	# of Days	Dredging Hours	Surface Water Temperature Range (°C)	Dredging Stations	Dates of Dredging	# of Sea Turtle Take
FY13	36	9	100.1	12 – 17.5	-22+500 - -40+000	1/8/13 - 1/16/13	0
FY14	113	21	313.6	7.2 – 15.6	-15+000 - -39+000 & 16+000 - 20+000	1/24/14 - 3/13/14	2

Table 3 compares the operation of a hopper dredge in the Brunswick Harbor entrance channel and the take of sea turtles during FY 2013 and FY 2014. The take rates observed in FY2014 indicate that no sea turtles would be expected to be taken during the smaller dredging effort in FY 2013.

Table 3. Comparison of Hopper Dredging Operations and Sea Turtle Take (FY 2013 & 2014)

Fiscal Year	# of Sea Turtle Take	# of Loads / Take	# of Days / Take	Dredging Hours / Take	Dredging Area (SF) / Take	Dredging Volume (CY) / Take
FY13	0	>36	>9	>100	>29,000,000	>119,000
FY14	2	56	10	157	28,184,887	173,244

The FY 2013 bed leveler report briefly discussed that temperature alone cannot explain the presence, or lack of, sea turtles in nearshore waters based on historical dredging records in Brunswick Harbor. However, it is obvious that an increase in the number of hours a draghead is dredging the bottom of the channel, the likelihood of sea turtle take increases.

Table 4 below compares operation of the hopper dredge and the bed leveler.

Table 4. Comparison of Hopper Dredging and Bed Leveling Operations (FY 2014 Evaluation)

Operation	Length (ft)	Width (ft)	Area (ft²)	Time (hrs)
Hopper Dredge	2,942,055	19.16	56,369,774	313.6
Bed Leveler	2,458,705	36	88,513,380	253

Notes:

Hopper Dredge

- “Length” was derived from the nautical miles dredged, converted to feet, for 113 loads as calculated from the National Dredging Quality Management Program (DQM) dredge profiles for the Terrapin Island for FY 2014. This length only represents the time the dragheads were dredging on the channel bottom where there was potential for turtle take.
- “Width” is the maximum hypotenuse of the triangular dragheads (total for both port and starboard dragheads) and is reflective of the total width of each dredging “cut”. Individual draghead widths were reported by the contractor.
- “Area” is the calculated square footage of affected channel bottom during hopper dredging.
- “Time” is the total pumping/dredging time reported by the contractor.

Bed Leveler

- "Length" was the total reported length the bed leveler was dragged in the same reaches of the channel that the hopper dredged for this evaluation.
- "Width" is the width of the bed leveler used.
- "Area" is the calculated square footage of affected channel bottom during bed leveling operations.
- "Time" is the total reported time that the bed leveler was actually dragged along the channel bottom.

After comparing these two different operations, the bed leveler was dragged approximately the same length of channel bottom that the hopper dredged, but covered 57 percent more area in less time without a single sea turtle take. The bed leveler design tested impacted sea turtles less than a hopper dredge.

The volume of sediment (cubic yards (CY)) either removed from the channel (hopper dredge) or "moved" within the channel (bed leveler) was not used in the comparison due to the widely different nature of operation (suction vs. physical movement). The volume of sediment removed by the hopper dredge is straight forward and calculable by instruments onboard the dredge (does not include that removed by the river currents during agitation of the sediments). On the other hand, surveys of the bed leveler show that approximately 64,640 CY of peaks were leveled to a depth of 36-40 feet, but over 200,000 CY of trenches had been "filled" to depths of 38-40 feet. This disparity is a result of agitation and settling of the sediments during the leveling process and disturbance of sediments beneath the bed leveler, i.e., wall collapse in trenches not directly attributed to the bed leveler itself. Likewise, catch per unit effort (CPUE) could not be compared to hopper dredging for this effort since the bed leveler had zero sea turtle take. (Note: Hopper dredge CPUE for Brunswick Harbor entrance channel since 2008 is 0.000005 - 22 sea turtles per 4,092,772 of cubic yards dredged as reported by the contractors.)

The second purpose of this evaluation was to determine the effectiveness of a bed leveler in dredging operations. USACE conducted "Before" and "After" hydrographic/bathymetry surveys for operation of both the hopper dredge and the bed leveler. Figure 5 shows survey results for one cross section of the entrance channel. The green line shows the channel bottom before the hopper dredge began operations on January 24th. The red line shows the channel bottom on March 21st after the hopper dredge completed dredging and before bed leveling was performed. The blue line shows the channel bottom on April 22nd after the bed leveler completed its operations. Unlike in FY 2013, the post-surveys for dredging and bed leveling were conducted closer together in time and more accurately demonstrate how effective the bed leveler was in smoothing the channel bottom. It is clear that the peaks and trenches left after hopper dredging operations were either removed or filled, respectively, by the bed leveler. All other cross section surveys can be found in Appendix G.

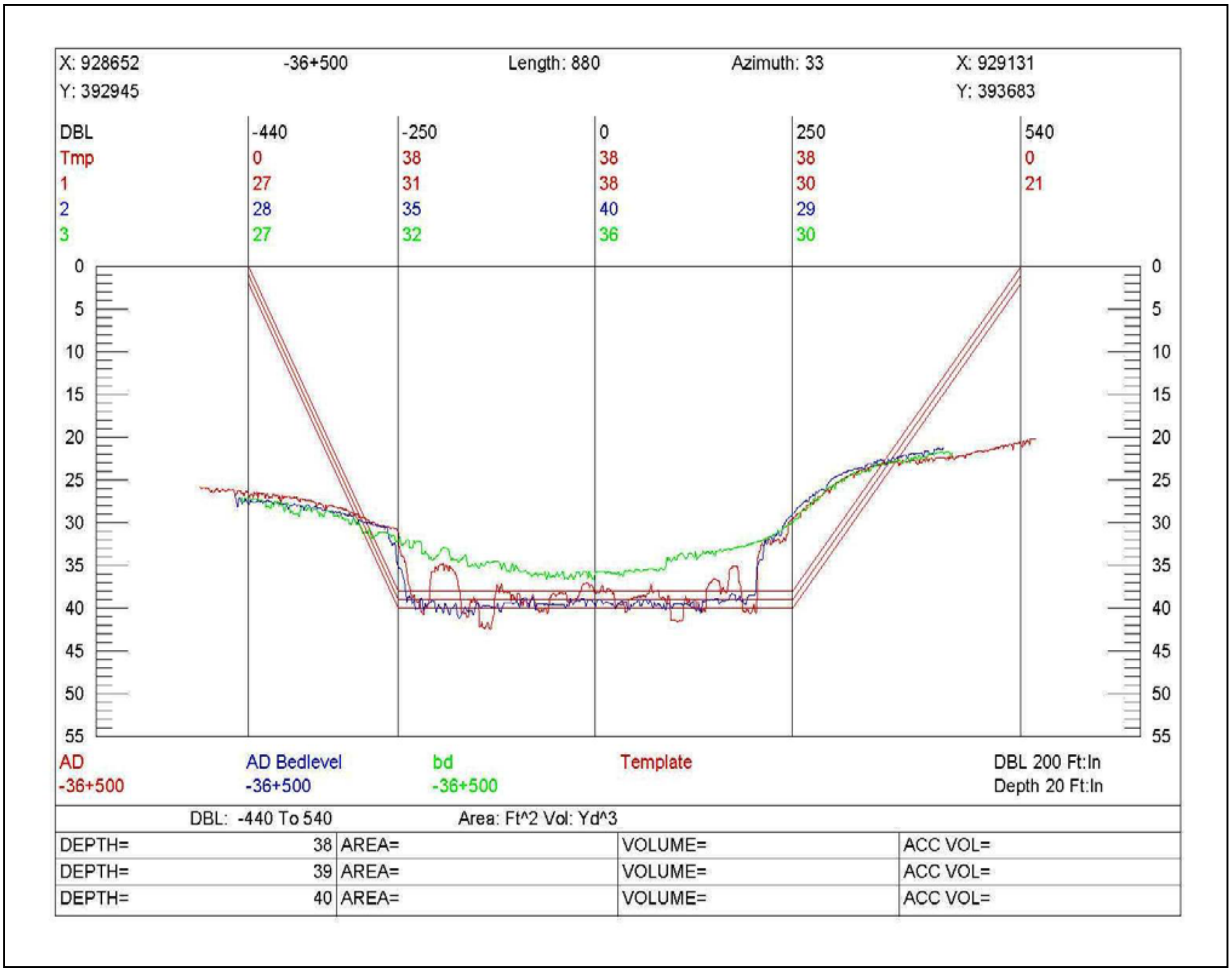

Figure 5. Survey cross section of hopper dredging and bed leveling.

4.0 Conclusions and Recommendations

The purpose of these evaluations was to (1) assess bed leveler impacts to sea turtles during hopper dredging activities and (2) demonstrate the effectiveness of a bed leveler at improving the channel bottom for deep-draft navigation projects. During the 2013 and 2014 evalutions, the live capture and releases of 38 sea turtles and two Atlantic sturgeon demonstrated that these species were present in the navigation channel. Based on the lack of mortalities of threatened and endangered species from these field operations, Savannah District believes that the use of similarly designed bed leveler devices may affect, but is not likely to adversely affect the continued existence of these species.

The bed leveler also allowed the dredging contractor to meet the requirements of the contract to remove all sediments above the 36-foot depth (approximate depth at which the bed leveler was set) in those reaches without making another pass of the hopper dredge in clean-up mode. It is believed that operation in clean-up mode results in more turtle takes than hopper dredge operations earlier in the project, i.e., “production” runs in which the hopper dredge does not anticipate passing over areas previously dredged.

Savannah District believes that these two evaluations have demonstrated a bed leveler to be a beneficial tool for both navigation and minimizing impacts to threatened and endangered species.

After conclusion of the first bed leveler evaluation, Mr. Mark Dodd with GADNR stated that if a second evaluation produced similar results (no adverse impacts to sea turtles), he would feel comfortable recommending that the restriction on bed leveler use be removed from GADNR’s Water Quality Certification for O&M dredging in Savannah and Brunswick Harbor entrance channels. GADNR subsequently granted that approval in November 2014 via email (Appendix H) for the 2014-2015 O&M dredging season. That email also stated that they intend to extend the approval indefinitely after review of the final report.

Approval was granted in October 2014 for the Savannah Harbor Expansion Project (SHEP) (Appendix H). Bed leveler and closed-net trawling were approved by NMFS for the SHEP in that project’s Biological Opinion.

Bed leveling was not considered in and is not authorized by the NMFS September 25, 1997 South Atlantic Regional Biological Opinion (SARBO). In a June 23, 2006 letter to CESAD (Appendix I), the NMFS said that the correct way to address bed leveling is through reinitiation of consultation on the SARBO. Their letter goes on to state that if consultation is reinitiated and subsequent analyses or studies confirm that the Endangered Species Act would not be violated by continuing activities during the reinitiation process, “the COE may continue with their bed-leveling operations during the reinitiation of consultation”.

CESAD requested formal reinitiation of the SARBO on April 30, 2007 and USACE provided a South Atlantic Regional Biological Assessment (SARBA) to NMFS in September 2008. Based on this prior coordination and communication, the past two successful bed leveler evaluations by USACE, and the State of Georgia’s verbal approval, USACE recommends that bed leveling be approved for routine use during new work and maintenance dredging projects in deep-draft navigational channels.

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Savannah District-Operations Division
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Dena Dickerson (ERDC)
Skipper and Crew of the Margaret Webb

The crew of the Margaret Webb pose with a leatherback turtle captured in Brunswick Harbor in 2014 before its release back into the channel.

(3) Calver

Protocol

South Atlantic Division Corps of Engineers
Hopper Dredging Protocol for Atlantic Coast
FY 98 - FY 03

1. Sea turtle deflecting dragheads will be used at all times.

2. Districts will inspect sea turtle deflecting dragheads systems to ensure that they are fully operational, prior to initiation of work.

3. Districts will ensure that draghead operators know how to properly use the sea turtle deflecting system.

4. Maintenance dredging at Savannah, Brunswick and Kings Bay Harbors must be restricted to 15 December through the end of March. Maintenance dredging at Charleston and Wilmington Harbors must be restricted to 1 December through the end of March where the sea turtle deflecting draghead system can not be used effectively. Dredging may begin as soon as mid-November in those portions of the Wilmington and Charleston Harbor channels where the sea turtle deflecting draghead can be used effectively. All Districts will cooperate to ensure that their scheduling of hopper dredging contracts, does not interfere with this Division priority work area.

5. Sea turtle observers, inflow screens and overflow screens will be used during all dredging operations, except for the months of January and February, which are optional. Variations from this provision may be granted by Division, but must be justified from a technical perspective.

6. All sea turtle takes will be reported promptly to SAD-ET-CO/PD and posted at usace.sad.turtle newsgroup on the Internet.

7. If two sea turtle takes occur within 24 hours, you should immediately notify the Division POC so that he can initiate reconsultation with National Marine Fisheries Service.

8. If a third take occurs on the project the district will cease operations and notify the South Atlantic Division. Continuation of dredging will occur only after cleared by Division. Upon taking three turtles, District will develop a risk assessment along with an appropriate risk management plan, and submit that to Division for assessment. Generally relative abundance and relocation trawling would be an integral part of a risk assessment and management plan. Should a total take of 5 sea turtles occur, for whatever reason, all work will be terminated unless other prior agreements had been reached with Division.

9. If a total of two endangered species of sea turtles are taken during a project, work will be suspended until further guidance from Division has been received.

10. Arrangements will be made for appropriate observation of all species of whales. The hopper dredge must not get closer than 750 yards of a right whale. Jacksonville and Savannah Districts will contribute their share of funding for the Right Whale Early Warning System early enough in the year to ensure that this is not a cause for delay in the program.

11. From Jacksonville District north through Wilmington District, sea turtle observers will also be responsible for monitoring takes of shortnose sturgeon. All takes of shortnose sturgeon must be reported to Division. Should a total take of three shortnose sturgeons occur, District will terminate hopper dredging until further guidance has been received from Division.

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March 15, 2021

Ms. Kim Garvey, Chief
USACE Savannah District Planning
Branch CESAS-
PD.SAS@usace.army.mil
Kimberly.L.Garvey@usace.army.mil

RE: Continued Discussion: Brunswick Harbor Modifications Study New Work and O&M, Brunswick Harbor, Glynn County, Georgia

Dear Ms. Garvey:

Thank you for your February 10, 2021 letter addressing our draft CZMA federal consistency determination conditional concurrence letter of November 3, 2020 and your submission of a revised Draft Integrated Feasibility Report and Environmental Assessment - Coastal Zone Management Federal Consistency Determination: Appendix J. This new submission extends our 60-day review period until April 11, 2021.

The revised consistency determination (CD) clarifies that Cutterhead dredging is the only type of dredge being proposed for the new work associated with the Brunswick Harbor modifications, while all dredge types are still being proposed for operation and maintenance (O&M)[1]. We have no objection to conducting the proposed harbor modifications via cutterhead dredging. Concern remains, however, that operation and maintenance (O&M) activities employing hopper dredges between April 1st and December 14th, or untested bed leveler designs between, or vessels over 26' traveling above 10 knots within the Southeast Seasonal Management Area (SMA) between April 16th and November 14th, are not consistent with the enforceable policies of Georgia's Coastal Management Program (GCMP).

We would like to continue discussions on the alternative measures, which if adopted by the Corps

[1] Draft Integrated Feasibility Report and Environmental Assessment Coastal Zone Management Federal Consistency Determination Appendix J, February 2021, Section 4.0 Project Description: "Upon project commencement, dredging activities (cutterhead) are anticipated to continue for approximately 12 months. Upon construction completion, O&M dredging (all dredge types) would occur annually as needed based on shoaling rates".

would allow Brunswick Harbor O&M hopper dredging activities to proceed in a manner consistent with GCMP. These alternative measures and discussion topics are outlined under separate cover and enclosed with this letter. We invite you to re-organize, re-word, expand, and provide additional information on the topics outlined to help us better understand the issues and come to agreement.

We would like to take the opportunity below to comment on some of the issues raised in your February 10, 2021 letter and provide additional scientific data and discussion for your consideration.

1. <u>USACE response to CRD concerns with the 2020 SARBO</u>

We agree that deficiencies in the 2020 SARBO, most notably National Marine Fisheries Services' (NMFS) failure to differentiate risk to the population from the loss of reproductive female loggerhead sea turtles versus the loss of juvenile and sub-adult loggerhead sea turtles; as well as the disproportionate impact to Georgia's much smaller Northern Recovery Unit (NRU) when lumped in with the much larger South Florida Recover Unit for the purposes of developing a regional take limit that combines two distinct population groups, should be taken up with NMFS and we seek to identify more effective avenues of communication.

NMFS' 2020 SARBO shortcomings, however, can be overcome by rigorously implementing the risk-assessment protocols delegated to the U.S. Army Corps of Engineers (USACE) and Bureau of Ocean and Energy Management (BOEM). Along with Georgia Department of Natural Resources' Wildlife Resources Division (GADNR/WRD), GCMP would like to share the attached GADNR/WRD Memo to assist USACE in developing a more accurate and meaningful risk-based assessment matrix for Georgia's threatened and endangered species. We believe a rigorous 2020 SARBO-required risk-assessment, which has not yet been completed or provided to us, will dictate cold water hopper dredge windows for continued survival of the loggerhead NRU.

NMFS Right Whale Ship Strike Reduction Rule, which places vessel speed restrictions on non-military vessels 65' and larger, have been in place for over a decade, and so has the promise to develop ship strike reduction measures for military vessels that have not materialized. The Florida II, USACE Jacksonville's survey vessel, was recently documented transiting the Southeast SMA doing 31 knots[2]. The intricate system of measures that includes appropriate speed reduction, use of observers, and adherence to conservation plans with NMFS, as described in your February 10, 2021 letter, surely cannot be effective at these speeds. Surveys can easily be conducted outside the right whale calving season or by using alternative routes or slower speeds within the SMA if winter surveys are critical, without jeopardizing USACE's mission. Note that our draft November 3, 2020 letter did not advocate to cease all use of high-speed survey vessels as described in your February 10, 2021 letter, but rather to restrict vessels 26' or greater in length to 10 knots within the SMA between November 15th and April 15th.

[2] Verbal communication, Mark Dodd

2. <u>The CRD claims regarding compliance with other regulations</u>

GEWA and GA Game and Fish Code

GCMP did not provide alternative measures that conflict with or overturn the 2020 SARBO, but rather additional measures that, if incorporated into Brunswick Harbor O&M hopper dredging activities, further minimize reasonably foreseeable impacts to Georgia's coastal resources. Implementation of NMFS 2020 SARBO falls squarely on the shoulders of USACE and provides substantial leeway for how USACE goes about employing the risk-assessment protocols. Nothing in the 2020 SARBO precludes adopting additional management measures that do no shift risk to another species or location within the region.

The Georgia Game and Fish Code[3] is a GCMP enforceable policy that must be addressed in your federal consistency determination. The fact that it prohibits incidental take of sea turtles does not obviate its inclusion as a valid enforceable policy. NFMS' authorized take under the 2020 SARBO allows you to meet the "consistent to the maximum extent practicable" bar for this enforceable policy rather than the "fully consistent" bar[4].

Marine Mammal Protection Act (MMPA) and the ESA Section 6

In addition to a Cooperative Agreement with NMFS under ESA Section 6, GADNR/WRD receives funding to implement North Atlantic Right Whale Recovery Activities in the Southeast U.S., including review of permit applications, project proposals and other human activities (attached). Specifically funded activities include review of federal proposals and activities that have the potential to impact right whales and right whale habitat in the Southeast U.S. and provide comments and recommendations to government agencies and responsible parties with the goal of mitigating impacts to right whales[5].

The inclusion of the alternative measures or conditions does not conflict with and is in no way a "veto" of the 2020 SARBO, nor is it an enforcement action. A GADNR Law Enforcement Officer giving a dredger a citation for "taking" a turtle is enforcement. Prescribing alternative measures or conditions is simply a management tool aimed at minimizing impacts to coastal resources. A proper risk-based assessment of the potential to cause disproportionate impacts to Georgia's NRU if egg-bearing females are taken needs to be weighed regionally with the minor imposition of seasonal vessel speed restrictions or conducting surveys outside the calving season. State and federal goals can be achieved when these interests are balanced.

Georgia Coastal Marshlands Protection Act

We agree that the Georgia Coastal Marshlands Protection Act (CMPA) is a relevant enforceable policy and should remain listed, as we stated in our draft November 3, 2020 letter, and appreciate

[3] O.C.G.A. 27-1-3(f)

[4] 15 CFR 930.32(a)(1)

[5] 2016-2021 Agreement to Implement North Atlantic Right Whale Recovery Activities in the Southeast U.S., Job #5

that you have updated Appendix J to clarify that a formal CMPA permit will not be required[6].

3. **Beneficial use (BU) of dredged material**

The Draft Integrated Feasibility Report and Environmental Assessment and Draft FONSI states, on page 66 at Alternative 2: Bend Widener, "Dredged material from this location would first be considered for beneficial use on Bird Island located approximately 1 mile to the northeast." If the project scope has changed so that beneficial use is no longer proposed, as described in your February 10, 2021 letter, this must be reflected in an updated Appendix J Federal Consistency Determination project description.

Appendix J has been updated to include the River and Harbor Development Act as a relevant enforceable policy. The assertion that contaminant analysis is necessary to determine beneficial use of uncontaminated dredge material stems from the October 26, 2020 Environmental Protection Division's Section 401 Water Quality Certification condition 1.b. "The applicant must ensure that any fill placed in state water must be clean fill that is free of solid waste, toxic, or hazardous contaminants"; and condition 3. "Before commencement of the new work dredging, the applicant will conduct sampling and analysis of channel bottom sediments at the footprints of the project's Turning Basing and Bend Widener dredging zones". The Georgia Water Quality Control Act, under which these conditions were promulgated, is an enforceable policy of the GCMP and conditions placed on specific State authorizations required under an enforceable policy become conditions of the federal consistency certification.

4. **Erosion at Andrew's Island dredged DMCA Weir #3 outfall**

We appreciate that you agree to do pre-and post-construction monitoring to determine if impacts are occurring from effluent at this location.

5. **NEPA Considerations**

Our specific question in the draft November 3, 2020 letter regarding expansion of the St. Simons Meeting Area was to determine whether or not this proposed action would cause secondary, non-environmental impacts, such as time delays associated with a new requirement to obtain a Section 408 permit prior to using this area for future beneficial use projects. Will the expanded St. Simons Sound Meeting Area include the Jekyll Creek scour hole BU placement site? If so, will a CWA Section 408 permit be required from USACE to use this site for BU placement in the future? Please address this potential impact in Appendix J.

The GCMP is a "networked" program in that multiple Divisions of GADNR retain implementation and enforcement responsibilities for the various enforceable policies that compose our Program. Those Divisions have not deferred any implementation or enforcement authorities to the GCMP.

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[6] The sentence "A Marsh permit would be obtained prior to starting construction of the proposed action" has been removed from Appendix J in the February 2021 update.

Rather, GCMP performs a coordination role and acts as the point of contact for the federal agency activity. It is appropriate for federal agencies to obtain approval directly from the Division responsible for implementing any specific law or act while CRD serves to coordinate these efforts through the GCMP.

The Coastal Zone Management Act at 16 U.S.C. 1456(c)(3)(A) provides coordination and cooperation guidelines for federal permits or licenses and is not applicable to this proposed project. As described in our February 19, 2021 Memorandum, CZMA 16 U.S.C. 1465(c)(1) and Subpart C [15 CFR 930.30-930.46] provide the correct legal framework for the Brunswick Harbor proposal.

We look forward to continued discussions on O&M hopper dredge concerns following the guidance provided by Subpart C under 15 CFR 930. Please contact Mark Dodd at (912) 506-7260 with GADNR/WRD Wildlife Conservation Program if you have technical questions regarding Georgia wildlife or Kelie Moore at (912) 262-2334 if you have federal consistency questions.

Sincerely,

Doug Haymans
Director

DH/km

Attachments: GADNR/CRD March 11, 2021 Memorandum: Alternative Measures Discussion
GADNR/WRD Feb. 22, 2011 Memorandum: Mark Dodd to Kelie Moore
Northern Recovery Unit Loggerhead Genetic Demographic Project Report, Oct. 21, 2020
NMFS ESA Section 6 Cooperative Agreement, 2020
NMFS 2016-2020 North Atlantic Right Whale Recovery Activities Grant

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MARK WILLIAMS
COMMISSIONER

DOUG HAYMANS
DIRECTOR

MEMORANDUM

To: Kim Garvey, USACE SAS Chief of Planning

From: Doug Haymans, GaDNR/CRD Director

Date: March 15, 2021

RE: Alternative Measures Discussion: Brunswick Harbor Modifications O&M, Glynn County, Georgia

Items for Further Discussion – Solutions to Explore:
(CRD potential solutions and/or additional information in lettered bullets)

1. All hopper dredging activities shall be restricted to 15 December through 31 March unless prior approval is obtained from GCMP;
    a. CRD, through practice, has found the following, and only the following, to be consistent with GCMP enforceable policies:
        i. The use of hopper dredges between 15 December and 31 March;
        ii. The use of hopper dredges between 1 April and 15 April when there was extraordinary justification (e.g. amount to be dredged was underestimated due to hurricane/severe weather between the hydrographic survey and the dredge work); and
        iii. The use of hopper dredges prior to 15 December and/or after 31 March when water temperatures were at or below 16 degrees Celsius, correlating to low turtle abundance in cold water.
    b. Is it possible to restrict dredge types to non-hoppers between 1 April 1 and 14 December?
        i. Are additional time delays unreasonable?
        ii. Are additional costs unreasonable?
        iii. Are there other factors to be considered?
2. Hopper dredging activities will be halted if sea turtle takes exceed the limits specified by NOAA;
    a. The 3-year take limit for the entire South Atlantic Division will disproportionately impact Georgia's loggerhead NRU if all 214 loggerhead turtles are adult females taken in Georgia. Can some maximum annual limit for sub-adult and adult loggerhead takes be adopted for Brunswick Harbor?
3. Dredges and other project vessels 26 feet in length or greater shall operate at 10 knots or less within the Southeast Seasonal Management Area (SMA) from 15 November to 15 April;
    a. We'd like to better understand your flexibility in scheduling surveys
        i. Can they be scheduled outside of the calving season?
        ii. Are there other constraints to consider?
        iii. What is the cost (in time and money) for survey boats to adhere to 10 knots

when transiting an SMA?

b. What is the cost (in time and money) for dredges and attendant vessels to adhere to 10 knots when transiting an SMA?

4. Dredges and other project vessels 26 feet in length or greater shall operate at 10 knots or less within the Mid-Atlantic SMA from 1 November to 30 April;
   a. We'd like to better understand your flexibility in scheduling surveys
      i. Can they be scheduled outside of the calving season?
      ii. Are there other constraints to consider?
      iii. What is the cost (in time and money) for survey boats to adhere to 10 knots when transiting an SMA?
   b. What is the cost (in time and money) for dredges and attendant vessels to adhere to 10 knots when transiting an SMA?

Items Assumed Partially Agreeable – Request Suggested Wording Changes to be Fully Agreeable:
(CRD **bolded** language assumed to be partially disagreeable)

5. Hopper dredges shall have 100% inflow and outflow screening that is kept functional to the maximum extent practicable. Should inflow screening become inoperable for more than 48 continuous hours, **operations shall cease until fully functional** (Note: GADNR/WRD-approval option to use only outflow screens removed);
6. Hopper dredge inspection checklists shall be provided to **GADNR/WRD** prior to commencing dredging;
7. Hopper dredges shall have protected species observers onboard to monitor each dredging event as unseasonably warm waters can cause higher than anticipated turtle abundance during the winter months (Note: GADNR/WRD-approved variance option removed);
8. Sea turtle takes shall be reported to **GADNR/WRD** within 24 hours;
9. **GADNR/WRD** personnel shall be allowed onboard the dredge at least once during each dredging event. Savannah District Corps' personnel shall coordinate access to hopper dredges for **GADNR/WRD** personnel within a reasonable timeframe of request, not to exceed 3 business days; and
10. Bed leveling equipment may not be used unless it is a 'Brunswick Harbor' design **that includes a 45 degree blade across the bottom with** no support structures extending beyond the blade, or it is a design that has been tested in waters clear enough to determine if it produces a sand wave in front of the leading face of the device such that it disturbs sea turtles off the sea/channel floor bottom (Note: GADNR/WRD-approval option removed).

Items Assumed Agreeable:

11. Include language in the dredging contract that pre- and post-construction surveys of the saltmarsh vegetation surrounding Weir #3 outfall is documented (e.g. via unmanned aerial vehicle photos) and any loss in vegetation will be rectified by restoring the area to its pre-construction elevation and replanted with *Spartina alternaflora*;
12. The Corps' shall notify GCMP of any modifications to the proposed activity;
13. Contact information for Savannah District Corps access coordinators shall be provided to

GCMP prior to each dredging event;

14. Vessels may operate at speeds greater than 10 knots when necessary to maintain safe steerage and navigation; and
15. Automatic Information Systems (AIS) shall be properly installed and operational on all dredges and project vessels 26 feet in length or greater.

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February 22, 2021

MEMORANDUM

TO: Kelie Moore

FROM: Mark Dodd

SUBJECT: Summary of Georgia DNR concerns regarding proposed summer hopper dredging in Georgia channels and the 2020 SARBO

Background

- The USACE uses trailing suction hopper dredges to maintain shipping channels in Georgia (Savannah, Brunswick, and Kings Bay). Annual removal of sediment is required to maintain shipping channels at approved depths for navigation.

-Hopper dredging activity has resulted in significant effects on protected species populations. Federally-listed species that may be impacted by hopper dredging activity in Georgia include: 1) North Atlantic right whale, 2) hard shelled sea turtles (loggerhead, Kemp's ridley, green), and 3) Atlantic sturgeon. Shortnose sturgeon are a species of concern but mortality has not been documented in hopper dredges in Georgia. Historically, loggerhead sea turtles have been the most significantly impacted by dredging activities through unrestricted summer hopper dredging activities and the loss of reproductively active females.

-The Georgia Department of Natural Resources (GADNR) has coordinated sea turtle, right whale and sturgeon conservation in Georgia for over 30 years. GADNR collects and maintains data for population assessments, conducts research, and implements management actions to recover listed species. The State of Georgia has invested significant resources over the last 30 years to recover sea turtle, right whale and sturgeon populations.

-The mortality of sea turtles in hopper dredging activities in Georgia is well documented. In 1991, a single observer monitoring spring and summer hopper dredging in the Brunswick and Savannah channels documented 35 sea turtle mortalities (Slay 1991). This estimate was considered a gross undercount of total sea turtle mortality because monitoring was limited to 25%-50% of total dredge loads. In addition, observers monitored overflow screening only. It's assumed that only a small proportion of the total sea turtle carcasses taken by hopper dredges are detected in the overflow screening. Most turtle carcasses are thought to be buried in sediment or are negatively buoyant and sink to the bottom of the hopper where they cannot be detected. Based on the 1991 estimate of mortality, NMFS issued a biological opinion that found that channel maintenance dredging activity in the southeast "jeopardized the continued existence" of listed sea turtles. The 1991 SARBO required dredging in the winter months to avoid times of high sea turtle abundance (12/1-3/31). In addition, protective measures were put in place to minimize any interactions between dredges and support vessels and right whales during the calving season. Atlantic sturgeon were not considered a species of concern at that time and not included in the development of early conservation measures. The winter dredging windows were adjusted several times over the following 7 years using sea turtle mortality data collected by observers on dredges.

-In 1995, GADNR added winter dredging requirements to the state's Clean Water Act 401 certifications for the Savannah channel maintenance dredging as a result of concerns over NMFS expansion of the dredging windows in the 1995 SARBO. Similar conditions were added on all subsequent 401 certifications issued by the state including the King's Bay ship channel and the Savannah Harbor Expansion Project. Requirements for the winter dredging window were also added to the Coastal Zone Management Act Federal consistency determination for King's Bay.

-In 1998, the USACE SAD developed a protocol based on negotiation with southeastern state resource agencies that restricted hopper dredging in southeast channels from 15 December to 31 March annually. During the same period USACE, NMFS and other agencies developed protocols to mitigate risk to right whales, including the Early Warning System (EWS) aerial surveys, speed measures for hopper dredges and requirements for dredge observers to report all whale sightings and collisions.

-In 2020, NMFS issued a new biological opinion for channel maintenance dredging in the south Atlantic coast. The opinion eliminated the use of hopper dredge windows to reduce sea turtle mortality. The USACE Savannah District has informed Georgia DNR that they intend to dredge the Brunswick and Savannah channels during the spring/summer 2021 (April-June).

Summary of protected species mortality in hopper dredges in Georgia

-There is significant spatial and temporal variation in the occurrence of Federally-listed species in shipping channels in Georgia. North Atlantic right whales and Atlantic sturgeon are present during the winter months (15 November-15 April). Sea turtles are found in shipping channels year round but abundance is several orders of magnitude higher in the spring, summer, and fall (1 April- 15 December). Data required to determine the optimal timing for hopper dredging in Georgia includes: 1) an estimate of the probability of mortality event by species and 2) the potential effect of the mortality on population recovery. In the following sections, we summarize the available data on the probability of protected species mortality in Georgia (take data) and the effects of the mortality on population recovery (status).

<u>Take levels associated with channel maintenance dredging</u>

-Data on sea turtle mortality in hopper dredging is available beginning in 1987. Initial observations were limited to the monitoring of overflow screening. The subsequent development of inflow boxes substantially improved the detectability of protected species mortality on hopper dredges. For the purposes of this summary, we use a time-series beginning in 1994 which represents a period where inflow boxes were implemented fleet-wide (C. Slay, pers. comm.). There are several caveats regarding this data including:

1) Channel maintenance dredging operations from 1994 to present were conducted during winter months (11/30-3/30).
2) Detectability of carcasses in inflow boxes is known to vary by project depending on box configuration, screen size, and the functionality of equipment (hydraulic box door failure, clogging, etc.).
3) From the period 1994-2007, relocation and sweep net trawling were used periodically during maintenance dredging when sea turtle mortality warranted protection measures.
4) NMFS discontinued the use of relocation trawling in 2008 as a result of concerns over the effects of capture and handling on sea turtles. Sweep or open bag trawling was used exclusively from 2008 to the present in cases where additional protection measures were warranted. The only exception was the Savannah Harbor Expansion Project (SHEP; 2016-2018) where relocation trawling was used.

-From 1994-2019, sea turtle mortality averaged 1.9 turtles per year in Georgia channels (Table 1). Approximately 66% of sea turtle mortalities were loggerheads. All sea turtle mortalities were in juvenile or subadult size classes.

Table 1. Protected species mortality for channel maintenance hopper dredging activities in Georgia channels, 1994-2019 (summarized from ODESS). The time series represents the period when the use of inflow screening was implemented in hopper dredges in Georgia. Data from Kings Bay 2013-2014 were not entered in ODESS and not included in this summary.

Channel	Years Maint. Dredging (1994-2019)	Loggerhead	Kemp's ridley	Green	Unk	Total Sea turtle	avg. sea turtle/yr	Atlantic sturgeon	Avg. Atlantic sturgeon/yr	shortnose sturgeon	right whale
Savannah	26	17	5	2	0	24	0.9	4	0.2	0	0
Brunswick	26	35	18	3	0	56	2.2	8	0.3	0	0
Kings Bay	24	45	14	8	1	68	2.8	5	0.2	0	0
Total	76	97	37	13	1	148	1.9	17	0.2	0	0

- Atlantic sturgeon were Federally listed in 2012. It's not clear when observers were first required to record sturgeon mortality in hopper dredges in Georgia. The first documented mortality of an Atlantic sturgeon in a hopper dredge per ODESS system was in 2015. For the purposes of this assessment, we will use data from the last 5 years because it represents a period of consistent survey effort. Mortality averaged 3.4 Atlantic sturgeon per year from 2015-2019 and mortalities were documented in all Georgia channels. Of the three Atlantic sturgeon mortalities for which length measurements were available, two (2) were subadults and 1 was a juvenile. The detectability of Atlantic sturgeon carcasses in hopper dredges is unknown but assumed to be lower than hard shelled sea turtle species.

-The genetic composition of Atlantic sturgeon taken in Georgia channels is not well known. During the winter months, adult and marine migratory juveniles from other river systems are known to use Georgia estuaries. Fox et al. 2018 found that 40% (8/20) of the tagged migratory Atlantic sturgeon in the St Marys River estuary (Cumberland Sound) were from Georgia populations. The remaining migratory sturgeon were from other river systems in the South Atlantic DPS. More research is necessary to determine the genetic composition of marine migratory Atlantic sturgeon taken during hopper dredging activities in Georgia.

-No lethal or injurious collisions were documented between North Atlantic right whales and hopper dredges or dredge support vessels in Georgia since the beginning of observation in 1991. The SARBO describes one potential interaction between a whale and a dredge in 2005, but a dead or injured whale was not observed and the encounter was never verified.

-Overall, the use of dredging windows was considered a highly successful multi-species approach to managing threatened and endangered species in Georgia. For over two decades, winter dredging windows have allowed the USACE to maintain deep water channels and protect Georgia's nesting loggerhead sea turtles and Atlantic sturgeon—and no lethal or injurious vessel collisions with right whales have been documented in the process.

<u>Take levels associated with 2009 summer dredging demonstration project</u>

-USACE Savannah District conducted a test project to determine the feasibility of summer dredging in the Brunswick and Savannah channels in 2009. Sweep trawling began in Brunswick on 8/30/09. Two dredges began work in Brunswick on 9/1/09. Four (4) loggerheads were killed in 9 days of dredging and the project was discontinued in Brunswick. One of the loggerheads had an estimated SCL of 81.5 cm (presumed subadult or adult). Dredging began in Savannah on 9/11/09 after 12 hours of open net trawling. Two (2) loggerheads were killed in 6 days of dredging. One of the animals was considered to be of adult size. Overall, 6 loggerheads were taken in 15 days of dredging. The CPUE for the summer demonstration project was 0.000020 turtle mortalities/cu yrd (6/292,734 cu yrd), over 8 times higher than the overall CPUE for sea turtle mortality during the winter dredging window (0.0000024; Table 2). The hypothesis put forth by Dickerson et al. 2007 that capture rates of sea turtles may be lower in the summer due to higher activity rates and less time on the bottom was not supported by this study. One caveat with the 2009 summer dredging project is that the sample size of this study is very low. The results may not be representative of all summer dredging in all years.

-No Atlantic sturgeon or right whales were taken during the summer dredging demonstration project.

Table 2. Sea turtle mortality and cubic yards dredged by hopper dredges during channel maintenance dredging in Georgia, 1994-2018. Data downloaded from ODESS and includes only years where sea turtle mortality and cubic yards of sediment dredged were available (Savannah-1994-2018; Brunswick-1994-2018; Kings Bay-1995-2012,2015-2017). The time series represents the period when inflow screening was used in hopper dredges in Georgia. A caveat from the USACE regarding this data is that it may not be 100% accurate for all dredge volumes. Reports from the contractor, DQM, and CESAS QA personnel do not agree in all areas.

	Years Maint. Dredging (1994-2018)	No. sea turtle mortalities	mortalities /yr	total cubic yards	CPUE-mortalities/cu yrd
Savannah	25	24	1.0	18,370,621	0.0000013
Brunswick	25	56	2.2	27,659,857	0.0000020
Kings Bay	21	68	3.2	16,661,919	0.0000041
Total	61	148	2.4	62,692,397	0.0000024

Take Levels Associated with SHEP

-From 2016-2018, the USACE deepened the Savannah channel from 42 to 47 feet to allow Post-Panamax vessels to use port facilities in Savannah. Closed-net relocation trawling was employed on 408 of the 463 total trawl days (88% of project). During the three-year project, a total of 26 sea turtle (12 loggerheads, 7 Kemp's ridley, and 7 green turtles) and 7 Atlantic sturgeon mortalities were documented. The overall CPUE for sea turtle mortality during SHEP project was ~0.0000033 (26/8 mil cu yrds) which is approximately 1.3 times higher than for overall channel maintenance dredging in Georgia (Table 2). It's unclear why the rate of sea turtle mortality was higher for SHEP particularly when relocation trawling was employed during the project. One difference between the SHEP project and channel maintenance dredging was that SHEP included the construction of new channel segments that had not been dredged previously which may have made trawling less effective. Also, hopper dredging activity for SHEP was continued through the end of March in each of the 3 years of the project which is a time of increasing water temperature and sea turtle abundance.

- The size class of loggerheads taken during the project was difficult to determine because 83% of carcasses were not collected intact. Four (4) of the loggerheads captured during the project were documented by observers as adults; however, it's not clear what standards were used by observers to make this determination. All Kemp's ridley and green turtles captured by hopper dredges were juveniles. A Kemp's ridley and four (4) green turtles were found alive in the hopper during this project. The capture of live juvenile sea turtles in the hopper is attributed to the use of large screening in the inflow boxes (9" x 9") which allowed small turtles to pass through the box.

- The CPUE for Atlantic sturgeon mortality for the SHEP project was 0.0000009 (7/8,000,000). Sturgeon mortality from SHEP was approximately 1.6 times lower than the CPUE for overall channel maintenance dredging (Table 3). This result suggests that relocation trawling may be effective in reducing Atlantic sturgeon mortality in hopper dredging operations. As with the 2009 summer dredging project, the sample size was very low and the results may not be representative of all projects with relocation trawling in all years. More data should be collected to determine if relocation trawling has a real effect on reducing sturgeon mortality in Georgia.

Table 3. Atlantic sturgeon mortality and cubic yards dredged by hopper dredges during channel maintenance dredging in Georgia, 2014-2018. Data downloaded from ODESS and includes only the most recent 5-year period where sea turtle mortality and total cubic yards of sediment dredged were available (Brunswick-2014-2018; Kings Bay-2015-2017). The time series represents a period from 2014-2018 when inflow screening was fully implemented on hopper dredges in Georgia. A caveat from the USACE regarding this data is that it may not be 100% accurate for dredge volumes. Reports from the contractor, DQM, and CESAS QA personnel do not agree in all areas.

	Years Maint. Dredging (2014-2018)	No. Atlantic sturgeon mortalities	mortalities /yr	total cubic yards	CPUE-mortalities/cu yrd
Savannah	5	4	0.8	3,026,993	0.0000013
Brunswick	5	8	1.6	3,785,604	0.0000021
Kings Bay	3	3	1.0	3,820,447	0.0000008
Total	13	15	1.2	10,633,044	0.0000014

-Length measurements were obtained for 3 of the 7 Atlantic sturgeon mortalities. Two of the 3 sturgeon were adult sized animals and one was a juvenile.

-a total of 137 Atlantic sturgeon were captured during relocation trawling. The age classes of captured sturgeon were 41.6% juvenile, 19.7% subadults, and 38.7% adult.

-Forty (40) loggerheads were captured during winter relocation trawling in SHEP. Three of the 40 were adult sized animals (>90 cm ccl). Two of the three adults were captured in late March when adult females are known to be present in Georgia coastal waters prior to the initiation of nesting in early May. All Kemps ridley (27) and green turtle captures (4) were in the juvenile size classes.

Species Status

<u>Loggerhead Sea turtle</u>

- Georgia DNR collaborated with Warnell School of Forest Resources and the USGS Coop Unit at the University of Georgia, North Carolina Wildlife Resources Commission and South Carolina DNR to develop a Bayesian integrated population model for the Northern Recovery Unit (NRU) of loggerhead turtles (see attached). We used a matrix population model operating at the level of the NRU linked to a multi-state mark-recapture model (10 years of genetic data) that allows detection probability to vary in the study area. Parameters are shared between the model components improving estimation and allowing prediction of the population trajectory into the future. Results from the model show that the NRU loggerhead population was very close to extirpation in the late 1990s, and that the population abundance is currently approximately half to a third of the size it was in the 1960s. A pulse of hatchlings from early nest protection efforts in the 1970s and 1980's and the implementation of Turtle Excluder Devices (TEDs) resulted in recent increases in nesting (last 10 years). The model predicts that a lack of recruitment from low nesting in the early 2000s will result in a plateau in population growth at current levels. If all current management protections stay in place, the population is predicted to remain stable or decline slightly until 2040. At that point, the population is expected to begin increasing toward historic levels. The model is particularly sensitive to adult female mortality and suggests that, at a minimum, protections for reproductive age loggerheads should stay in place over the next 20 years to ensure the population does not decline from current levels. Given the size of the NRU population, it's unlikely that the loss of 214 benthic juvenile loggerheads over 3 years will influence population recovery. The loss of 214 adult female loggerheads over a 3-year period could result in NRU population decline or declines in local populations adjacent to shipping channels. We intend to further refine the model including conducting sensitivity analysis to assess the effect of the loss of reproductively active females on overall population recovery.

-In 2019, the NMFS/USFWS Loggerhead Recovery Team published an assessment of population status for loggerhead turtles (NMFS/USFWS 2019). The recovery team reviewed progress toward recovery for the NW Atlantic Population of loggerheads 10 years after publication of the recovery plan (2008). Three of the 5 recovery units did not show an increasing trend in nesting. This was a particular concern for the Peninsular Florida Recovery Unit because it represents the largest loggerhead nesting assemblage in the NW Atlantic subpopulation. One of the four recovery units (Northern) showed an annual increase in the number of nests of 1.3% annually. This rate of increase is below the 2% annual increase criterion for consideration for a change in listing status. The data from the Dry Tortugas population was too incomplete to determine a trend.

- Georgia DNR collaborated with Warnell School of Forest Resources at the University of Georgia, North Carolina Wildlife Commission and South Carolina DNR to develop a database of genetic tags (genotypes) for the NRU loggerhead nesting females. A single egg was taken from every documented nest in the NRU over a 10-year period allowing researchers to estimate the size of Georgia's female nesting population. The number of loggerheads using Georgia beaches over the most recent 3-year period (2017-2019) was 2,022 females. The 2020 SARBO allows the USACE to legally take approximately 11% (214/2,022) of the adult female nesting population in Georgia over a 3-year period. The number of loggerhead females using beaches adjacent to the Brunswick ship channel (Jekyll, St. Simons, Sea Island) and the Savannah ship channel (little Tybee, Tybee, Daufuskie, Hilton Head Island) was 245 and 456, respectively. The SARBO allows the USACE to legally take up to 87% (214/245) and 47% (214/456) of the females nesting in the vicinity of the Brunswick and Savannah ship channels over a 3-year period. Data was not available from Florida beaches at the writing of this summary, so a similar estimate could not be generated for the King's Bay channel. Georgia has 3 ship channels which means a significant proportion of Georgia's sea turtle nesting population will be affected by mortality in ship channels. This level of mortality could lead to significant declines in local loggerhead nesting populations.

-Loggerhead turtles exhibit natal homing and high nesting site fidelity. If local nesting populations are significantly reduced or extirpated, its unlikely loggerheads from adjacent beaches will reestablish nesting in a reasonable amount of geological time. The recovery of Georgia's loggerhead turtle population is considered a high priority for the state. As such, Georgia DNR has spent considerable time and energy recovering Georgia's loggerhead sea turtle population.

North Atlantic Right Whale

-Pace et al. 2017 developed a Bayesian mark-recapture model to assess trends in North Atlantic right whale population abundance. The authors found that North Atlantic right whale abundance increased at approximately 2.8% from 1990 to 2010 followed by a decline in abundance from 2010 to 2015. The probability of the post-2010 decline was estimated to be very high (99.9%). In addition, the survival rate for adult females was found to be lower than males leading to a proportionally larger reduction in adult females. Recent data collected since the publication of the model shows a continued declining trend in total and adult female abundance. The overall population estimate is less than 400 animals. The poor outlook for population recovery for North Atlantic right whales is a result of low adult female survival from entanglements in fishing gear and vessel mortality. In addition, low calving rates are not sufficiently high to replace the loss of adults.

-Hopper dredges and associated support vessels have been operating in Georgia waters (with restrictions) during the calving season for over 30 years. No lethal or injurious interactions have been documented. There is no evidence that hopper dredging activity has contributed to population decline in the North Atlantic right whale. There is no reason to assume that the probability of interaction between North Atlantic right whales and hopper dredges or support vessels will increase in the future.

Atlantic Sturgeon

-Georgia supports two of the largest remaining populations of Atlantic Sturgeon in the South Atlantic DPS including the Altamaha and Savannah river populations. Three additional rivers in Georgia hold remnant populations including the Ogeechee, Satilla, and St. Marys rivers (Fox et al. 2018; Fox and Peterson 2019). Monitoring abundance and status of adult sturgeon populations is difficult due to their migratory behavior. However, young juvenile sturgeon remain in nursery habitats for the first year allowing annual cohorts to be effectively sampled. The Altamaha River hosts the largest known population of Atlantic sturgeon in the southeast DPS with annual recruitment from several hundred to thousands of individuals (Schueller and Peterson 2010). More recent information on Atlantic sturgeon recruitment in the Altamaha River are being summarized and will be available in 2021. In the Savannah River, Fox et al. 2020 found consistent presence of age 1 cohorts from 2013-2020 indicating that the population is reliably reproducing. Recruitment remained stable over that period suggesting that the population was recovering. The Savannah population is of particular concern due to loss of spawning habitat (Augusta Bluff Lock and Dam) and significant modifications to the lower river system from the Savannah Harbor Expansion Project. The Ogeechee and Satilla Rivers have small populations with intermittent recruitment. The St. Mary's population was thought to be extirpated for several decades but a recent study documented successful reproduction in 1 of 7 years of surveys (Fox et al. 2018). The St. Marys river population persists at a remnant level.

-Population models are not available to assess the status of Atlantic sturgeon populations or the effect of anthropogenic mortality on population recovery in Georgia. However, based on the size of the Savannah and Altamaha river populations and the fact that documented mortalities to date are primarily juveniles and subadults, it's unlikely that the current level of mortality associated with channel maintenance dredging (3.4 Atlantic sturgeon annually across 3 channels) will have an effect on population recovery. There is a concern that the loss of adults from the King's Bay ship channel could have an effect on the remnant local population in the St. Marys River. As such, it is suggested that the use of hopper dredges in the inner harbor at King's Bay be discontinued in favor of a pipeline dredge.

Relocation trawling should be used if a hopper dredge is used in the inner harbor during the winter months to reduce Atlantic sturgeon mortality.

Risk-based Assessment Conclusions

-Unrestricted hopper dredging in Georgia will result in significant mortality of marine wildlife and the possible extirpation of species including loggerhead turtles, Atlantic sturgeon, and North Atlantic right whales.

- North Atlantic right whales occur off the Georgia coast from 15 Nov-15 April. The North Atlantic right whale population is currently declining and has a significant chance of extinction unless entanglement in fishing gear and vessel strikes are mitigated. Hopper dredging activity has occurred concurrently with the right whale calving season in Georgia for over 30 years. No fatal on injurious incidents have occurred. Although the consequences of a single right whale mortality are high, the data shows that the probability of an event occurring is extremely low. The risk of hopper dredging in the right whale calving season is discountable. With mitigation measures in place hopper dredging can occur safely year-round without any effect on population recovery.

-Loggerhead turtles occur in Georgia ship channels year-round. Loggerhead abundance is low during the winter months (15 December-31 March), increases in early spring (1 April) and peaks during the fall (September; Dickerson et al. 1995). Adult nesting loggerheads are found in ship channels from 1 April through 31 August. The NRU loggerhead population came very close to extirpation in the early 2000's and has sustained a recent increase in nesting as a result of intensive beach management and the implementation of TEDs. Modeling exercises predict that the population will plateau and possibly decline slightly as a result of lack of recruitment from low nesting in the early 2000s. Allowable take limits for adult loggerheads in the 2020 SARBO (214 over 3 years) could lead to a decline in the overall NRU population or declines in local populations adjacent to ship channels. The risk of mortality of nesting females is high during the spring and summer and hopper dredging should be avoided during this period. Similarly, dredging during fall will result in high mortality rates estimated to be 8 times higher than winter. Dickerson et al. 1995 found that sea turtle abundance and activity in southeast channels declined at water temperatures below 16 degrees Celsius. The seasonal time periods that corresponds to water temps below 16 degrees C in Georgia is 15 December through 31 March. In order to assure recovery of the NRU population of loggerheads, hopper dredging activity in Georgia should be restricted to winter months (15 December-31 March).

- Atlantic sturgeon are found in the lower estuaries and shipping channels during the winter and spring (Dec-May). Georgia supports two of the largest remaining populations of Atlantic Sturgeon in the South Atlantic DPS including the Altamaha and Savannah river populations. Three additional rivers in Georgia hold remnant populations including the Ogeechee, Satilla, and St. Marys rivers (Fox et al. 2018; Fox and Peterson 2019). Population models are not available to assess the status of Atlantic sturgeon populations or the effect of anthropogenic mortality on population recovery in Georgia. The optimal time to dredge to avoid the take of Atlantic sturgeon is summer and fall. However, based on the size of the Savannah and Altamaha river populations and the fact that documented mortalities to date are primarily juveniles and subadults, it's unlikely that the current level of mortality associated with channel maintenance dredging (3.4 Atlantic sturgeon annually across 3 channels) will have an effect on population recovery. There is a concern that the loss of adults from the King's Bay ship channel could have an effect on the remnant local population in the St. Marys River.

Overall, the loggerhead turtle population has been most significantly impacted by hopper dredging activity in Georgia. Dredging can occur at any time of year without having effects on population recovery of North Atlantic right whale or Atlantic sturgeon population recovery. The mortality of adult female loggerheads during the spring and summer could lead to population declines in the NRU. We do not concur with the USACE's and NMFS's claim that the 2020 SARBO has improved multi-species management of threatened and endangered species in Georgia. For over two decades, winter dredging windows have allowed the USACE to maintain deep water channels and protect Georgia's nesting loggerhead sea turtles—and no lethal or injurious vessel collisions with right whales have been documented in the process.

Deficiencies with the 2020 SARBO

-The 2020 SARBO has significant deficiencies that should be addressed prior to implementation including:

1- The primary justification provided in the SARBO for eliminating seasonal dredging restrictions in Georgia was to shift dredging effort outside the winter right whale calving season to minimize the chances of vessel collision. Further, it is argued that "high speed" survey vessels are necessary for channel maintenance dredging and pose risks to right whales. The available data does not support either of these arguments. First, hopper dredges have been used in Georgia channels during the calving season with restrictive measures in place for 30 years with no whale fatalities. The SARBO describes one potential interaction between a whale and a dredge in 2005, but a dead or injured whale was not observed and the encounter was never verified. It's illogical to conclude that winter hopper dredging activity should be shifted from the calving season when there have been no fatalities or injurious events in over 30 years.

Second, the SARBO suggests that "high speed surveys vessels" are required for dredging operations (survey and transit) in Georgia. The SARBO implies that survey vessels must travel at high speeds to complete surveys. This is not the case. Survey vessels can travel at a range of speeds including slower speeds ($\leq$ 10 knots) where they will not pose a threat to right whales. Most survey work is conducted at speeds less than 10 knots. Survey work at the ends of the channel or offshore disposal sites does not require vessels to travel at high speeds. Further, survey vessels are not required to transit to and from channels and disposal sites at high speed. Small trailerable vessels can be launched from inshore boat ramps (e.g. Gannett) and larger survey vessels can transit between channels using the intracoastal waterway. In particular, the survey vessel used by the USACE in NE Florida and SE Georgia (Florida II) is inappropriate for offshore use in seasonal right whale habitat at speeds $\geq$ 10 knots. Again, for more than 30 years, "high speed" survey vessels have been used for hopper dredging activities in Georgia. No right whale mortalities or interactions have been documented.

2-The 2020 SARBO proposes to mitigate right whale collision risk with adaptive measures that require vessels to temporarily reduce their speed when whales are sighted within a specified distance of vessels. Adaptive measures like this are less protective than static seasonal speed reductions because: 1) detection probability from aerial platforms is only approximately 50% (Hain et al. 1999), 2) survey teams can only fly 2-3 days per week on average because of weather and other constraints and 3) telemetry data show that individual whales can move 40-60 miles in a day (Georgia DNR unpubl. data). As such, we recommend that all dredges, survey vessels and other support vessels operate at 10 knots or less within the Southeast SMA from 15 November to 15 April, and from 1 November to 30 April in the Mid-Atlantic SMA.

3- A significant deficiency of the SARBO is that NMFS does not take into account the age class or life stage of species taken by hopper dredging activities when assessing jeopardy and developing take limits. This is particularly important for sea turtle species with delayed sexual maturity. Loggerhead turtles, Georgia's primary nesting sea turtle, are not sexually mature until approximately 30 years of age. Other species of concern in Georgia (Atlantic sturgeon and right whales) are sexually mature at an average age of 8-10 years. It takes approximately 3 times as long to replace an adult loggerhead that is removed from the population by dredging than the other species of concern. The large discrepancy in age to sexual maturity should be taken into account when assessing take and the effects of mortality on population recovery.

5- Georgia DNR collaborated with Warnell School of Forest Resources and the USGS Coop Unit at the University of Georgia, North Carolina Wildlife Resources Commission and South Carolina DNR to develop a Bayesian integrated population model for the Northern Recovery Unit loggerhead population (see attached). We used a matrix population model operating at the level of the NRU linked to a multi-state mark-recapture model (10 years of genetic data) that allows detection probability to vary in the study area. Parameters are shared between the model components improving estimation and allowing prediction of the population trajectory into the future. Results from the model show that the NRU loggerhead population was very close to extirpation in the late 1990s, and that the population abundance is currently approximately half to a third of the size it was in the 1960s. A pulse of hatchlings from early nest protection efforts in the 1970s and 1980's and the implementation of Turtle Excluder Devices (TEDs) resulted in recent increases in nesting (last 10 years). The model predicts that a lack of recruitment from low nesting in the early 2000s will result in a plateau in population growth at current levels. If all current management protections stay in place, the population is predicted to remain stable or decline slightly until 2040. At that point, the population is expected to begin increasing toward historic levels. The model is particularly sensitive to adult female mortality and suggests that, at a minimum, protections for reproductive age loggerheads should stay in place over the next 20 years to ensure the population does not decline from current levels. Given the size of the size of the NRU population, it's unlikely that the loss of 214 benthic juvenile loggerheads over 3 years will influence population recovery. The loss of 214 adult female loggerheads over a 3-year period could result in population decline particularly in local populations. We intend to further refine the model including conducting sensitivity analysis to assess the effect of the loss of reproductively active females on overall population recovery.

6-The legal allowable take for adult loggerheads could lead to significant local declines in loggerhead populations in Georgia. Nesting loggerhead sea turtles are known to use shipping channels during the inter-nesting period (Scott 2006). Georgia DNR collaborated with Warnell School of Forest Resources at the University of Georgia, North Carolina Wildlife Commission and South Carolina DNR to develop a database of genetic tags (genotypes) for the NRU loggerhead nesting females. A single egg was taken from every documented nest in the NRU over a 10-year period allowing researchers to estimate the size of Georgia's female nesting population. The number of loggerheads using Georgia beaches over the most recent 3-year period (2017-2019) was 2,022 females. The 2020 SARBO allows the USACE to legally take approximately 11% (214/2,022) of the adult female nesting population in Georgia over a 3-year period. The number of loggerhead females using beaches adjacent to the Brunswick ship channel (Jekyll, St. Simons, Sea Island) and the Savannah ship channel (little Tybee, Tybee, Daufuskie, Hilton Head Island) was 245 and 456, respectively. The SARBO allows the USACE to legally take up to 87% (214/245) and 47% (214/456) of the females nesting in the vicinity of the Brunswick and Savannah ship channels over a 3-year period. Data was not available from Florida beaches at the writing of this summary, so a similar estimate could not be generated for the King's Bay channel. Georgia has 3 ship channels which means a significant proportion of Georgia's sea turtle nesting population will be affected by the mortality of nesting loggerhead females in ship channels. This level of mortality could lead to significant declines in local loggerhead nesting populations.

7-- The take estimates and conclusions regarding jeopardy for sea turtles developed in the 2020 SARBO are based on rates of mortality documented during the winter dredging window. The calculation of mortality for sea turtles does not take into account high sea turtle mortality rates associated with summer dredging. In 2009, The USACE conducted a demonstration project to assess the effects of hopper dredging activity on sea turtles in the summer months in Georgia. Hopper dredging was initiated in the Brunswick ship channel on 1 September and the Savannah channel on 11 September. Sweep trawling was used to disturb turtles in the channel in the hope of reducing sea turtle mortality. Six loggerhead turtles were taken in 15 days including two loggerheads that were either large subadults or adults. Capture/mortaliity rates in September were found to be 8 times higher than during the winter dredging window. Results from the summer dredging project in Georgia suggest that year-round dredging will result in take levels substantially higher than those used to assess jeopardy.

8-The SARBO does not take into account important recent information on the status of loggerhead turtles. In 2019, the NMFS/USFWS Loggerhead Recovery Team published an assessment of population status for loggerhead turtles (NMFS/USFWS 2019). The recovery team reviewed progress toward recovery for the NW Atlantic Population of loggerheads 10 years after publication of the recovery plan (2008). Three of the 5 recovery units did not show an increasing trend in nesting. This was a particular concern for the Peninsular Florida Recovery Unit because it represents the largest loggerhead nesting assemblage in the NW Atlantic subpopulation. One of the four recovery units (Northern) showed an annual increase in the number of nests of 1.3% annually. This rate of increase is below the 2% annual increase criterion for consideration for a change in listing status. The data from the Dry Tortugas population was too incomplete to determine a trend. The assessment of loggerhead trends in nesting in the 2020 SARBO is limited to a qualitative assessment of nesting patterns (i.e. the population increased for a number of years or declined for a number of years). It's common for sea turtle nesting populations to show annual and cyclic variation in nesting. NMFS should use a quantitative model to assess trends over the time series to assess population status.

9-NMFS does not present a risk assessment in the SARBO as a basis for how decisions were made regarding seasonal restrictions on dredging activity. NMFS should be required to provide a risk assessment including the probability and consequences of dredge mortality on Federally-listed species to justify how decisions were made regarding the elimination of dredging windows.

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An integrated population model for loggerhead sea turtles in the Northern Recovery Unit

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Contents

1 Introduction

Sea turtle populations are difficult to assess and monitor primarily because efficacious surveys are only feasible during nesting. Entire life stages are practically unobservable, and even mature females spend variable numbers of years at sea between breeding seasons. Females nest multiple times in a season, but distances between consecutive nests may be on the scale of tens of kilometers. The latter attribute has restricted the scope of inference of sea turtle tagging efforts on discrete beaches.

Previous efforts to estimate vital rates of the loggerhead Northern Recovery Unit (NRU) were limited either by data paucity (SEFSC, 2009) or by the analysis framework (Shamblin et al., 2017). With this effort, we make use of the two most comprehensive nesting datasets yet collected for the NRU. The first, nest survey and monitoring efforts organized by state wildlife agencies of Georgia, South Carolina and North Carolina, includes records for 102,096 nests over the period 1997–2019, including information on the number of eggs and hatchlings produced. The second is the genetic mark-recapture dataset of Shamblin et al. (2017) plus subsequent additions, which includes 77,960 detections of 11,477 individual females over the period 2008–2019.

Our approach is to use a Bayesian integrated population model (IPM; Besbeas et al. 2002; Kery and Schaub 2012) that links a matrix population model operating at the level of the NRU, to a multi-state mark-recapture model that allows nest detection probability to vary along the NRU coast (i.e., GA, SC, NC). Parameters are shared between the two model components, improving estimation and allowing prediction of the population trajectory into the future. Critical to the operation of the model is the incorporation of major changes to sea turtle management that occurred in the NRU, including the adoption of turtle excluder devices (TEDs) and nest protection. The model is allowed to alter appropriate population parameters (e.g., hatchling survival) in years corresponding to these management changes. Information from surveys of invertebrate prey in areas where non-breeding adults forage has also been incorporated.

Our objectives in building the loggerhead IPM were to: 1) improve estimation of population vital rates, and 2) allow prediction of future changes to the population, under various management scenarios. We now describe separately the mark-recapture and projection models, then their integration, and the process of model fitting. Subsequent sections explore sensitivities of the model, and describe how the parameterized projection model may be used as a decision support tool.

1.1 Year indices

Throughout the report, three year indexes are used: t for the entire projection period, tm for the period of mark-recapture data (2008–2019), and ts for the period of nest count data (1997–2019). The index $t(tm)$ indicates the values of t corresponding to the years covered by tm; $t(ts)$ is defined similarly.

2 Mark-recapture model

The mark-recapture portion of our model has the general form of a multistate Jolly-Seber model (Kery and Schaub, 2012; Kery and Royle, 2016), in which individuals are allowed to recruit into the breeding population over the course of the study. Non-breeding females may occupy one of a number of states corresponding to the number of years since last breeding. No attempt is made to account for male turtles, since they are never observed.

The mark-recapture model estimates a number of parameters jointly with the NRU-wide projection model; these are enumerated in chapter 4. They include survival, number of nests laid (clutch frequency), and annual, NRU-wide, per nest detection probability.

2.1 Input data

The data input to the mark-recapture model comprise nest records for individuals in the genetic mark-recapture dataset. The data were organized in two distinct matrices. The first, called here D^l, contains information about individual nests, including: 1) location $x \in (0, 1)$ along the scaled, 'linearized' coast (with the southern extreme being 0, the northern end 1); 2) clutch size c, and 3) emergence rate e, the ratio of hatchlings that emerged from the nest, to the number of eggs laid. There were 77,960 such nest records in all.

The second individual-based data matrix, called here D^n, tabulated the number of nests assigned to each individual $i \in 1, 2, \ldots, I$ in each year $tm \in 1, 2, \ldots, T_m$. The dimensions of D^n were $I =$ 11,477 rows by $T_m = 12$ columns.

2.2 Coastal segments

Space is treated explicitly in two ways in the mark-recapture model; both rely on conceiving of the NRU coast as a linear feature. The first use of space was in constructing a nesting kernel for each female, from nest locations. The second spatial process was nest detection probability, which was applied at the level of the *coastal segment*.

We defined coastal segments by locating breaks in beach features that did not split logical beach units such as barrier islands, or jurisdictions of monitoring organizations. Coastal segments could contain several discrete beaches. Estuaries and inlets provided good natural boundaries (Table 2.1).

Table 2.1: Coastal segments used in the loggerhead sea turtle integrated population model. Geographic features represent the northern end of each segment; the southern end of segment 1 is the St. Mary's River (the border between Florida and Georgia). The sum of the total beach lengths of the segments is 1,065.5 km.

Number	Northern boundary	State	Total beach length (km)
1	St. Andrew Sound	GA	33.9
2	St. Simon's Sound	GA	15.0
3	Altamaha Sound	GA	24.6
4	Sapelo Sound	GA	31.0
5	St. Catherine's Sound	GA	16.6
6	Ossabaw Sound	GA	16.8
7	Wassaw Sound	GA	14.5
8	Savannah River	GA	11.9
9	Port Royal Sound	SC	29.3
10	St. Helena Sound	SC	45.0
11	North Edisto River	SC	32.0
12	Stono Inlet	SC	19.0
13	Charleston Harbor	SC	27.4
14	Dewees Inlet	SC	15.6
15	Bulls Bay	SC	15.4
16	Key Inlet	SC	5.2
17	Romaine River	SC	20.0
18	South Santee Inlet	SC	7.3
19	Winyah Bay	SC	11.3
20	North Inlet	SC	12.6
21	Pawley's Inlet	SC	7.2
22	Midway Inlet	SC	2.4
23	Murrells Inlet	SC	11.0
24	Little River Inlet	SC	57.5
25	Tubbs Inlet	NC	7.2
26	Shallotte Inlet	NC	22.7
27	Lockwoods Folly Inlet	NC	14.4
28	Cape Fear River	NC	23.1

Continued next page...

Table 2.1: **Coastal segments** continued.

Number	Northern boundary	State	Total beach length (km)
29	Carolina Beach Inlet	NC	34.3
30	Masonboro Inlet	NC	6.5
31	Mason Inlet	NC	7.7
32	Rich Inlet	NC	7.6
33	Howard's Channel	NC	5.9
34	New River Inlet	NC	41.8
35	Brown's Inlet	NC	12.3
36	Bear Inlet	NC	5.8
37	Bogue's Inlet	NC	5.6
38	Beaufort Inlet	NC	43.1
39	Ocracoke Inlet	NC	90.0
40	Oregon Inlet	NC	124.9
41	Rappahannock River	NC,VA	130.1

Coastal segments were defined as straight line segments connecting the boundary points; nests were then projected perpendicularly onto the nearest segment. We then treated the entire coast as a continuous linear feature of unit length, as though the coastal segments had been 'straightened' out, like a surveyor's chain.

2.3 Segment-level detection probability

Nest searching effort has not been constant through space or time on NRU beaches. Each segment $s \in \{1, 2, \ldots, S = 41\}$ had an associated, time-varying nest detection probability, $p^d_{s,ts}$, with $ts \in \{1, 2, \ldots, T_s = 23\}$ indexing the years of the nest survey data.

Nest searching effort data was available for all beach-year combinations in the nest survey data: effort has generally increased within segments during the period of nest monitoring (1997–2019), as has the number of segments receiving effort. Effort $f_{s,ts} \in [0, 1]$ was calculated as the ratio of km·days over which nest searching was conducted, to the total possible beach km·days during the breeding season. We used a restrictive model to relate detection probability to effort, to reflect field observations that nest detection probability should rise approximately linearly with effort, with slope near 1:

$$p^d_{s,ts} = p^{min}_s + (p^{\max} - p^{min}_s) \times \text{cdf}_\beta(f_{s,ts}, a^d, 1/a^d)$$

$$a^d \sim \text{Unif}(0.5, 2)$$

$$p^{\max} \sim \text{Unif}(0.97, 1)$$
$$p_s^{min} \sim \text{Unif}(0, 0.05)$$

where cdf_β is the cumulative distribution function for the beta distribution. The curve's intercept is segment-dependent because some segments are monitored by volunteers who act independent of formal surveys; thus, some segments may have nests registered in the database even though $f_{s,ts} = 0$.

2.4 Nesting kernels

To translate the time-varying detection probabilities associated with coastal segments to individual detection probabilities for females, we used the notion of a nesting kernel. We redefined each nest's location as a proportion, where the value represented the relative distance from the southern end of the coast. Along the linearized coast, the nesting kernel is conceived of as a unimodal beta distribution that is fitted to the vector of observed nest locations for an individual female:

$$x \sim \text{Beta}(a_i^k, b_i^k) \ \forall x \in \mathbf{x}_i$$

We initially used vague Gamma distributions as priors for a_i^k and b_i^k, but found that estimates of individuals' kernels were unreasonably wide (implying that individuals' detection probabilities were unrealistically low; see $p_{i,t}^{avg}$ definition below). We therefore fit unimodal beta distributions to each individual's observed nest locations before fitting the population model, and passed the parameter values a_i^k and b_i^k as constants to the model. An alternative solution would involve the use of an additional level of hierarchy, with hyperparameters used to share information about kernel widths across individuals. We will continue to investigate this approach to kernel estimation.

We thus make a strong assumption about how an individual's nests are distributed: if nests are observed within two non-adjacent segments, our choice of a unimodal beta to describe the nesting kernel implies that the probability of the individual nesting between those two segments is high. However, some segments are known to have lower nesting densities (e.g., segment 24 containing Myrtle Beach), and survey effort is concomitantly lower as well. To provide information to the model regarding these differences in nest density, we produced a constant vector **int** of expected 'nesting intensity' in each segment s (Fig. 2.1). Each int_s was calculated by 1) dividing the observed number of nests d_{ts}^{tot} by the amount of effort $f_{s,ts}$ put toward surveys of the segment in those years; 2) taking the mean value of the result in each segment, over years 2015-2019; and then 3) normalizing the resulting vector by dividing it by the the sum of its elements.

For each individual, we then assessed the amount of probability mass of its kernel corresponding to each coastal segment s, and multiplied that probability by the segment's nesting intensity int_s:

$$k_{i,s} = int_s \times \left[\text{cdf}_\beta(s, a_i^k, b_i^k) - \text{cdf}_\beta(s-1, a_i^k, b_i^k)\right].$$

The resulting values represented the probability the individual will nest in each coastal segment. Notice that all elements of this expression are constants in the model, since the nesting kernels are regarded as fixed.

In a given year t, the ith individual's per nest detection probability is the vector product

$$p_{i,t}^{avg} = k_{i,\cdot} \cdot p_{\cdot,t}^{d}$$

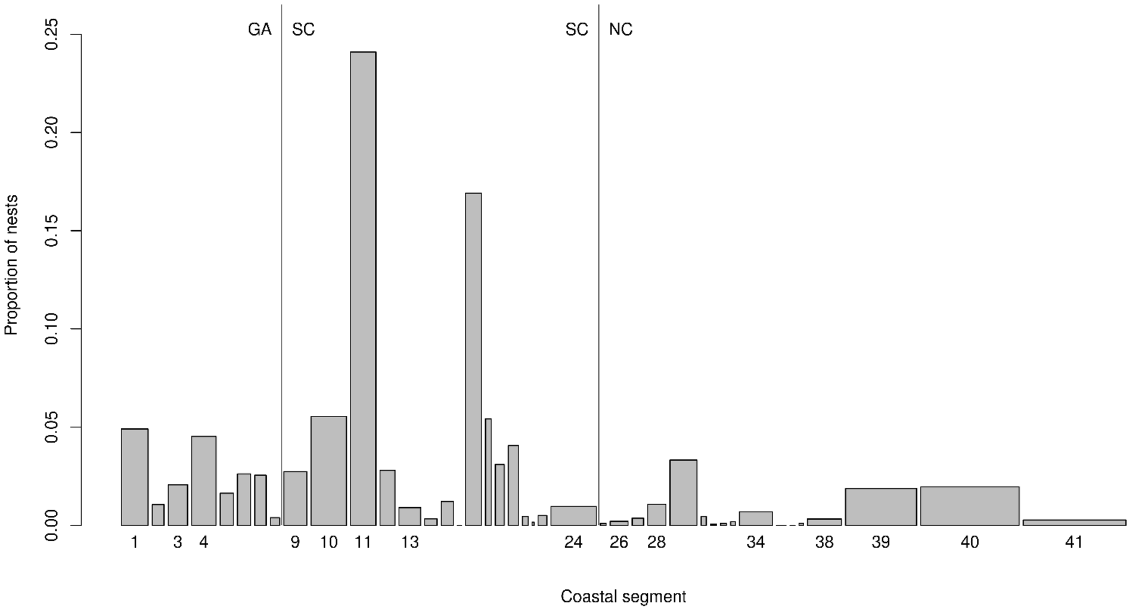

Figure 2.1: Calculated nesting intensity across coastal segments (Table 2.1), in the Northern Recovery Unit; used as data in integrated population model. Bar width is proportional to the amount of beach in the segment. Compare to Fig. 4.1.

where $p^d_{s,t}$ is fixed to 0 if no survey occurred in the segment that year. The number of nests observed for individual i in year t, that is the ith row and tth column of matrix D^n, was modeled as a binomial process:

$$d^n_{i,t} \sim \text{Binom}(p^{avg}_{i,t}, n_{i,t})$$

where n is the true number of nests, which is dependent on the state of the turtle in a given year (see section 2.6).

We thus assume that any coastal segment within the nesting kernel of a turtle will be chosen as a nest site, with probability corresponding to the overlap of the kernel with the segment, times a measure of the observed proportion of NRU nests laid within the segment, which we call nesting intensity.

2.5 Individual states, and transition matrix

Individuals' states were defined by the $I \times T$ matrix Z. Two states were used for initial entry into the breeding population, one for breeding, one for death, and 11 for remigration (Table 2.2).

Table 2.2: Possible individual states in the mark-recapture model.

Number	State
1	Juvenile
2	Non-breeder with unknown history
3	Non-breeder: 12 years since breeding
4	Non-breeder: 11 years since breeding
5	Non-breeder: 10 years since breeding
6	Non-breeder: 9 years since breeding
7	Non-breeder: 8 years since breeding
8	Non-breeder: 7 years since breeding
9	Non-breeder: 6 years since breeding
10	Non-breeder: 5 years since breeding
11	Non-breeder: 4 years since breeding
12	Non-breeder: 3 years since breeding
13	Non-breeder: 2 years since breeding
14	Breeder
15	Dead (absorbing state)

Individuals were initially assigned to one of three states in year $t = 1$:

1. juvenile ($z = 1$),
2. non-breeding adult with unknown history ($z = 2$), or
3. breeding adult ($z = 14$).

Individuals left state 1 to become breeders with probability r, and left state 2 to become breeders with probability v. Breeding females either bred again, died, or were moved into state 13. Breeders survived with probability ϕ_t^{br}.

The 15×15 transition matrix M for year tm of the genetic mark-recapture period is:

$$
M_{tm} = \begin{bmatrix}
1-r & 0 & 0 & 0 & \dots & 0 & 0 & r & 0 \\
0 & 1-v & 0 & 0 & \dots & 0 & 0 & v & 0 \\
0 & 0 & 0 & 0 & \dots & 0 & 0 & \phi^{nb} & 1-\phi^{nb} \\
0 & 0 & \phi^{nb}(1-p^{br}_{t,11}) & 0 & \dots & 0 & 0 & \phi^{nb}p^{br}_{t,11} & 1-\phi^{nb} \\
0 & 0 & 0 & \phi^{nb}(1-p^{br}_{t,10}) & \dots & 0 & 0 & \phi^{nb}p^{br}_{t,10} & 1-\phi^{nb} \\
0 & 0 & 0 & 0 & \dots & 0 & 0 & \phi^{nb}p^{br}_{t,9} & 1-\phi^{nb} \\
0 & 0 & 0 & 0 & \dots & 0 & 0 & \phi^{nb}p^{br}_{t,8} & 1-\phi^{nb} \\
0 & 0 & 0 & 0 & \dots & 0 & 0 & \phi^{nb}p^{br}_{t,7} & 1-\phi^{nb} \\
0 & 0 & 0 & 0 & \dots & 0 & 0 & \phi^{nb}p^{br}_{t,6} & 1-\phi^{nb} \\
0 & 0 & 0 & 0 & \dots & 0 & 0 & \phi^{nb}p^{br}_{t,5} & 1-\phi^{nb} \\
0 & 0 & 0 & 0 & \dots & 0 & 0 & \phi^{nb}p^{br}_{t,4} & 1-\phi^{nb} \\
0 & 0 & 0 & 0 & \dots & 0 & 0 & \phi^{nb}p^{br}_{t,3} & 1-\phi^{nb} \\
0 & 0 & 0 & 0 & \dots & \phi^{nb}(1-p^{br}_{t,2}) & 0 & \phi^{nb}p^{br}_{t,2} & 1-\phi^{nb} \\
0 & 0 & 0 & 0 & \dots & 0 & \phi^{br}_t(1-p^{br}_{t,1}) & \phi^{br}_t p^{br}_{t,1} & 1-\phi^{br}_t \\
0 & 0 & 0 & 0 & \dots & 0 & 0 & 0 & 1
\end{bmatrix}
$$

In the seven-column block elided from the above matrix, indicated by ellipses, all elements are zero except for the lower off-diagonal, which continues the sequence $\phi^{nb}(1 - p^{br}_{t,i})$, $i \in \{11, 10, \dots, 3, 2\}$. Note that the model assumes that adult turtles that have not bred for 12 years (row 3 of matrix) either breed, or die.

The rows of each M_t sum to 1, and the state $z \in \{1, 2, \dots, 15\}$ of each individual i for year $t+1$ is given by:

$$z_{i,t+1} \sim \text{Categorical}(m_{z_{i,t}\cdot}) \tag{2.1}$$

where $m_{z_{i,t}\cdot}$ represents the $z_{i,t}$th row of M_t.

Breeding season survival ϕ^{br}_t applies only to state 14 (the only observable state), to which also applies the first breeding probability value, $p^{br}_{t,1}$. Likewise, non-breeding survival applies to the unobserved states 4–13, to which apply the remainder of the breeding probability values. Using turtle detections only, then, breeding and non-breeding adult survival and the vector of remigration probabilities are confounded, and by itself, the model cannot estimate them without strong priors.

2.6 State-dependent fecundity

Turtles vary in the number of detected nests in a breeding season, and although some of this variation may be to detection probability, we also reasoned that turtles killed during the breeding season would on average have less time to lay nests and fewer clutches. We therefore made clutch frequency state-dependent. Clutch frequency was modeled as a mixture of Poisson distributions, with the parameter used corresponding to an individual's state in year $t+1$. That is, turtles that would be dead in year $t+1$ generated clutches in year t according to a potentially different Poisson distribution than those that would be alive in year $t+1$. The Poisson parameter for surviving turtles, λ^{live} was constructed according to:

$$\lambda^{live} \sim \text{Pois}(sh_1^{live}, sh_2^{live})$$

$$sh_1^{live} \sim \text{Unif}(0, 20)$$

$$sh_2^{live} \sim \text{Unif}(0, 20)\,.$$

The parameter for doomed turtles, λ^{die}, was constrained to be $\leq \lambda^{live}$:

$$\pi^{die} \sim \text{Unif}(0, 1)$$

$$\lambda^{die} = \pi^{die} \times \lambda^{live}\,.$$

An indicator of next year's state $w_t^{live} \in \{0, 1\}$ was then used to choose the proper parameter in the generation of clutch frequency n:

$$n_{i,t} \sim \text{Pois}(w_t^{live} \times \lambda^{live} + (1 - w_t^{live}) \times \lambda^{die})\,.$$

3 Matrix projection model

We used a projection model to control the stage-specific abundances within the loggerhead NRU population. This female-only matrix model is conceptually stage-based, with the following distinct life stages (SEFSC, 2009). Hatchlings are defined as hatched turtles less than one year of age; juvenile stages include pelagic, small benthic and large benthic; adults are divided into breeding and non-breeding females (Figure 3.1).

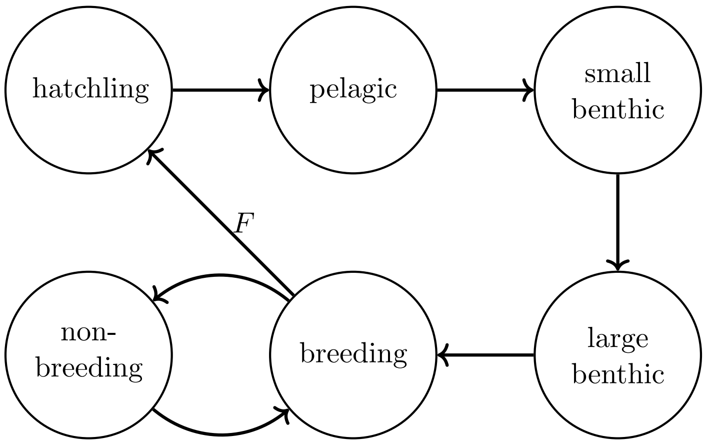

Figure 3.1: General sketch of loggerhead sea turtle life stages used in the population projection model. Per capita fecundity F determines the number of hatchlings.

To allow a better fit to the nest survey time series, life stages were expanded to into age-based sections of the projection matrix for pelagic, small benthic and large benthic juveniles. These age-based sections allow for the propagation of age-specific cohorts through time, a feature that is lacking from a purely stage-based model. For example, years with above-average hatchling production induce a 'pulse' of recruits that is preserved (though dampened) as it moves through life stages over time. The hatchling stage is equivalent to age, since the definition of a hatchling is simply a turtle of age ≤ 1 year.

The section of the matrix corresponding to adult females was divided into subsections for breeding and non-breeding turtles. Although absolute cohort ages are not preserved in the adult stages, the non-breeding section is year-based: cohorts of non-breeding turtles are divided each time step, with portions directed into the breeding stage, dying, or remaining in the non-breeding stage. In the latter case, turtles are moved into the class denoting one additional year spent in the non-breeding stage.

Fecundity rate F is a weighted average of rates F_s, which applies to turtles that will survive the breeding season, and F_d, which applies to those that will die before next year. The weights are simply the breeding survival rate and its complement, respectively.

3.1 Management epochs

Key to the inferential power of the integrated population model is the definition of five management epochs along the time period covered by the model (Table 3.1). The first epoch begins with the first year of the projection model. The second epoch begins in 1970, when organized nest protection efforts began on NRU beaches. Nest protection activity then increased steadily until 1988. The third epoch begins in 1989, when nest protection efforts doubled immediately. The fourth epoch begins in 1991, with the adoption of turtle excluder devices (TEDs) on shrimp trawlers: these TEDs were large enough to exclude small benthic juveniles and the majority of large benthic juveniles. The fifth and final epoch, which continues until the end of the projection period (i.e., until 2066) begins in 2003 with the adoption of TEDs large enough to exclude breeding adults from trawl nets.

Table 3.1: Definition of management epochs, in the matrix projection model, showing which survival parameters were free to change at the onset of each epoch. Survival of hatchlings, pelagic juveniles, and non-breeding adults was assumed to be constant across all epochs. Empty cells indicate that the value was fixed to that used during the previous epoch. *Note that nest survival ramps linearly up from ϕ_1^{nst} to $0.5 \times \phi_2^{nst}$ over Epoch 2.

		Survival Values			
Epoch	Years	Nest	Small Benthic	Large Benthic	Breeding Females
1	start–1969	ϕ_1^{nst}	ϕ_1^{sml}	ϕ_1^{lrg}	ϕ_1^{br}
2	1970–1988	*			
3	1989–1990	ϕ_2^{nst}			
4	1991–2002		ϕ_2^{sml}	ϕ_2^{lrg}	
5	2003–2066				ϕ_2^{br}

The use of these management epochs allows the model to change in specific ways, to match historical events. This adds realism to the model, but also provides important patterns of freedom and constraint in survival parameters, which help the model fit the data time series while maintaining reasonable parameter values.

3.2 Prior distributions for survival parameters

SEFSC (2009) provide candidate distributions of annual survival probability for NRU loggerhead sea turtles, derived from reported studies. We used the distributions given there to establish uniform prior distributions for annual survival of hatchlings and juvenile turtles.

Table 3.2: Prior distributions for survival parameters. Ranges for hatchling and juvenile stages taken from SEFSC (2009).

Stage	Symbol	Distribution	Parameters
Nest	ϕ_1^{nst}, ϕ_2^{nst}	Uniform	0, 1
Hatchling	ϕ^{hat}	Uniform	0, 0.05
Pelagic	ϕ^{pel}	Uniform	0.59, 0.88
Small benthic	ϕ_1^{sml}, ϕ_2^{sml}	Uniform	0.74, 0.89
Large benthic	ϕ_1^{lrg}, ϕ_2^{lrg}	Uniform	0.74, 0.93
Non-breeding adult	ϕ^{nb}	Uniform	0, 1
Breeding adult	ϕ_1^{br}, ϕ_2^{br}	Uniform	0, 1

3.3 Stage duration and remigration model

Proposed ranges of stage duration in years for the three juvenile stages are provided by SEFSC (2009): pelagic (10,18), small benthic (9,12), large benthic (4,12). In order to allow the model to fit closely to the time series of NRU nest counts, we expanded the juvenile stages and the non-breeding adult stage into age-based compartments of the projection matrix.

For the juvenile stages, we used the maximum number of years for the stage given in SEFSC (2009) as the size of the square, age-based compartment. From the beginning of stage *stg* until the minimum stage duration value, turtles progressed to the next year within the stage at the rate $P^{stg} = \phi^{stg}$. On reaching the age of minimum stage duration, turtles were sent to the next stage at a rate of G_a^{stg}, where $a \in \{1, 2, ..A\}$ tracked the number of years eligible to graduate, and persisted in the stage at the rate $P_a^{stg} = \phi^{stg} - G_a^{stg}$. Graduation rate G_a^{stg} was modeled as a beta-binomial process, so that by the maximum allowable age, all turtles would be graduated from the stage.

$$G_a^{stg} = \phi^{stg} \times \text{cdf}_B(a, p_G^{stg}, A)$$

where cdf_B is the cumulative distribution function for the binomial, and

$$p_G^{stg} \sim \text{Beta}(sh_1^{stg}, sh_2^{stg})\,.$$

with sh_1^{stg}, sh_2^{stg} given vague Gamma priors. For large benthic turtles, the subsequent stage was breeding adult (rather than non-breeding).

The adult portion of the projection matrix resembled closely the transpose of the state transition matrix. After breeding, females left the breeding stage with probability $\phi^{br}(1-p_1^{br})$, or bred again at the rate $\phi^{br}p_1^{br}$. Continued persistence in the non-breeding stage carried turtles 'backward' through the non-breeding compartment of the matrix, until they were forced to breed or die at the end of the sequence of p^{br} values.

Breeding probability was modeled as a beta-binomial, similar to the juvenile stages, but with one additional feature. The observed sequence of NRU nest totals oscillates fairly dramatically. To fit modeled nest numbers to these oscillations, we used a random effect of year t to alter the

p^{br} values. With $J = 11$ the number of years in the mark-recapture dataset minus 1:

$$p^{br}_{j,t} = \text{cdf}_B(j-1, p^{\alpha}_t, J-1)\ \forall j \in \{1, 2, ...J\}$$

$$p^{\alpha}_t = \text{logit}^{-1}(\text{logit}(p^{br}_p) \times \alpha_t)$$

$$p^{br}_p \sim \text{Beta}(sh^{br}_1, sh^{br}_2)\,.$$

$$\alpha_t \sim \text{Norm}(0, \sigma)$$

sh^{br}_1, sh^{br}_2 vague Gammas and $\sigma \sim \text{Unif}(0, 10)$.

Thus the average condition of p_{br} is represented by p^{br}_p, since this implies that $\alpha_t = 0$.

Given the age-based compartments within it, the projection matrix was therefore large (54×54), and the abundance vector correspondingly long. However, this proved necessary to fit the model to the highly variable series of nest counts.

3.4 Fecundity

The fecundity rate, as is typical in matrix projection models, appears in the top right corner of the projection matrix. Reflecting the use of a mixture of Poisson distributions to model clutch frequency in the mark-recapture model, fecundity in the projection model makes use of a weighted average of expected clutch frequencies for turtles surviving to year $t + 1$ and those dying in the current breeding season.

$$F_t = (\phi^{br}_t \times \lambda^{live} + (1 - \phi^{br}_t) \times \lambda^{die}) * \phi^{nst}_t \times C/2 \times p^{em}$$

where C is the mean clutch frequency, divided by 2 to enforce an equal sex ratio among hatchlings, and p^{em} is the estimated emergence success of hatchlings. C is estimated using a negative binomial model fit to the observed clutch sizes in the mark-recapture dataset; p^{em} is derived from a zero-inflated Binomial model that also employs ϕ^{nst}, and is fit to the emergence information in the mark-recapture data.

4 Integrated model

Some parameters, including those for adult survival, breeding probability, clutch frequency, emergence success and nest survival, appear directly in both the mark-recapture and projection model. Several other features are used to link the two model components, in addition.

To make use of the nest count time series in conjunction with the projection model, we needed to model detection probability at the level of the NRU population. To get an overall detection probability p_t^{Avg} for the NRU each year, we found the weighted average of the coastal segments' detection probabilities, with the weights coming from a normalized sum k^{Tot} of all turtles' nesting kernels (a constant vector, since individuals' kernels were fixed in this version of the model):

$$p_t^{Avg} = k^{Tot} \cdot p_{.,t}^{d}\,.$$

Then, total nest counts d_{ts}^{tot} were modeled as:

$$d_{ts}^{tot} \sim \text{Binom}(p_{t(ts)}^{Avg}, n_{t(ts)}^{tot})$$

where the subscript $t(ts)$ indicates the elements in the projection times series t that correspond to the survey times series ts. The value n_t^{tot} was derived directly from the abundance vector $\mathbf{a}_t$:

$$n_t^{tot} = \text{round}(a_{54,t} * ((1-\phi_t^{br})\lambda^{die} + \phi_t^{br}\lambda^{live})$$

where element 54 of $\mathbf{a}_t$ holds the breeding female abundance.

As mentioned in section 2.4, individuals' nesting kernels were fixed in the mark-recapture component and entered the model as data. Because the individuals considered in each data shard differed, the normalized sum of their kernels k^{Tot} also differed among shards (Fig. 4.1).

4.1 Model fitting

We fit the model using JAGS (Plummer, 2017) called from R (R Core Team, 2020); however, the model is large and very time-consuming to update. Even with parallelization, running the model took too long for it to be of much use. We therefore used a method to split the data and re-join the parameter estimates known as Consensus MCMC (Scott et al., 2016). We split the mark-recapture data into ten 'shards' according to individuals, ran the same model on each set, then took weighted averages of the parameter values across the MCMC chains, with weights equal to 1/variance of the estimate. Using a burn-in of 5,000 iterations and 5,000 sample iterations, the time to complete a run using a single chain was approximately 20 hours. Results from the consensus MCMC run are reported in section 5.1.

In fact, estimates were largely similar across the shards, and in sections 5.2–5.3 below, estimates are obtained from a single representing 10% of individuals in the dataset. These runs used 3,000 burn-in and 2,000 sampling iterations.

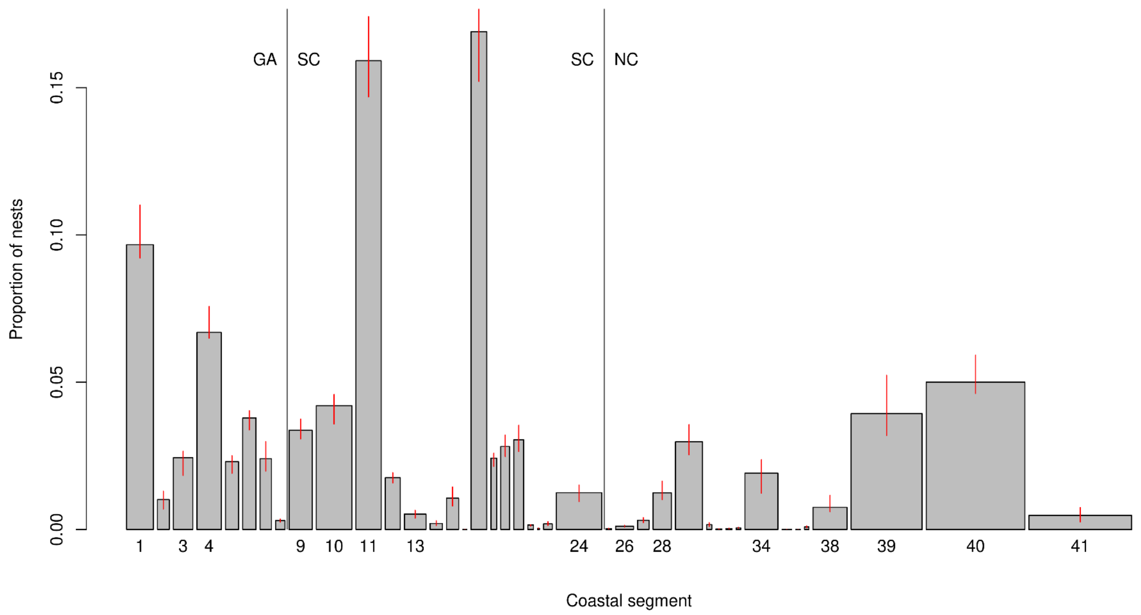

Figure 4.1: Median values of the normalized sum of individuals' nesting kernels, k^{Tot}, across the ten data shards used in the consensus MCMC model fitting procedure. Red bars indicate 2.5th and 97.5th percentiles. Compare to Fig. 2.1

Convergence of some parameters was slow, including those that were partially confounded, such as survival of juvenile stages. However, in examining trace plots, we observed that values of these parameters across MCMC chains was consistently confined to rather narrow ranges. We conclude, therefore, that extended MCMC runs would eventually converge around estimates similar to what we report. Future work will include confirming this proposition.

5 Results and model sensitivity

Although constraints have been placed on parameters and their interrelationships throughout the IPM, we expect estimates of latent parameters such as ϕ^{nb} to be highly dependent upon the values of other parameters, and on the functional forms for segment-level detection probability and probability of breeding in relation to remigration interval.

We therefore first report results from a model version with prior distributions as described above; then, from versions with constraints upon the curve relating segment-level detection probability to search effort. Finally, we demonstrate the use of the IPM as a management tool, by predicting the population-level effects of a future increase in mortality of breeding females.

5.1 Full model

The full, unconstrained model had a long 'burn-in' period of 20 years: the projection period began in 1947. We found this burn-in period to be sufficiently long to allow the projection model to stabilize within first epoch. All parameters that were free to change during the time series did so, and significantly (Table 5.1). Hatchling and pelagic juvenile estimates (> 0.049 and > 0.87) remained very close to the upper limit of their allowed ranges (0.05 and 0.88), indicating they provided constraints on the model behavior. Likewise, large and small benthic survival began, after TED implementation in 1991, to move to hover near the upper limit of their respective ranges. These patterns demonstrate that interpretation of estimates from these unobservable early stages should be done with care; however, the general pattern of increased survival of small and large benthic juveniles following 1991 can be safely interpreted: those changes allow the model to fit the nest count time series.

Breeding survival is predicted to have been quite low before adult TEDs were implemented; whereas in the present era, this value is estimated at $\hat{\phi}_2^{br} = 0.994$ (0.998, 0.999). Non-breeding survival is estimated to be lower, $\hat{\phi}^{nb} = 0.961$ (0.964, 0.966); overall adult survival is between these two values, and depends on the remigration interval. Estimated remigration intervals are in turn dependent upon detection probability (Fig. 5.1) and our assumptions regarding nesting kernels. Interpretation of breeding survival against non-breeding survival therefore requires some care.

Probability of breeding, across the range of years since breeding (Fig. 5.2), reveals an important aspect of the model: in an average year, most non-breeders return to breed before being away four years. However, there is variation among years ($\hat{\sigma} = 0.43$ (0.34, 0.58)), and this variation shifts the breeding probability curve along the x-axis (shifts to the right are more extreme than to the left). Variation due to this random effect can be seen in the future uncertainty in breeding adult abundance (Fig. 5.3), nests (Fig. 5.4), hatchlings (Fig. 5.5), and juveniles (Figs. 5.6–5.8).

Table 5.1: Posterior estimates (point estimate and 95% Bayesian credible interval) from the full integrated population model, fit with consensus MCMC.

Parameter	Symbol	Median (2.5%, 97.5%)
Hatchling survival	ϕ^{hat}	0.050 (0.049, 0.050)
Pelagic juvenile survival	ϕ^{pel}	0.880 (0.879, 0.880)
Small benthic juvenile survival (–1990)	ϕ_1^{sml}	0.751 (0.749, 0.771)
Small benthic juvenile survival (1991–)	ϕ_2^{sml}	0.889 (0.889, 0.890)
Large benthic juvenile survival (–1990)	ϕ_1^{lrg}	0.923 (0.918, 0.926)
Large benthic juvenile survival (1991–)	ϕ_2^{lrg}	0.928 (0.928, 0.929)
Breeding adult survival (–2002)	ϕ_1^{br}	0.851 (0.867, 0.869)
Breeding adult survival (2003–)	ϕ_2^{br}	0.994 (0.998, 0.999)
Non-breeding adult survival	ϕ^{nb}	0.961 (0.964, 0.966)
Expected clutch frequency of surviving breeders	λ^{live}	2.82 (2.78, 2.86)
Expected clutch frequency of dying breeders	λ^{die}	2.61 (2.14, 2.84)

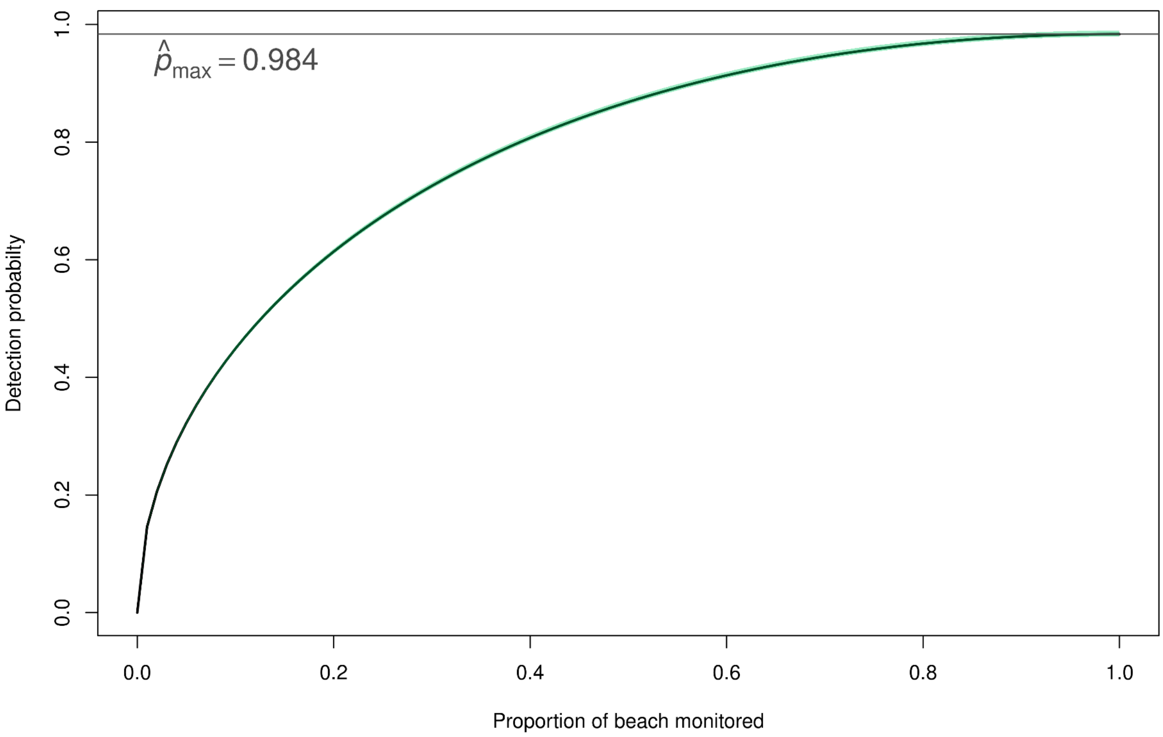

Figure 5.1: Relationship of coastal segment detection probability to nest survey effort, in the full integrated population model, for a segment in which no turtles are found when survey effort is zero. Note that segments were free to have non-zero y-intercepts (see section 2.3.)

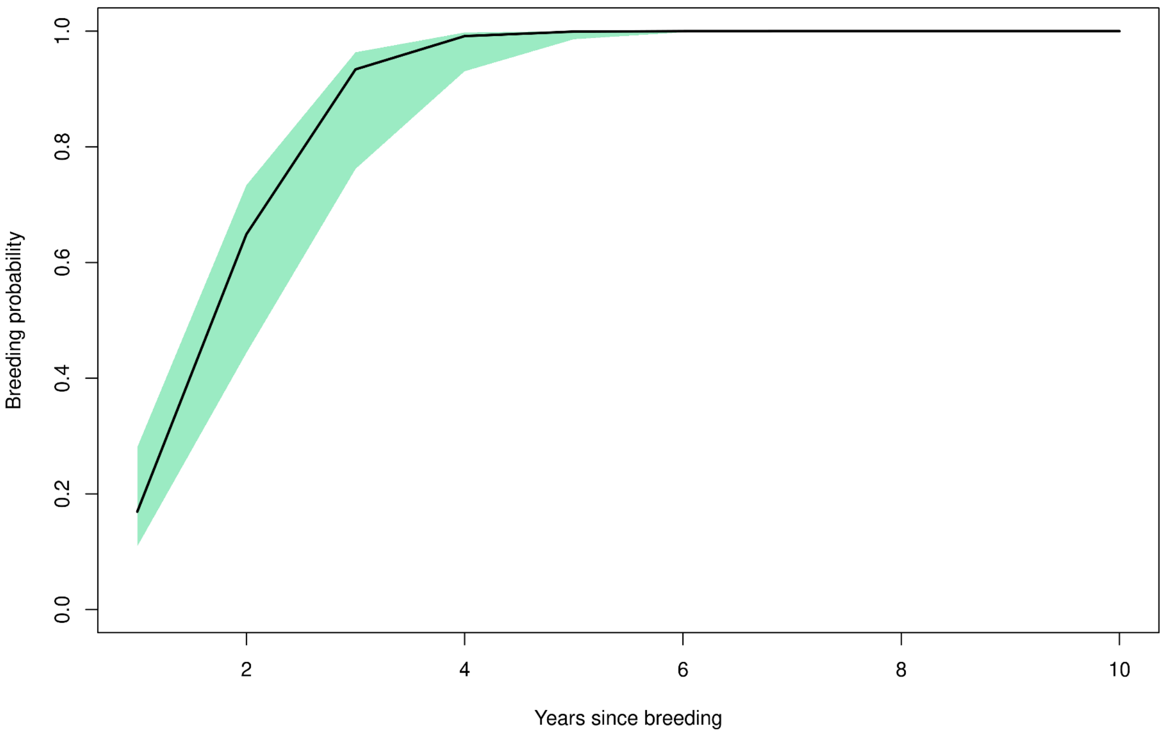

Figure 5.2: Predicted average relationship of probability of breeding, to years since breeding, for loggerhead sea turtles in the Northern Recovery Unit.

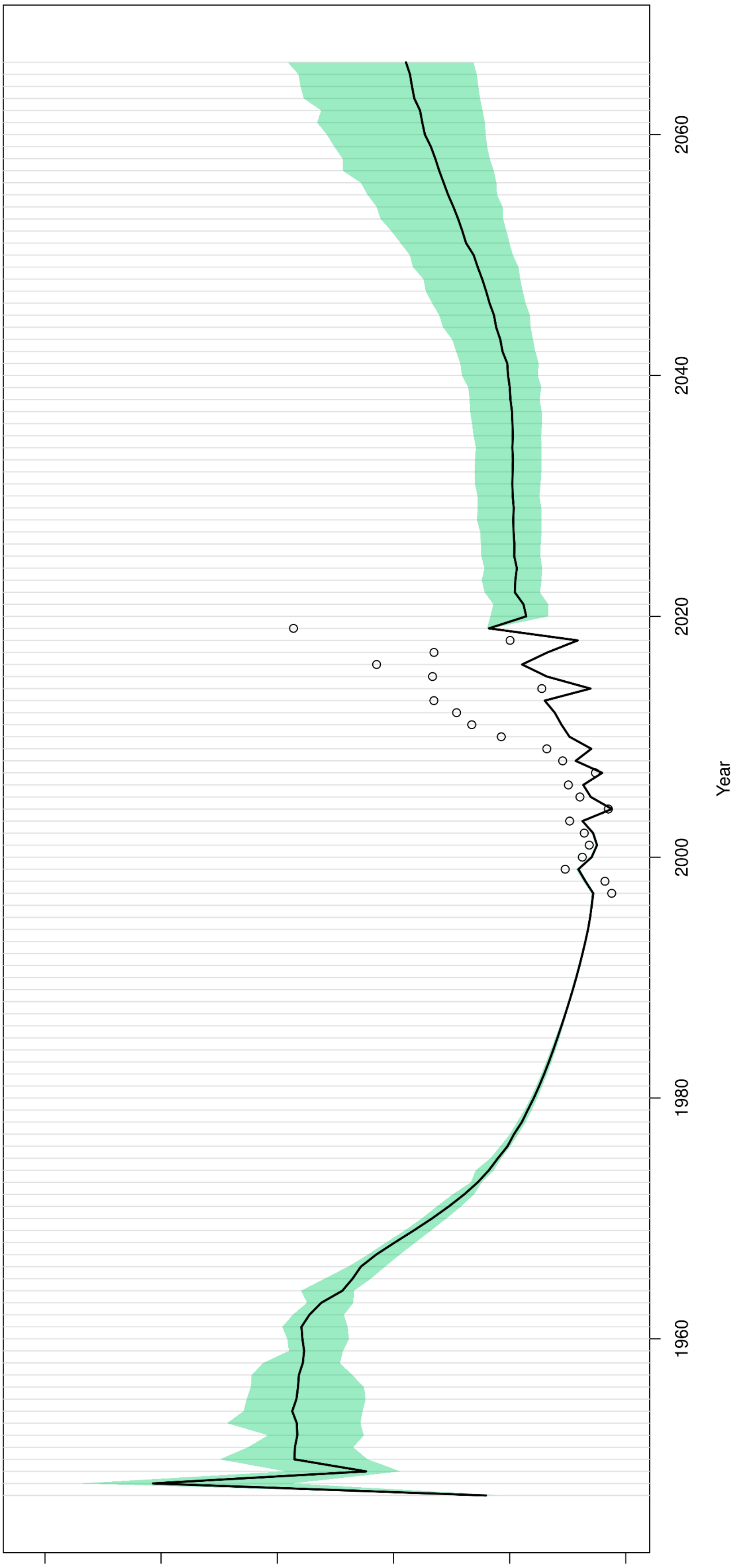

Figure 5.3: Predicted abundance of breeding adult female loggerhead sea turtles in the Northern Recovery Unit. Open circles show the raw NRU nest counts.

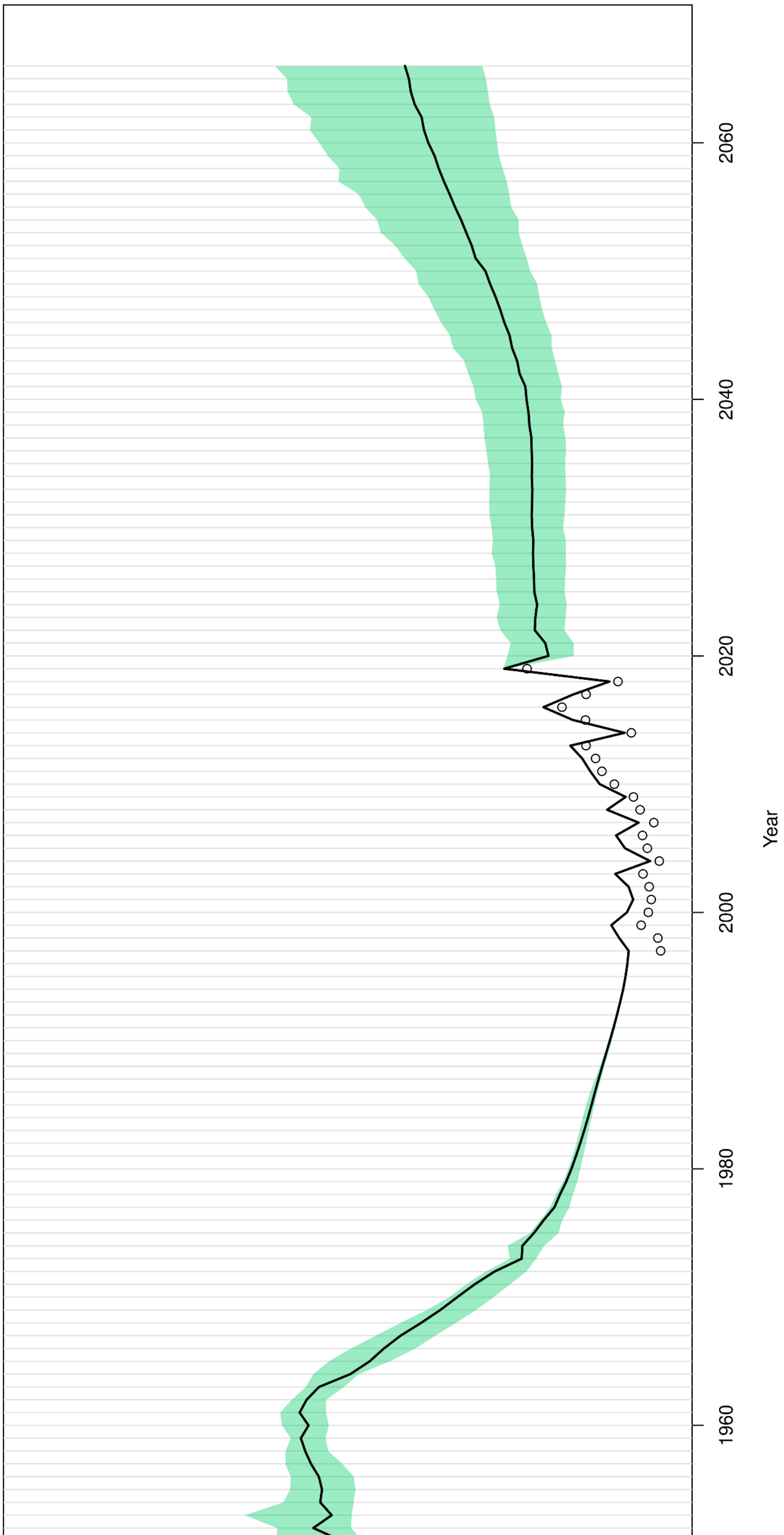

Figure 5.4: Predicted number of loggerhead sea turtle nests in the Northern Recovery Unit. Open circles show the raw NRU nest counts.

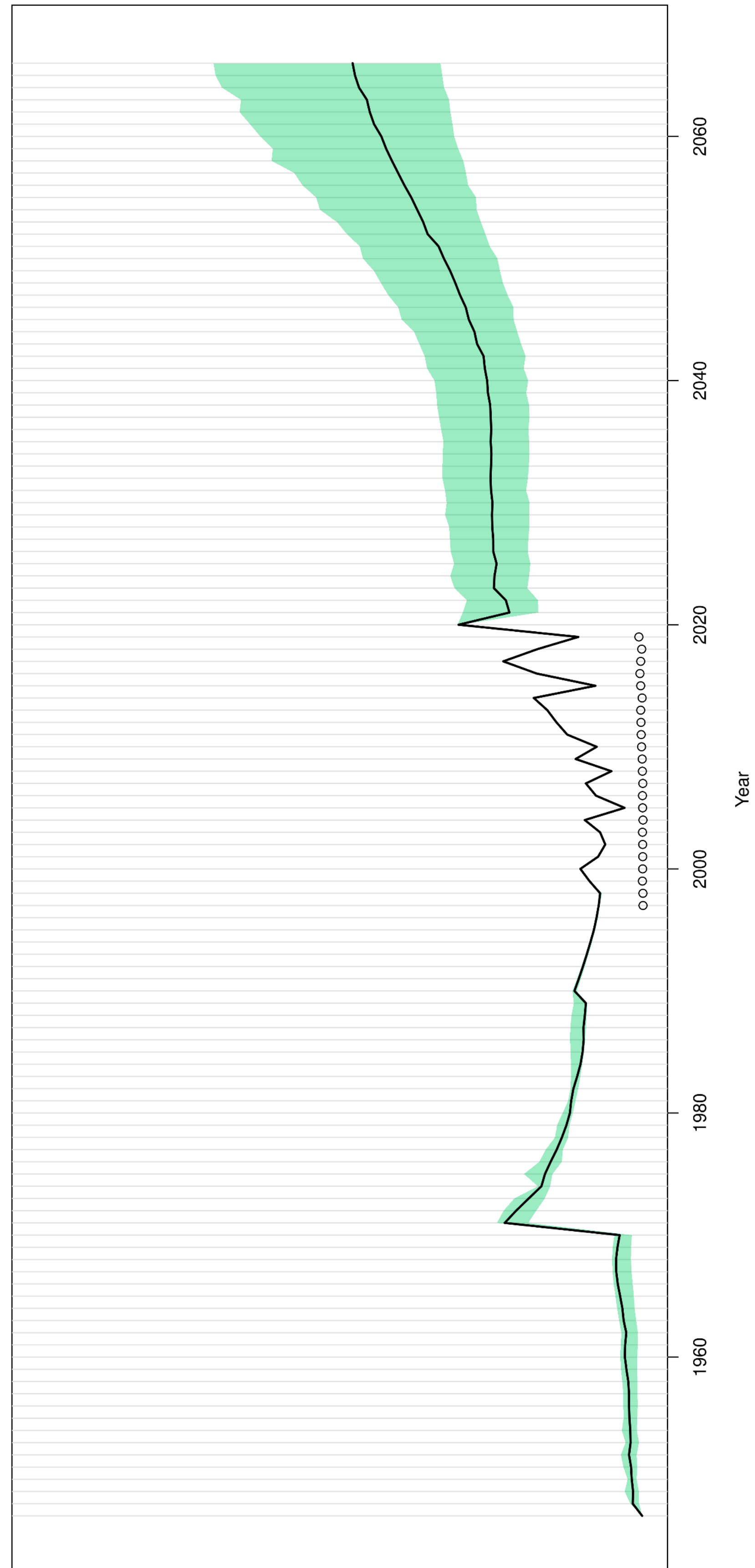

Figure 5.5: Predicted number of female hatchling loggerhead sea turtles in the Northern Recovery Unit. Open circles show the raw NRU nest counts.

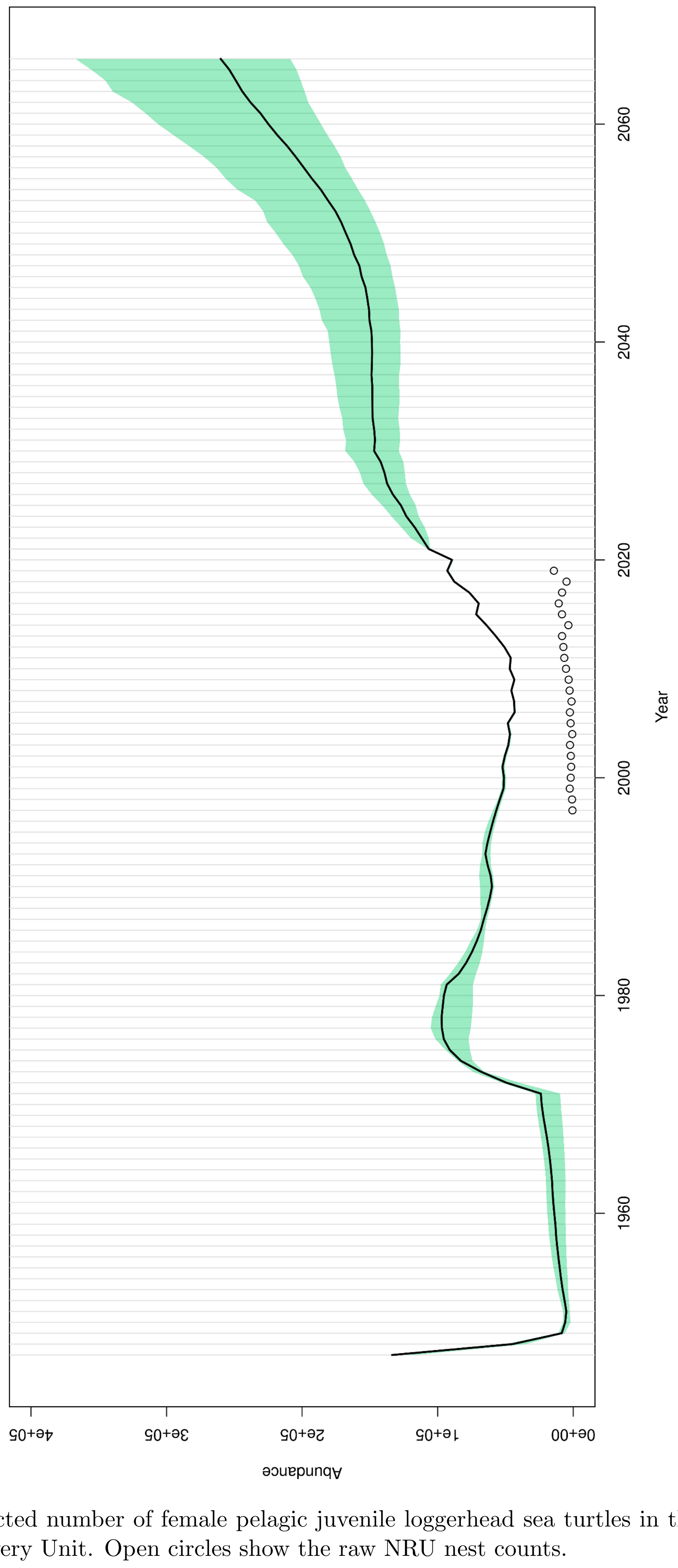

Figure 5.6: Predicted number of female pelagic juvenile loggerhead sea turtles in the Northern Recovery Unit. Open circles show the raw NRU nest counts.

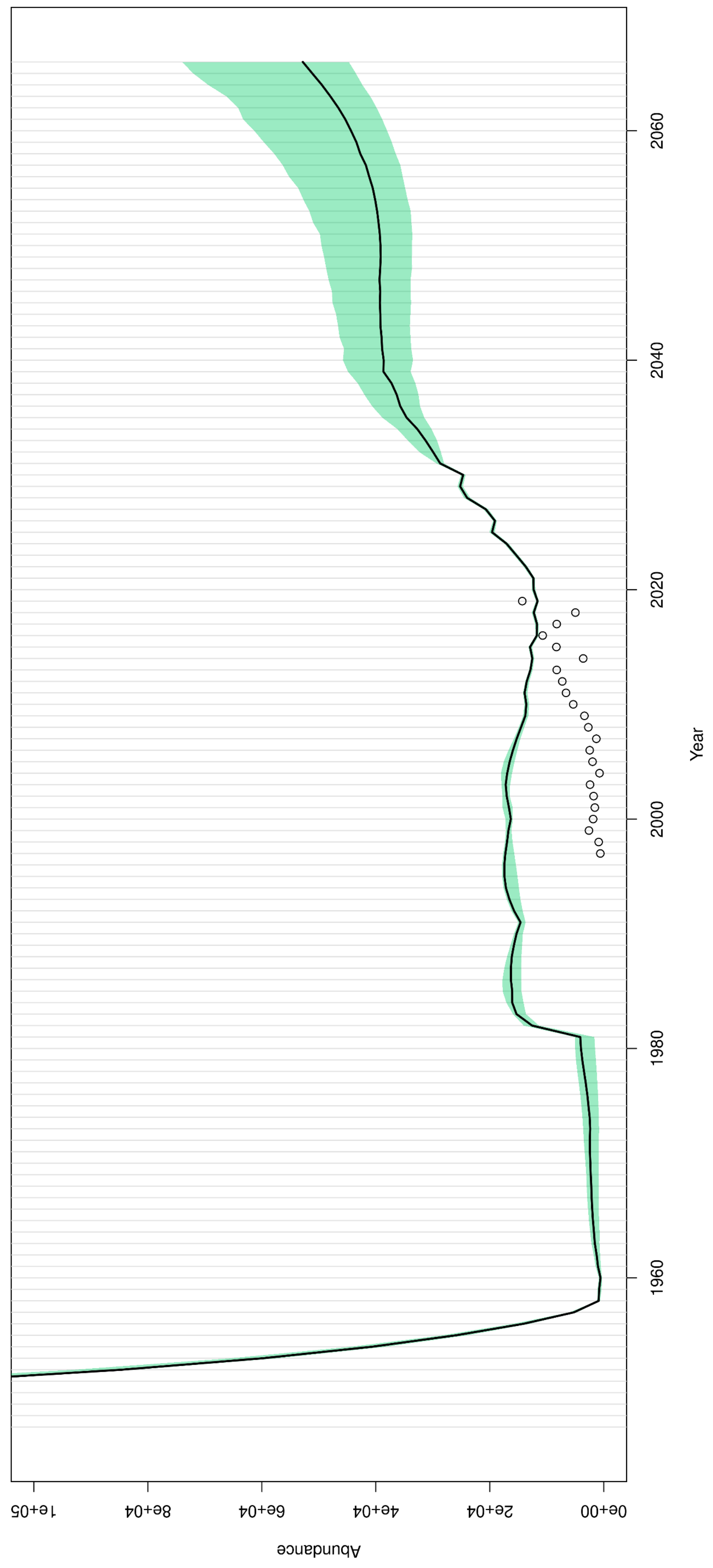

Figure 5.7: Predicted abundance of female small benthic loggerhead sea turtles in the Northern Recovery Unit. Open circles show the raw NRU nest counts.

Adult female abundance showed a distinct oscillation in the time series (Fig. 5.9), a pattern that is predicted to continue. These oscillations are clear in the the other life stages as well, and show that the population, despite improved adult survival in recent years, will have periods of vulnerability in which recruitment to the adult stage is low, and that these periods may themselves last decades.

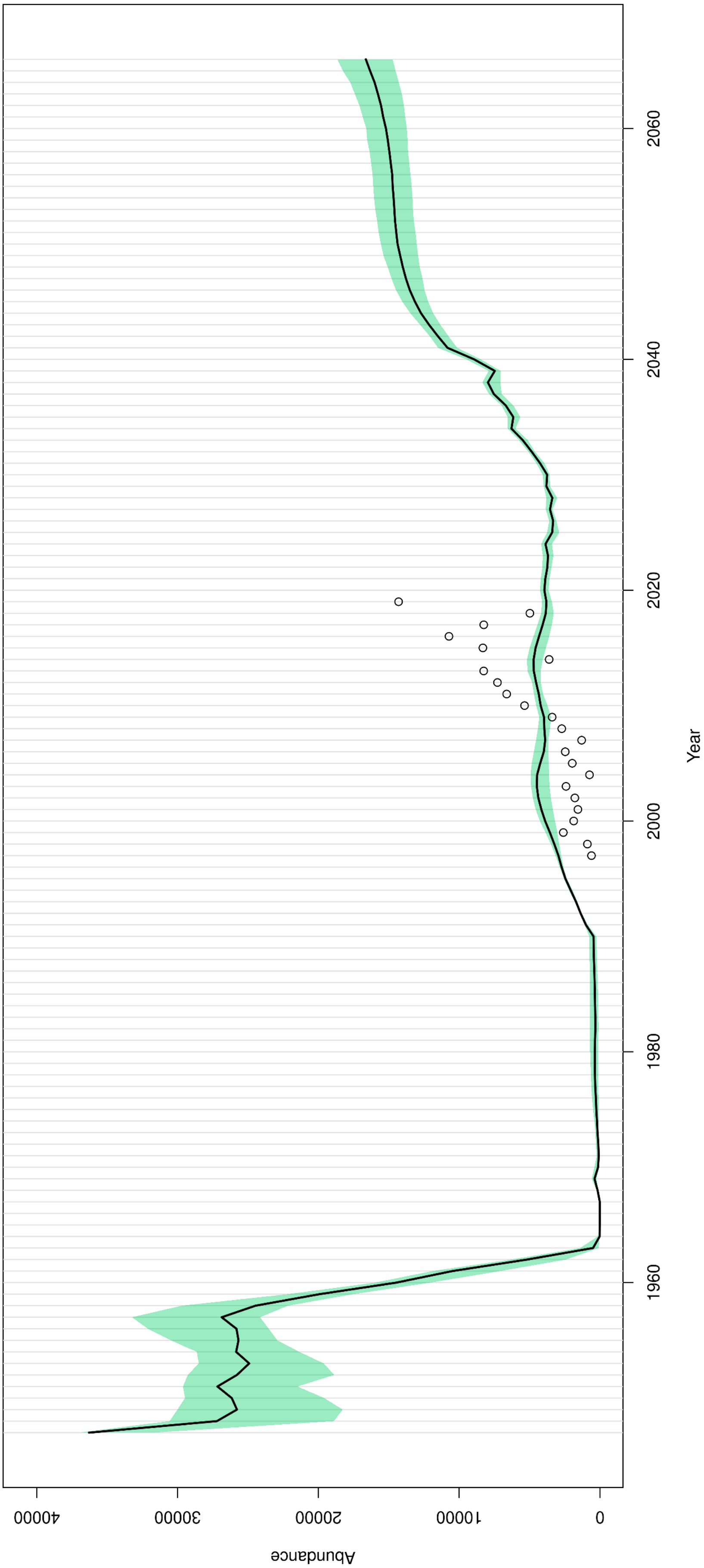

Figure 5.8: Predicted abundance of female large benthic loggerhead sea turtles in the Northern Recovery Unit. Open circles show the raw NRU nest counts.

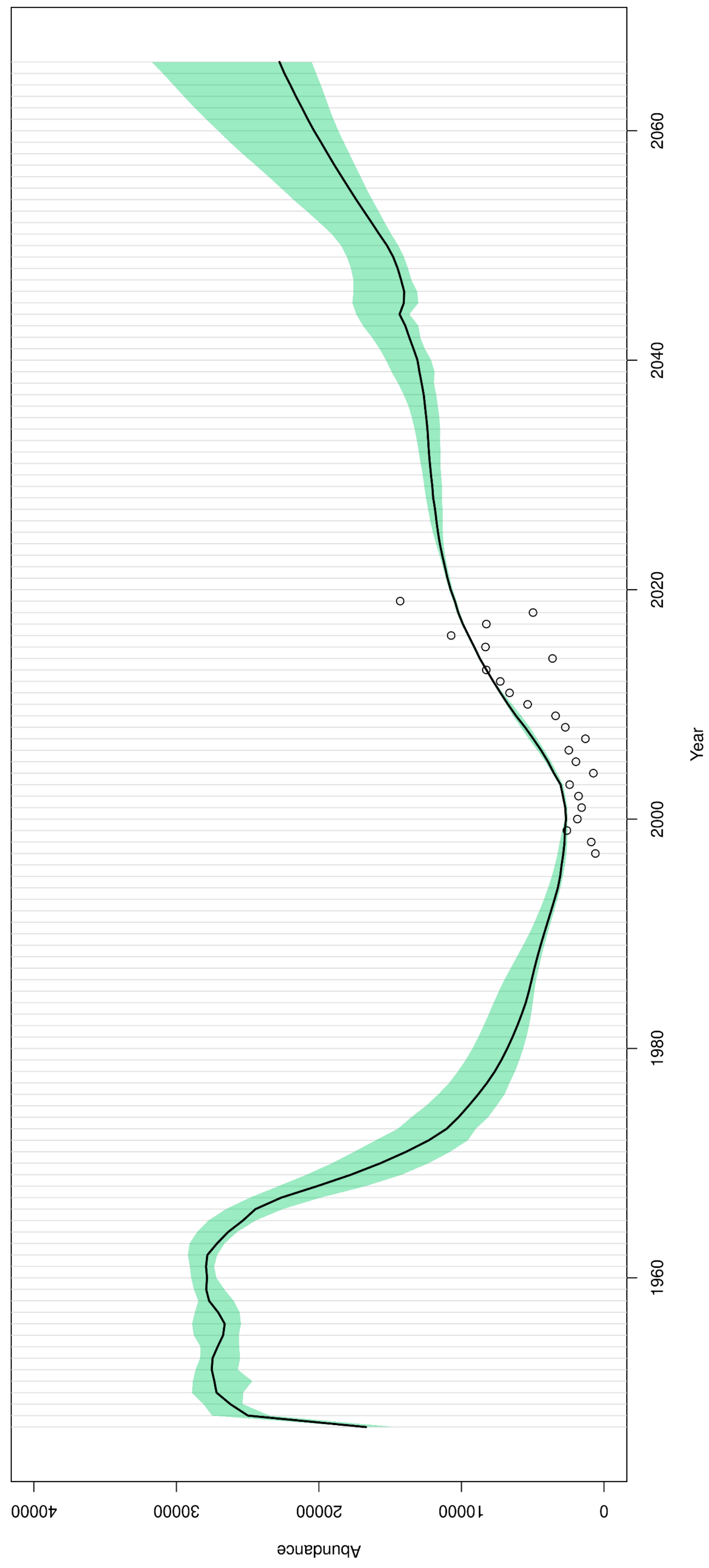

Figure 5.9: Predicted abundance of adult female loggerhead sea turtles in the Northern Recovery Unit. Open circles show the raw NRU nest counts.

5.2 Models with constrained detection curves

Detection is influential in many models such as ours that feature a state-space organization. We assessed estimates from three model versions (*HiDet*, *1to1*, *LoDet*), which differed only in the constraint placed upon the curve relating segment-level detection probability to nest survey effort (Figs. 5.10–5.12).

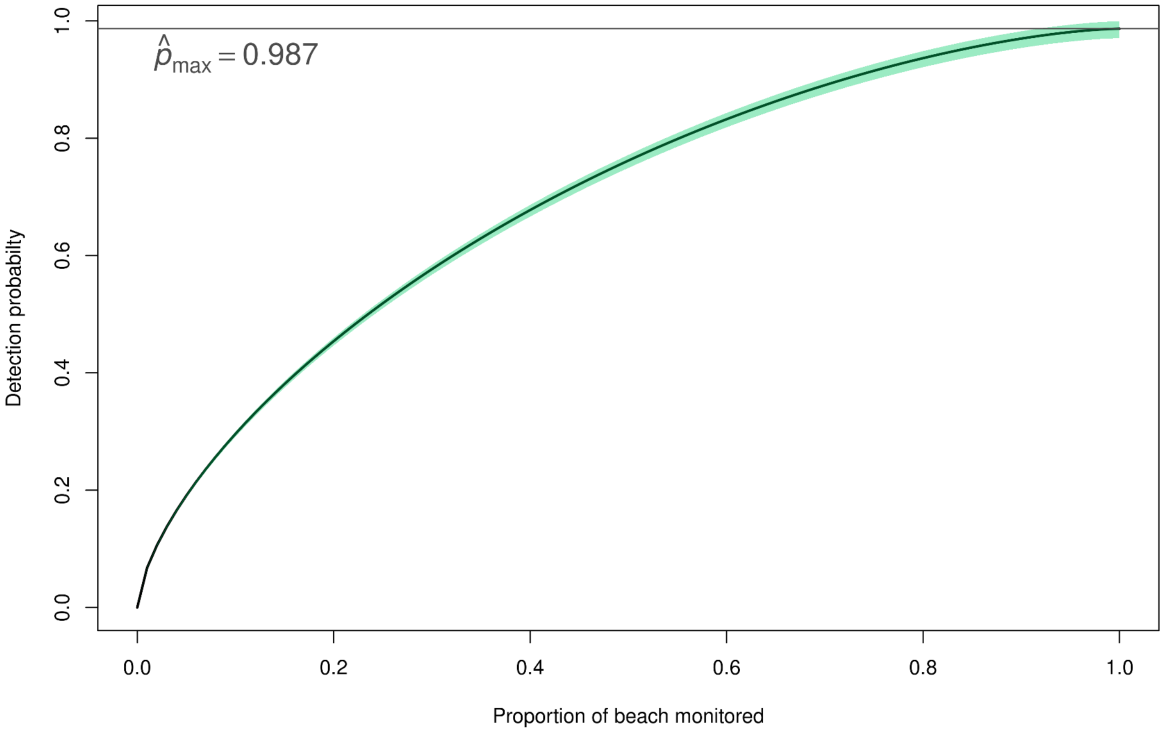

Figure 5.10: Relationship of coastal segment detection probability to nest survey effort, in the constrained model *HiDet*. Compare to the detection curve from the full IPM (Fig. 5.1.

Constraining the detection probability curve did alter estimates of important life history parameters (Table 5.2). Some estimates were considerably different. Expected clutch size, for instance, was lower when detection probability was constrained high, and the difference between λ^{live} and λ^{die} was small. In contrast, when detection was assumed to be lower, expected clutch size for surviving breeders λ^{live} was much higher, and λ^{die} lower and less precise.

The difference emphasizes how important an assessment of detection probability could be, in making inference and predictions about the NRU population. It may be that information already exists, that could aid in modeling the detection process; but some small additional effort during surveys to assess detection probability (e.g., some sort of double observer design) might provide considerable benefit to population modeling efforts.

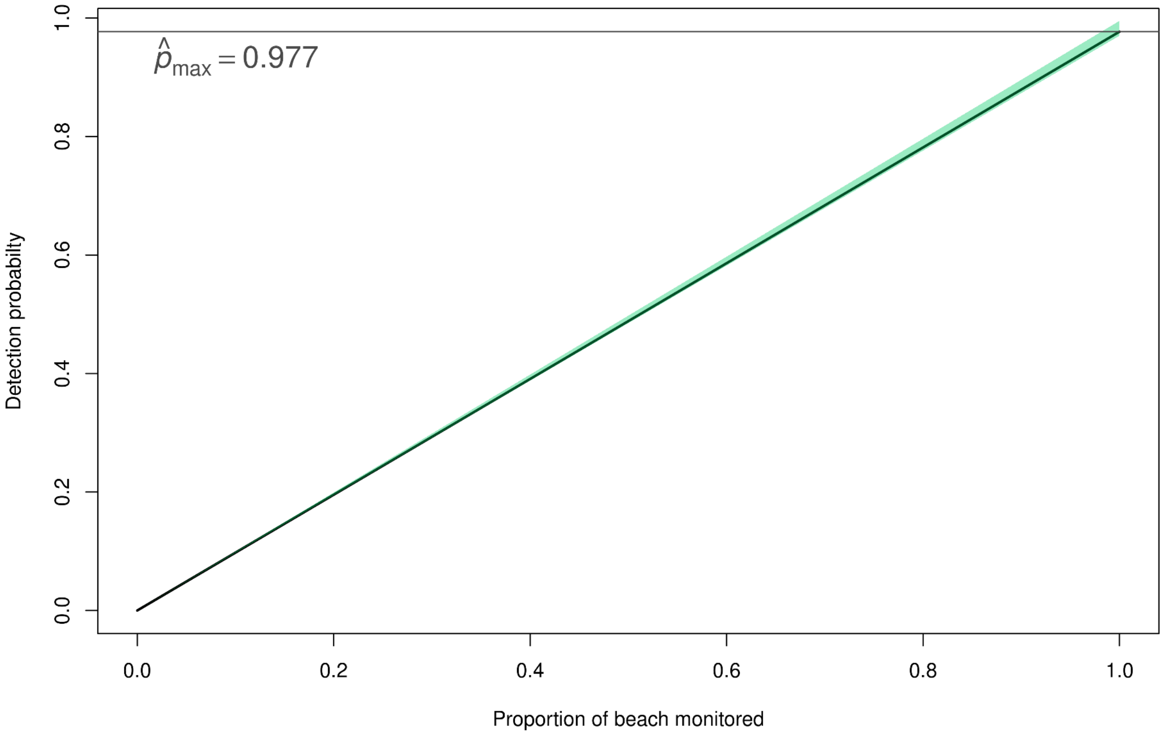

Figure 5.11: Relationship of coastal segment detection probability to nest survey effort, in the constrained model *1to1*.

Table 5.2: Posterior estimates (point estimate and 95% Bayesian credible interval) from two constrained models, *HiDet* and *LoDet* (estimates from the *1to1* model were intermediate).

Parameter	Symbol	*HiDet*	*LoDet*
Breeding adult survival (–2002)	ϕ_1^{br}	0.903 (0.897, 0.812)	0.876 (0.847, 0.885)
Breeding adult survival(2003–)	ϕ_2^{br}	0.990 (0.967, 1.00)	0.972 (0.983, 0.992)
Non-breeding adult survival	ϕ^{nb}	0.960 (0.949, 0.966)	0.960 (0.951, 0.992)
Expected clutch frequency of surviving breeders	λ^{live}	2.98 (2.89, 3.07)	3.98 (3.823, 4.097)
Expected clutch frequency of dying breeders	λ^{die}	2.82 (1.76, 3.02)	0.693 (0.016, 3.718)

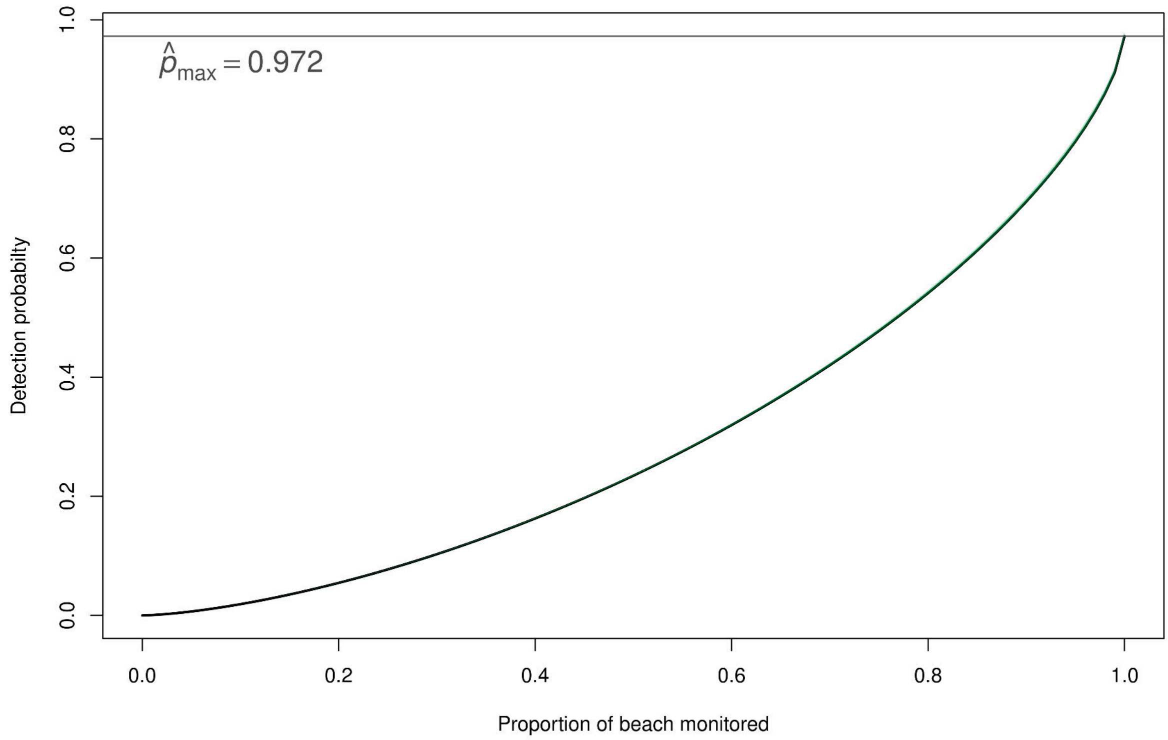

Figure 5.12: Relationship of coastal segment detection probability to nest survey effort, in the constrained model *LoDet*.

5.3 Example of assessment of planned management actions

To demonstrate how our model might be used to assess the consequences of management actions, we fit a model with a simple intervention that began in year 2021. We removed 500 breeding adult females from the population each year. The resulting female abundance trajectory shows a strong dip in the near term, but also a long term change in the trajectory around which the population will oscillate.

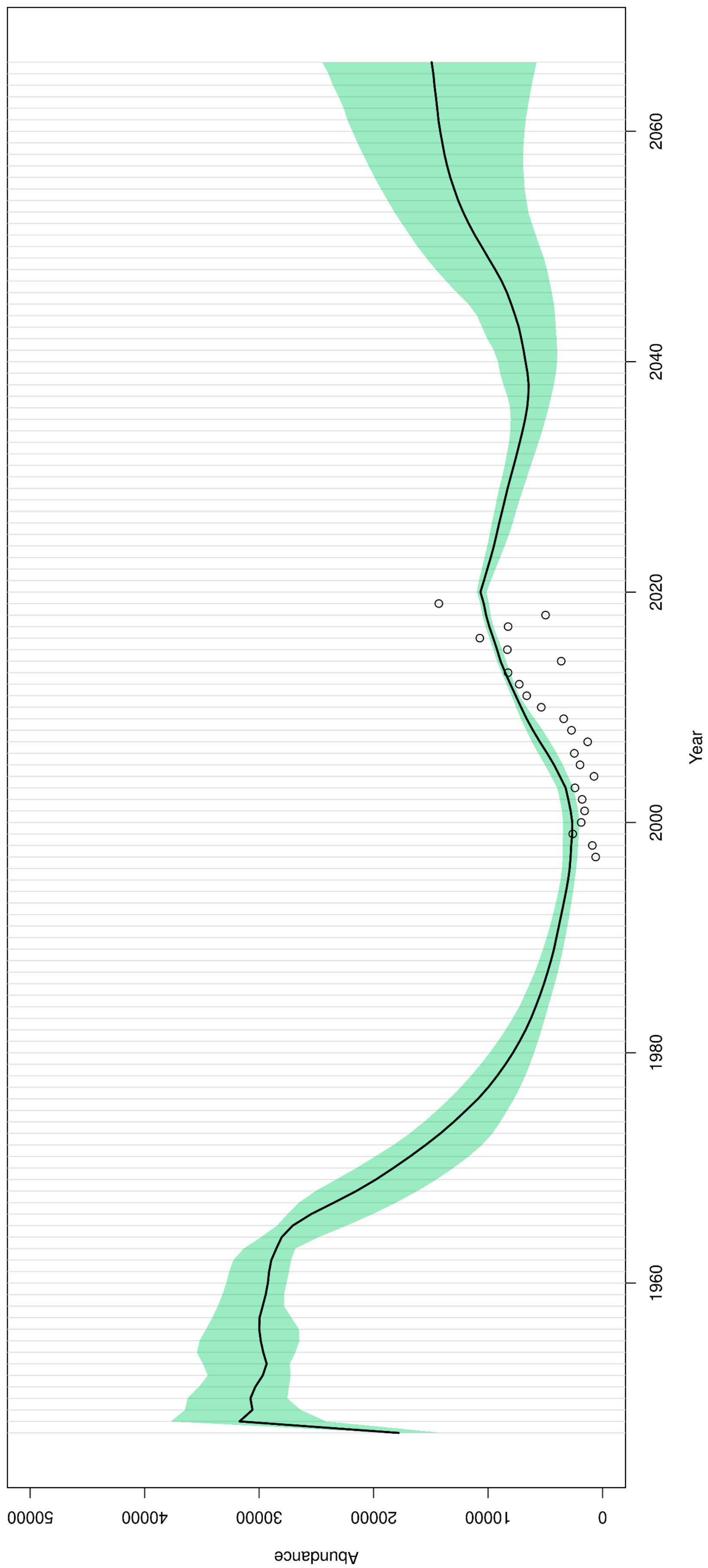

Figure 5.13: Predicted abundance of adult females, under a model that removed 500 adult females annually from the breeding population beginning in 2021. Open circles show the raw NRU nest counts.

6 Interpretation and management implications

Different model versions are in good agreement regarding the general population trajectory through the projection period. Although female abundance has increased since a low point around 2000, current adult abundance is approximately 1/3 to 1/2 the mean abundance in the 1960's.

Examination of the stage-based abundance time series (Figs. 5.4–5.9) reveal the qualitative explanation for the model's parameter estimates and forecast. Low fecundity began to be ameliorated by nest protection efforts in the NRU beginning in 1970. Simultaneously, however, high mortality of breeding females drastically reduced adult abundance and the per capita number of nests laid. The two counteracting influences on hatchling production resulted in a peak in pelagic juveniles, cresting just before 1980 then declining. Implementation of small TEDs in the late 1980's allowed this pulse to remain strong as it moved through the small and large benthic stages. The pulse began recruiting into the adult stage in the early 2000's. Simultaneous implementation of large TEDs boosted breeding season survival, resulting in better retention of females in the population and increased per capita nests laid. The result was the observed increase in NRU nests from 2008 to the present.

Following 2020, recruitment into the adult stage is predicted to decline as the tail end of the hatchling pulse of the late 1970's and early 1980's reaches maturity. In the absence of significant recruitment, adult abundance will decline according to the adult survival rate, which is predicted to be fairly high ($\hat{\phi}^{nb} = 0.961$ (0.964, 0.966)). Then in the 2040's, the next pulse of hatchling production from the 2000's and 2010's will begin to mature into the adult stage. The population will continue to oscillate in this way, with a period corresponding to the maturation interval, around an apparently positive long-term trajectory. The oscillations are predicted to dampen over time, if conditions remain static. Female abundance is projected to reach its 1970's mean by around 2050.

The steep decline of adult abundance throughout the 1980's and 90's brought the population close to extinction; nest protection efforts and the adoption of TEDs appear to have allowed a pulse of recruits to rescue the population, but slowing recruitment for the next two decades will make the population vulnerable once again to adult mortality. The large increase predicted to begin in the 2040's depends on low adult mortality and sustained high hatchling production in the 2020's. Therefore, our model predictions suggest that continuing protection of adults (with TEDs) and nest protection at current levels should be prioritized. Declines in reproductive output and survival may delay recovery or result in future population declines. Our model has great utility in the exploration of the effects of proposed management action, and we will continue to develop it for that purpose.

It is worth noting that the variance across years in breeding probability is estimated to be high, though changes to adult numbers take place over the course of decades. As an indicator of population status, then, nest counts alone would be difficult to interpret. Explaining this variance and better resolving remigration intervals would lead to improved survival and abundance estimates, since remigration, survival and detection probability are so tightly linked. Nest monitoring and genetic mark-recapture efforts should continue at current levels, in order to: 1) assess whether the predicted pattern of nest numbers and breeding females is borne out in the coming years, and 2) better resolve the probability of long remigration intervals.

Adult survival estimates and the remigration probability curve (Fig. 5.2) are interdependent. If adults are capable of delaying breeding in the NRU for 10 or more years, adult survival may be extremely high. However, additional questions would arise as to why turtles' remigration intervals vary so widely. To better resolve both adult survival and remigration patterns, continuing the genetic mark-recapture effort in the NRU should be a priority.

Table 6.1: Total number of segments in which NRU loggerhead turtles appear, in the genetic mark-recapture dataset.

Number of segments	Number of individuals
9	4
8	4
7	33
6	66
5	184
4	476
3	1167
2	2879
1	6666

6.1 Assumptions, caveats and future work

Several important assumptions are worth emphasizing, in interpreting the model results. Perhaps most importantly, we assume that the NRU population is closed, such that turtles hatched in the NRU do not emigrate to other populations either temporarily or permanently: the only way to exit the population is via mortality. Moreover, no turtles enter the the population through immigration, either temporary or permanent. The reasonableness of this closure assumption is unknown, but there are suggestions in the genetic mark-recapture data that suggest it may be violated. For example, of 11,479 individual turtles identified in the NRU during 2008-2019, 1,896 (16.5%) have only been observed once. And the large number of turtles' apparent nesting kernels clustered at the southern edge of the NRU territory implies a potential for exchange of turtles across that boundary (Fig. 4.1).

The only spatially-explicit component of the present model is detection probability, which is related to effort devoted to finding nests and identifying the females to which they belong. If other life history parameters vary spatially, such as breeding or nest survival, accounting for spatial pattern in those parameters could improve both understanding of the population and management decisions.

We did not attempt to group individuals according to the size of their nesting kernels, though this does vary (Table 6.1). If the size of the nesting kernel is related to age, for example, this would have implications for demographic modeling and prediction.

Several simple constraints could be added to the model to bring parameter estimates into closer agreement with general understanding about loggerhead life history and conservation in the NRU. For instance, it may be reasonable to require that adult breeding survival should always be less than or equal to non-breeding survival; and that changes in survival of small and large benthic juveniles from the pre-TED to the post-TED era should be similar (Table 5.1). Adding such constraints, as well as investigating alternative functional forms and distributional assumptions for model components such as individuals' intra-seasonal clutch number and nesting kernel, will be undertaken as we prepare this work for publication.

7 Acknowledgments

We thank Dr. Clinton T. Moore for his assistance and guidance throughout the process of constructing the model, and for helpful comments on the manuscript.

8 References

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Limited Cooperative Agreement Between the

United States Department of Commerce

National Oceanic and Atmospheric Administration

National Marine Fisheries Service and the

Georgia Department of Natural Resources for the

Conservation of Threatened and Endangered Species

This limited cooperative agreement is entered into pursuant to Section 6(c)(1) of the Endangered Species Act of 1973, as amended (hereinafter referred to as "the Act"), and Georgia Endangered Wildlife Act of 1973., O.C.G.A. § 27-3-130 et seq. and the Georgia Game and Fish Code, O.C.G.A. § 27-1-6, as may be amended, between the United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS), and the Georgia Department of Natural Resources (GDNR). Hereinafter, the parties shall be referred to as NMFS and GDNR respectively. All terms contained herein shall be given the same meaning as defined at 50 C.F.R. Section 222.102.

Whereas, the Act authorizes the Secretary of Commerce (hereinafter referred to as "the Secretary") to enter into cooperative agreements in accordance with Section 6 with states that establish and maintain adequate and active programs for the conservation of endangered and threatened species;

Whereas, GDNR is authorized to enter into agreements with federal agencies for the conservation of endangered and threatened species;

Whereas GDNR has the authority to establish a conservation program(s) consistent with the purposes and policies of the Act for species of fish and wildlife, occurring within the state, which have been deemed by the Secretary to be endangered or threatened and under the jurisdiction of NMFS;

Whereas, the purposes of the Act are to provide a means whereby the ecosystems upon which endangered and threatened species depend may be conserved, to provide a program for the conservation of such endangered and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions set forth in subsection 2(a) of the Act;

Whereas, the Secretary has delegated to the Assistant Administrator for Fisheries of NMFS the authority to enter into cooperative agreements with states for the purpose of supporting programs for endangered and threatened species conservation;

Whereas, the Act requires the Secretary to determine, and annually reconfirm, that: (1) the state agency is authorized to establish conservation programs, including the acquisition of land or aquatic habitat, or interests therein, for the conservation of resident endangered or threatened species of fish or wildlife; (2) the state agency is authorized to conduct investigations to determine the status and requirements for survival of resident species of fish and wildlife; (3) the state agency has made provision for public participation in designating resident species of fish and wildlife as endangered or threatened; and (4) the state agency has established and provided copies of acceptable plans, consistent with the purpose and policies of the Act, to give immediate attention to those resident threatened and endangered species that NMFS and the state agency have agreed are most urgently in need of conservation programs;

Whereas GDNR and NMFS share a mutual desire to work in harmony for the common purposes of planning, developing and conducting programs to protect, manage and conserve those resident endangered and threatened fish and wildlife which NMFS and GDNR agree are most urgently in need of conservation programs, and which are listed in Appendix A, as may be amended;

Whereas, NMFS hereby determines that GDNR satisfies the Act’s legal requirements for such cooperative agreements and will annually reconfirm this determination in accordance with the Act;

Whereas, the parties to this agreement are in accord that the programs administered by Georgia are designed to conserve resident endangered and threatened species, and that it is the mutual desire of GDNR and NMFS to cooperate for the common purpose of planning, developing, and conducting programs to protect, manage, and enhance populations of all resident endangered and threatened species covered by this agreement within Georgia;

Whereas, the Assistant Administrator for Fisheries of NMFS has the administrative authority to establish programs for the conservation of endangered and threatened species; to provide periodic review of the state program at no greater than annual intervals; to provide funding for the development of endangered and threatened species conservation programs or to assist in monitoring candidate and recovered species as such funding is available and in accordance with the terms of the

Act; to provide coordination among the programs of various states; and to exchange with states such biological data or other information that may result in the continued conservation of endangered or threatened species;

Whereas, the Assistant Administrator for Fisheries of NMFS authorizes the Southeast Regional Administrator of NMFS to monitor the implementation of this cooperative agreement and update the status of species listed in Appendix A of this agreement;

Therefore the parties agree as follows:

1. Consistent with Section 6(d) of the Act, NMFS may provide financial assistance to GDNR for the development of endangered and threatened species conservation programs or to assist in monitoring candidate and recovered species. Such projects shall be approved by NMFS in accordance with the Act.

2. NMFS and GDNR shall carry out the cooperative program for the conservation of endangered and threatened species, which may involve law enforcement, research, management, and public information and education activities conducted to recover resident endangered and threatened species in Georgia for their aesthetic, ecological, educational, scientific, historical, and recreational value to the Nation and its people.

3. Pursuant to section 6(c)(1)(ii) of the Act, entry into this agreement shall in no way affect the applicability of the prohibitions set forth in or authorized pursuant to section 4(d) and section 9 of the Act with respect to the taking of any resident endangered or threatened species of

fish or wildlife.

4. Effective Date and Renewal

(a) This agreement shall become effective when signed by the Assistant Administrator for Fisheries of NMFS and the Commissioner of GDNR, and may be renewed in the following manner: Not later than June 30 each year GDNR shall submit to the Assistant Administrator for Fisheries of NMFS the following: (1) the current list of the state-listed resident endangered and threatened fish and wildlife within the jurisdiction of NMFS and a description of all changes to such list or the listing process since the date of the previous submission of the list to NMFS; (2) a certification of any amendments in GDNR's legal or regulatory authority that affect the conservation of endangered and threatened fish and wildlife that were made since the date of the previous submission of the program to NMFS; (3) a list of all changes or proposed changes in the endangered and threatened species conservation programs since the date of the previous submission of the program to NMFS; and (4) any additional information requested by the Assistant Administrator for Fisheries of NMFS that pertains to GDNR's program for the conservation of endangered and threatened fish and wildlife;

(b) The Southeast Regional Administrator will, on or before October 1 of each year, notify GDNR in writing whether the cooperative agreement is renewed effective October 1 of that year, or that the state's program or authorities are no longer in compliance with the criteria of Section 6(c) of the Act, and unless appropriate changes are made by June 30 of the following year, this agreement shall be terminated. If GDNR, after satisfying the renewal provisions of the immediately preceding paragraph, has not been notified concerning the renewal of this agreement by October 1 of each year, then the agreement shall continue in force and effect as if it had been renewed.

5. Amendment

This agreement may be amended at any time with the written concurrence of the signatories. With the written consent of the signatories below or their authorized representatives, Appendix A may be amended to accurately reflect the status of resident species under the Act, without need for further modification to this agreement. The Southeast Regional Administrator is an authorized representative of the Assistant Administrator for Fisheries and may consent to amendments to Appendix A, consistent with NMFS's existing policies, during the renewal process described in paragraph 4.

6. Termination

This agreement may be terminated: (a) by mutual agreement; (b) by GDNR upon 60 days written notice to the Assistant Administrator for Fisheries of NMFS; or (c) notwithstanding the renewal provisions in Section 4(b) of this cooperative agreement, by NMFS upon 60 days notice to GDNR from the Assistant Administrator for Fisheries of NMFS, stating reasons why the state's conservation program for endangered and threatened species is no longer in compliance with the criteria in section 6(c) of the Act, or that the state has otherwise violated provisions of this agreement. The GDNR may submit a written request for review to the Secretary within 30 days of the receipt of the termination notice. The Secretary shall consider all evidence submitted by GDNR in its request for review and either reaffirm the termination of this agreement at the end of the 60 day notification period, or reverse the determination of the Assistant Administrator for Fisheries of NMFS and revoke the notice of termination. Any Federal funds that have been awarded pursuant to this agreement to GDNR, but not expended by GDNR, as of the date of termination of this agreement or of final reaffirmation thereof shall be returned to NMFS for reallocation pursuant to section 6(d) of the Act. To the extent permissible by law, this agreement shall be binding upon any successor in interest of the GDNR and shall not be rendered invalid solely because the GDNR is renamed, reorganized, or consolidated.

9/29/20

Chris Oliver
Assistant Administrator for Fisheries
National Marine Fisheries Service

Date

10/1/20

Mark Williams
Commissioner
Georgia Department of Natural Resources

Date

APPENDIX A

Resident Endangered Species

- Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), New York Bight, Chesapeake Bay, Carolina, and South Atlantic Distinct Population Segments
- Shortnose sturgeon (*Acipenser brevirostrum*)
- North Atlantic right whale (*Eubalaena glacialis)*
- Sperm whale (*Physeter macrocephalus*)
- Fin whale (*Balaenoptera physalus*)
- Sei whale (*Balaenoptera borealis*)
- Hawksbill sea turtle (*Eretmochelys imbricata*)
- Leatherback sea turtle (*Dermochelys coriacea*)
- Kemp's ridley sea turtle (*Lebidochelys kempii*)

Resident Threatened Species

- Giant manta ray (*Manta birostris*)
- Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), Gulf of Maine Distinct Population Segment
- Green sea turtle (*Chelonia mydas*), North Atlantic and South Atlantic Distinct Population Segments
- Loggerhead sea turtle (*Caretta caretta*), Northwest Atlantic Ocean Distinct Population Segment

PROJECT NARRATIVE

Applicant:	Georgia Department of Natural Resources Wildlife Resources Division
Granting Agency:	NOAA National Marine Fisheries Service Protected Resources Division Southeast Regional Office
Study Title:	Implement North Atlantic Right Whale Recovery in the Southeastern United States
Funding Opportunity No.:	NMFS-SE-2007-2001134
Federal Funds Available:	$164,000.00
Duration:	1 September 2007 – 31 August 2008
Geographic Location:	Coastal Georgia and Northeast Florida

A. OBJECTIVES

1. Reduce injury or mortality to right whales caused by ship collisions

2. Minimize threats to right whales from interactions with fishing gear

3. Maximize efforts to acquire information from dead right whales

4. Monitor right whale population health, demographics and habitat use

5. Protect habitats essential to the survival of right whales

6. Cooperate with federal, state and private efforts to implement the North Atlantic Right Whale Recovery Plan

7. Participate in right whale education and outreach efforts

B. TASKS

1. Reduce or eliminate injury or mortality to right whales caused by ship collisions

The Georgia Department of Natural Resources Wildlife Resources Division (GDNR) will cooperate with Florida Fish and Wildlife Conservation Commission (FWC), NMFS and New England Aquarium (NEA) to conduct right whale aerial surveys off of Georgia to document right whale locations and habitat use. These efforts will contribute to real-time ship strike reduction efforts and long-term habitat use, temporal and spatial distribution studies.

a. Survey Requirements

The GDNR will coordinate and implement the Northern Early Warning System (NEWS) right whale aerial survey through a contract with Wildlife Trust (WT). GDNR and/or WT staff will fly daily aerial surveys, weather permitting, from Dec. 1 to March 31 in the area extending from northern Sapelo Island, GA to mid-Cumberland Island and from the shoreline out to approximately 60 km from shore along the transect lines bounded by the waypoints listed in Table 1.

Table 1. News Survey Transect Waypoints

	Western Waypoint		Eastern Waypoint	
Line	Latitude	Longitude	Latitude	Longitude
1	31°32'	81°09'	31°32'	80°34'
2	31°29'	81°10'	31°29'	80°34'
3	31°26'	81°13'	31°26'	80°38'
4	31°23'	81°15'	31°23'	80°38'
5	31°20'	81°15'	31°20'	80°40'
6	31°17'	81°16'	31°17'	80°40'
7	31°14'	81°16'	31°14'	80°44'
8	31°11'	81°20'	31°11'	80°44'
9	31°08'	81°20'	31°08'	80°47'
10	31°05'	81°23'	31°05'	80°47'
11	31°02'	81°23'	31°02'	80°47'
12	30°59'	81°22'	30°59'	80°47'
13	30°56'	81°22'	30°56'	80°47'
14	30°53'	81°22'	30°53'	80°47'

NMFS will provide GDNR with a NOAA AOC aircraft and crew for the period of Dec. 1 to March 31. Surveys will be flown in sea state 3 or less for most of the survey area. Sea state 4 conditions may be surveyed in proximity of shipping channels. Surveys will be flown under Visual Flight Rules (VFR) conditions at an altitude of 1000 feet above sea level at an airspeed of approximately 160km/hr. GDNR and WT will conduct NEWS survey flights in coordination with Central and Southern Early Warning System (CEWS, SEWS) right whale surveys conducted by NEA and FWC, respectively. In the event that either or both CEWS and/or SEWS survey teams is unavailable to fly regularly scheduled survey and this fact is made known 24 hours in advance, GDNR and WT will coordinate with the CEWS and/or SEWS survey team leaders to implement a two-plane or one-plane contingency plan. Likewise, if the NEWS survey team is unavailable to fly a regularly scheduled survey, every effort will be made to notify the CEWS and SEWS survey team leaders 24 hours in advance.

In the event that a dead, entangled or injured whale is sighted or reported, the NEWS survey team may proceed to that location, or be directed to such a location by NMFS. Every effort will be made coordinate such effort with NMFS and the CEWS and SEWS survey teams.

At least one NEWS aerial survey team member shall have at least 20 hours of experience in radio telemetry and be familiar with aerial tracking techniques as described in the 1997 Telonics Newsletter addressing fixed wing aircraft tracking.

GDNR and NEWS survey team members will comply with all NOAA AOC and SERO aircraft safety procedures for NOAA or commercial aviation services contractors. All survey team members will attend a preseason Observer Orientation and Training Workshop prior to Dec. 1. Survey team members must also have attended and completed an emergency egress and sea survival training course within the preceding five years. Survey team members will wear Nomex fire retardant flight suits and FAA approved survival vests containing a strobe light, rescue streamer, knife, and Personal Locator Beacon (PLB), to be provided by GDNR.

b. Data Collection

GDNR and WT shall collect the following data during each survey:

i. Survey effort data,
ii. Timed position coordinates, taken in a 30 second interval,
iii. Number and location of right whales,
iv. Digital photographs of individual right whales,
v. Number and type of vessels
vi. Incidents of whale/vessel close calls or harassment,
vii. Incidents of entangled, dead or injured right whales.

Within 30 minutes of a right whale sighting, GDNR and/or WT will: 1) forward the sighting information to the U.S. Navy's Fleet Area Control and Surveillance Facility Jacksonville (FACSFACJAX) and 2) enter sighting information onto the Mandatory Ship Reporting System (MSRS) website. GDNR and/or WT will contact NMFS within 30 minutes in the event that a dead, entangled or injured right whale, or right whale whale/vessel harassment is documented. GDNR and/or WT will provide NMFS with a summary of any documented right whale/vessel or harassment or close approach within 24 hours.

Survey event data will be processed and stored according to protocols established by the North Atlantic Right Whale Database (NARWD) manager. NOAA Fisheries' SE Right Whale Recovery Program Coordinator will provide clarification, when necessary, if NARWD manager directions are confusing. Photo-identification data will be collected, processed and stored according to protocols established by the North Atlantic Right Whale Catalogue (NARWC) manager.

c. Data Submission and Reporting

GDNR and/or WT will submit concise weekly reports to NMFS via email summarizing the preceding week's effort, right and humpback whale sightings, observations of fixed fishing gear/activities, and any special events (e.g. dead whales). GDNR will deliver aerial survey event data and photo-identification data to NMFS, and the NARWD and NARWC database managers, respectively, by April 31. By June 30, GDNR will submit to NMFS a "NEWS Aerial Survey Report" written in standard scientific format and summarizing the results of the NEWS survey. The report will include the following data and analyses:

i. The number of right whales inhabiting the study area during the study period, including age, sex, and reproductive status, and whether the animals were unique to the NEWS area.
ii. The number and identification of right whales documented that were unique to surveys conducted under this contract, including age, sex, and reproductive status,
iii. Temporal and spatial residence patterns and movements,
iv. Sighting distances for all right whales,
v. Number of entangled whales observed, and summaries of incidents
vi. Number of dead whales observed,
vii. Number of near misses and illegal close approaches observed, including incident summaries,
viii. Humpback whale sightings,

ix. Map of effort density distribution,
x. Map of sighting density distribution (SPUE).

2. Minimize threats to right whales from interactions with fishing gear

As an active member of the Atlantic Large Whale Disentanglement Network (ALWDN), GDNR will cooperate with NMFS, Provincetown Center for Coastal Studies (PCCS), FWC and other ALWDN members in responding to reports of entangled right whales. A large whale disentanglement equipment cache will be housed and maintained at GDNR's Brunswick facility. GDNR will make the cache available for right whale disentanglement efforts that occur in Southeast U.S. waters.

Entangled large whales observed during aerial surveys will be recorded and reported immediately to NMFS. Likewise, reports of entangled right whales from other sources will be investigated immediately, weather permitting. Upon verification, GDNR will consult with NMFS and PCCS regarding appropriate course of action. GDNR will be available, to the extent possible, to provide aerial and/or on-the-water support, upon request, during attempts to tag or disentangle entangled right whales.

GDNR will participate on the Atlantic Large Whale Take Reduction Team and advise the Team of potential conflicts between right whales and fisheries. GDNR will remain abreast of fisheries related issues off Georgia that are relevant to right whales.

3. Respond to stranded and injured right whales

GDNR will cooperate with NMFS and other members of the Southeast Marine Mammal Stranding Network to document and investigate reports of dead or injured right whales. All reports or sightings of dead or injured right whales off Georgia will be verified, conditions permitting. Upon verification, GDNR will consult with NMFS immediately regarding appropriate course of action. In the event of a dead floating or stranding right whale, GDNR will provide on-site stranding coordination, which may include carcass recovery, landing, necropsy and disposal. GDNR will also cooperate with and assist FWC and South Carolina DNR staff with recovery and necropsy of right whales in those states when possible. GDNR will update its right whale stranding contingency plan as needed and notify NMFS regarding any significant changes in response capability.

4. Monitor right whale population health, demographics and habitat use

GDNR will attempt to photo-document all right whales observed by air (see B.1) or water, following protocols established by NMFS and NEA. Photo-identification data will be used to monitor calf production, calving interval, etc. NEWS aerial survey team members will photo-document whales in a manner that does not interfere with completion of the NEWS aerial surveys. Demographics data will be summarized in the "NEWS Aerial Survey Report" as described in B.1 above.

GDNR will cooperate with NMFS and FWC to collect biopsy samples from right whale calves and undarted adults and juvenile right whales off of Georgia and Florida. Samples and confirming photographs will be collected according to protocols established by NMFS and NEA. Samples will be processed and submitted according to NMFS protocols.

GDNR will use a NOAA Fisheries-provided rigid hull inflatable boat (RHIB) for biopsy cruises. GDNR will comply with all NOAA and SERO small boat policies related to maintenance and operation of the NOAA Fisheries RHIB.

GDNR will document and investigate any activities or events that have the potential to impact right whale habitat use (e.g. emerging commercial fisheries, oil spills, boater harassment, etc.). GDNR will notify NMFS of such activities and events, and provide NMFS with relevant data in a timely manner.

5. Protect habitats essential to the survival of right whales

GDNR will review state and federal permits and other actions that have the potential to impact right whales and/or the calving area critical habitat. GDNR will provide comments and/or recommendations aimed at minimizing or eliminating impacts to right whales.

6. Cooperate in federal, state and private efforts to implement the North Atlantic Right Whale Recovery Plan

GDNR will cooperate with NMFS, FWC, NGOs, and private organizations to encourage right whale conservation in the Southeastern U.S. GDNR staff will participate on the Southeast Implementation Team (SEIT), assist with outreach activities, attend right whale related meetings (e.g. The North Atlantic Right Whale Consortium annual meeting) and actively participate in other right whale-related policy and management activities.

7. Participate in right whale education and outreach efforts

GDNR will distribute right whale posters, pamphlets, videos and/or other education materials to the public, including shipping industry, marinas, recreational boaters, school groups and others. GDNR will conduct active public outreach when possible (e.g. presentations to school groups, etc.).

C. SUMMARY OF COSTS

Federal	$164,000.00
10% State Match	$16,400.00
Project Total	$180,400.00

D. PERSONNEL

1. Project Coordination and Implementation

Clay George, Wildlife Biologist I
Leigh Youngner, Wildlife Technician II

2. Project Administrative Support

Brad Winn, Program Manager

E. SCHEDULE

Activity	Month S	O	N	D	J	F	M	A	M	J	J	A
B1				X	X	X	X	X				
B2				X	X	X	X	X				
B3				X	X	X	X	X				
B4				X	X	X	X	X				
B5	X	X	X	X	X	X	X	X	X	X	X	X
B6	X	X	X	X	X	X	X	X	X	X	X	X
B7	X	X	X	X	X	X	X	X	X	X	X	X

PROJECT DESCRIPTION

PROJECT TITLE:	Implement North Atlantic Right Whale Recovery Activities in the Southeast U.S.
PROJECT DURATION:	September 1, 2016 – August 31, 2021
APPLICANT:	Georgia Department of Natural Resources, Wildlife Resources Division
PRINCIPAL INVESTIGATOR:	R. Clay George GDNR WRD Nongame Conservation Section 1 Conservation Way, Brunswick, GA 31520 clay.george@dnr.ga.gov Office: 912-262-3336, mobile: 912-269-7587

ESTIMATED COST:

FY	Federal Amount	Match (10%)	Total
2016	$219,467	$24,386	$243,853
2017	$228,284	$25,365	$253,649
2018	$235,957	$26,218	$262,175
2019	$246,988	$27,443	$274,431
2020	$282,442	$31,383	$313,825
Total	$1,213,138	$134,795	$1,347,933

FY16 FFO#: NOAA-NMFS-SE-2016-2004891

PROJECT SUMMARY:

The Georgia Department of Natural Resources (GDNR) Wildlife Resources Division (WRD) proposes to implement North Atlantic right whale recovery efforts in the Southeast U.S. in cooperation with the National Marine Fisheries Service's (NMFS) Southeast Regional Office (SERO), Florida Fish and Wildlife Conservation Commission (FWC) and other partners. In so doing, this project will contribute to numerous North Atlantic Right Whale Recovery Plan objectives, including monitoring the right whale population, reducing human causes of mortality and serious injury, monitoring and protecting right whale habitat, and assisting NMFS with Recovery Plan coordination and implantation efforts. More specifically, GDNR and partners will monitor the SEUS calving habitat and contribute to ongoing population monitoring efforts by conducting right whale aerial surveys, boat surveys, photo-identification, biopsy sampling and other field activities. GDNR and partners will reduce mortality and injury from fishing entanglements and vessel-strikes by conducting education and outreach, entering whale sighting data into the Early Warning System, serving on the Atlantic Large Whale Take Reduction Team and responding to reports of dead, injured and entangled whales. GNDR staff will identify and mitigate negative impacts to right whales and habitat by reviewing permit applications, project proposals and other human activities. Lastly, GDNR staff will help NMFS to implement other Recovery Plan tasks by participating in the Southeast Implementation Team for Right Whale Recovery, North Atlantic Right Whale Consortium and other public and private conservation efforts.

OBJECTIVES:

1) Contribute to ongoing right whale population monitoring efforts,
2) Identify and reduce human causes of mortality and serious injury,
3) Monitor and protect right whale habitat in the Southeast U.S., and

4) Cooperate with NMFS and other organizations to implement the North Atlantic Right Whale Recovery Plan.

ACTIVITIES:

<u>YEAR 1 (September 1, 2016 – August 31, 2017):</u>

Year 1, Job 1: Aerial Surveys

GDNR will conduct right whale aerial surveys through a contract with Sea to Shore Alliance (S2S) of Sarasota, FL. Aerial surveys will be conducted in parallel with an aerial survey project conducted by FWC staff. The primary objective of aerial surveys will be to collect right whale photo-identification data and other population monitoring data. Additional objectives include: 1) reducing vessel strikes by entering near-real-time whale sighting data into the Early Warning System (EWS) system, 2) monitoring right whale habitat, 3) documenting dead, injured and entangled whales, and 4) supporting boat surveys and other on-water research and monitoring efforts.

Aerial surveys will be flown December 1, 2016 – March 31, 2017. The survey area will include nearshore ocean waters offshore of Georgia, South Carolina and northeast Florida. Transect lines surveyed will change throughout the season in response to sea surface temperature, whale distribution and other factors. In the event of a sighting or report of an entangled or dead floating whale, the survey team may be temporarily redirected to an alternate location to assist with carcass recovery and/or disentanglement efforts. Surveys will be conducted aboard a NOAA AOC aircraft[1]. Surveys will be flown at a standard operational altitude of 1000 feet above sea level and not less than 750 feet. Operational survey airspeed will be 160 km/hr. Surveys will be flown only in safe operating conditions, under visual flight rules (VFR) flight conditions and in accordance with "NOAA Fisheries SER Minimum Aircraft and Crew Provisions for Right Whale Aerial Surveys." Aerial survey communications will be conducted in accordance with "EWS Aerial Survey Protocols." The survey crew will include at least 2 observers positioned on each side of the aircraft. An additional dedicated data recorder may be utilized. Observers will have previous experience conducting surveys for marine mammals and photographing marine mammals for photo-identification studies. At least one crewmember onboard the aircraft will be permitted by NMFS to conduct right whale aerial surveys. Additional scientific crew and/or non-scientific passengers (e.g., managers, media) may participate in surveys when approved in advance by GDNR and NMFS.

Photo-identification images, sighting data and survey effort data will be collected in accordance with North Atlantic Right Whale Consortium (NARWC) and EWS aerial survey protocols. GDNR and S2S will provide aerial survey data to NMFS promptly when requested to support real-time management needs (e.g., injured and entangled whales). Changes to EWS aerial survey protocols and other survey methods will be made cooperatively by GDNR, FWC, S2S and NMFS.

Year 1, Job 2: Boat Surveys and Biopsy Sampling

GDNR will conduct boat surveys and biopsy sampling in cooperation with the FWC boat survey team and FWC and S2S aerial survey teams. Objectives of boat surveys will include: 1) collecting biopsy

1 Right whale aerial survey implementation is contingent upon NMFS providing a NOAA AOC survey aircraft at no cost to GDNR and S2S. NMFS will provide GDNR with an estimate of available flight hours before surveys commence and will promptly convey any subsequent changes in flight hour estimates or aircraft availability to GDNR. GDNR and S2S will coordinate with NOAA AOC pilots to ensure that flight hour estimates are not exceeded. In the event that a NOAA aircraft is unavailable, GDNR and S2S will attempt to contract with a commercial aerial survey vendor if additional funds are available.

samples from calves and other previously un-sampled right whales, 2) collecting high-resolution photo-identification images from individual whales and 3) documenting and responding to reports of entangled, injured and dead whales.

Boat surveys will be conducted during December 1, 2016 – March 31, 2017 as weather and whale availability permit. The survey area will include nearshore ocean waters offshore of Georgia, South Carolina and northeast Florida. Surveys will usually be conducted within the same spatial extent as aerial surveys, thereby enabling boat teams to respond to real-time reports of right whales observed by aerial survey teams. Surveys may be conducted off- or on-effort depending on various factors. Surveys will be conducted in small boats (typically 18-25 ft rigid hull inflatable boats) with a minimum of 2 experienced crewmembers. At least one crewmember onboard the boat will be permitted by NMFS to approach right whales and collect biopsy samples. At least one NOAA-certified small boat operator will be present any time that NOAA-owned boats are used.

Biopsy samples and photo-identification data will be collected and processed in accordance with NARWC protocols and as outlined in the relevant NMFS research permit. Skin samples will be split 3-ways when possible. Subsamples will be submitted to Trent University, Peterborough, ON for genetics analysis and to the NMFS Northeast Fisheries Science Center right whale tissue archive. The remaining skin subsample and blubber (if collected) will be archived at the GDNR Brunswick office or at another NMFS-approved facility. Photos of biopsy-sampled right whales will be shared with FWC and other partners immediately after each survey to ensure that no right whales are sampled twice.

Photo-identification data may be collected using an Unmanned Aerial System (UAS, i.e., drone) if equipment, research permits and other authorizations become available during the project period. UAS technology may provide some advantages over current handheld camera methods, such as reducing harassment from close boat approaches. UAS methods would be implemented in coordination with NMFS and other agencies as appropriate. The timeline for UAS implementation is currently unknown.

Year 1, Job 3: Other Research and Monitoring Activities

GDNR and S2S may assist NMFS, FWC and other partners with additional research and monitoring efforts as management needs arise and as resources allow. Examples of such activities may include but not be limited to satellite tagging, acoustic monitoring and UAS research. All such activities will be coordinated with NMFS and FWC. Field activities would most likely occur during December 1, 2016 – March 31, 2017.

Year 1, Job 4: Reduce Mortality and Serious Injury

GDNR and S2S will coordinate with NMFS, FWC, Provincetown Center for Coastal Studies and other Atlantic Large Whale Disentanglement Network (ALWDN) members to document and respond to reports of entangled right whales. A whale disentanglement equipment cache will be housed and maintained at GDNR's Brunswick office. Disentanglement supplies will be carried aboard GDNR research boats when possible. GDNR will make disentanglement tools and staff available for disentanglement activities reported offshore of Georgia, South Carolina and Florida. Disentanglement response activities will be conducted by permitted GDNR staff (Clay George, Level 5 responder; Mark Dodd, Level 4 responder; Trip Kolkmeyer, Level 3 responder) with assistance from FWC, S2S and other GDNR staff. Fishing gear obtained from entangled right whales will be collected, documented and transferred according to NMFS protocols. Disentanglement activities will most likely occur during December 1, 2016 – March 31, 2017, but could occur at other times of year.

A GDNR WRD biologist will serve on the Atlantic Large Whale Take Reduction Team (ALWTRT) and attend ALWTRT meetings when possible. GDNR WRD staff will coordinate with NMFS, GDNR Coastal Resources Division and GDNR Law Enforcement Division staff to identify and mitigate fishing activities that pose a risk to right whales in the Southeast U.S.

GDNR and S2S will notify commercial, federal and military vessels about right whale collision risk by disseminating near-real-time whale sighting data as outlined in the EWS aerial survey protocols. Pilot boats, ships and other vessels may be notified directly when appropriate. This work will be conducted primarily when aerial surveys are being conducted, December 1, 2016 – March 31, 2017.

GDNR will cooperate with FWC, NMFS, S2S and the Southeast Marine Mammal Stranding Network to document and investigate reports of dead or injured right whales. All reports or sightings of dead or injured right whales offshore of Georgia will be verified when possible. Once verified, GDNR will notify NMFS immediately and an action plan will be implemented. In the event of a floating or stranded right whale carcass, GDNR will provide on-site stranding coordination if requested by NMFS, which may include carcass towing, necropsy and disposal. Stranding response may occur at any time of year, but would most likely occur December 1, 2016 – March 31, 2017.

Year 1, Job 5: Identify and Mitigate Impacts to Right Whales and Habitat

GDNR staff will review state, federal and private proposals and activities that have the potential to impact right whales and right whale habitat in the Southeast U.S. GDNR will provide comments and recommendations to NMFS, other government agencies, or other responsible parties with the goal of mitigating impacts to right whales.

GDNR and S2S will document and investigate activities and events that have the potential to impact right whales and habitat (e.g., emerging commercial fisheries, oil spills, boater harassment, etc.). GDNR will notify NMFS and submit relevant data in a timely manner.

Year 1, Job 6: Cooperate with NMFS and Other Organizations to Implement the Right Whale Recovery Plan

GDNR will cooperate with NMFS, FWC and other organizations to encourage right whale conservation in the Southeast U.S. GDNR staff will participate on the Southeast Implementation Team (SEIT) for Right Whale Recovery, attend the NARWC annual meeting and participate in other meetings and workshops as appropriate. GDNR staff will conduct right whale education and outreach via social media, GDNR's website, presentations and other methods.

YEAR 2 (September 1, 2017 – August 31, 2018):

Year 2, Job 1: Aerial Surveys

GDNR will conduct right whale aerial surveys through a contract with Sea to Shore Alliance (S2S) of Sarasota, FL. Aerial surveys will be conducted in parallel with an aerial survey project conducted by FWC staff. The primary objective of aerial surveys will be to collect right whale photo-identification data and other population monitoring data. Additional objectives include: 1) reducing vessel strikes by entering near-real-time whale sighting data into the Early Warning System (EWS) system, 2) monitoring right whale habitat, 3) documenting dead, injured and entangled whales, and 4) supporting boat surveys and other on-water research and monitoring efforts.

Aerial surveys will be flown December 1, 2017 – March 31, 2018. The survey area will include nearshore ocean waters offshore of Georgia, South Carolina and northeast Florida. Transect lines surveyed will change throughout the season in response to sea surface temperature, whale distribution and other factors. In the event of a sighting or report of an entangled or dead floating whale, the survey team may be temporarily redirected to an alternate location to assist with carcass recovery and/or disentanglement efforts. Surveys will be conducted aboard a NOAA AOC aircraft[2]. Surveys will be flown at a standard operational altitude of 1000 feet above sea level and not less than 750 feet. Operational survey airspeed will be 160 km/hr. Surveys will be flown only in safe operating conditions, under visual flight rules (VFR) flight conditions and in accordance with "NOAA Fisheries SER Minimum Aircraft and Crew Provisions for Right Whale Aerial Surveys." Aerial survey communications will be conducted in accordance with "EWS Aerial Survey Protocols." The survey crew will include at least 2 observers positioned on each side of the aircraft. An additional dedicated data recorder may be utilized. Observers will have previous experience conducting surveys for marine mammals and photographing marine mammals for photo-identification studies. At least one crewmember onboard the aircraft will be permitted by NMFS to conduct right whale aerial surveys. Additional scientific crew and/or non-scientific passengers (e.g., managers, media) may participate in surveys when approved in advance by GDNR and NMFS.

Photo-identification images, sighting data and survey effort data will be collected in accordance with North Atlantic Right Whale Consortium (NARWC) and EWS aerial survey protocols. GDNR and S2S will provide aerial survey data to NMFS promptly when requested to support real-time management needs (e.g., injured and entangled whales). Changes to EWS aerial survey protocols and other survey methods will be made cooperatively by GDNR, FWC, S2S and NMFS.

Year 2, Job 2: Boat Surveys and Biopsy Sampling

GDNR will conduct boat surveys and biopsy sampling in cooperation with the FWC boat survey team and FWC and S2S aerial survey teams. Objectives of boat surveys will include: 1) collecting biopsy samples from calves and other previously un-sampled right whales, 2) collecting high-resolution photo-identification images from individual whales and 3) documenting and responding to reports of entangled, injured and dead whales.

Boat surveys will be conducted during December 1, 2017 – March 31, 2018 as weather and whale availability permit. The survey area will include nearshore ocean waters offshore of Georgia, South Carolina and northeast Florida. Surveys will usually be conducted within the same spatial extent as aerial surveys, thereby enabling boat teams to respond to real-time reports of right whales observed by aerial survey teams. Surveys may be conducted off- or on-effort depending on various factors. Surveys will be conducted in small boats (typically 18-25 ft rigid hull inflatable boats) with a minimum of 2 experienced crewmembers. At least one crewmember onboard the boat will be permitted by NMFS to approach right whales and collect biopsy samples. At least one NOAA-certified small boat operator will be present any time that NOAA-owned boats are used.

Biopsy samples and photo-identification data will be collected and processed in accordance with NARWC protocols and as outlined in the relevant NMFS research permit. Skin samples will be split 3-ways when possible. Subsamples will be submitted to Trent University, Peterborough, ON for genetics

2 Right whale aerial survey implementation is contingent upon NMFS providing a NOAA AOC survey aircraft at no cost to GDNR and S2S. NMFS will provide GDNR with an estimate of available flight hours before surveys commence and will promptly convey any subsequent changes in flight hour estimates or aircraft availability to GDNR. GDNR and S2S will coordinate with NOAA AOC pilots to ensure that flight hour estimates are not exceeded. In the event that a NOAA aircraft is unavailable, GDNR and S2S will attempt to contract with a commercial aerial survey vendor if additional funds are available.

analysis and to the NMFS Northeast Fisheries Science Center right whale tissue archive. The remaining skin subsample and blubber (if collected) will be archived at the GDNR Brunswick office or at another NMFS-approved facility. Photos of biopsy-sampled right whales will be shared with FWC and other partners immediately after each survey to ensure that no right whales are sampled twice.

Photo-identification data may be collected using an Unmanned Aerial System (UAS, i.e., drone) if equipment, research permits and other authorizations become available during the project period. UAS technology may provide some advantages over current handheld camera methods, such as reducing harassment from close boat approaches. UAS methods would be implemented in coordination with NMFS and other agencies as appropriate. The timeline for UAS implementation is currently unknown.

Year 2, Job 3: Other Research and Monitoring Activities

GDNR and S2S may assist NMFS, FWC and other partners with additional research and monitoring efforts as management needs arise and as resources allow. Examples of such activities may include but not be limited to satellite tagging, acoustic monitoring and UAS research. All such activities will be coordinated with NMFS and FWC. Field activities would most likely occur during December 1, 2017 – March 31, 2018.

Year 2, Job 4: Reduce Mortality and Serious Injury

GDNR and S2S will coordinate with NMFS, FWC, Provincetown Center for Coastal Studies and other Atlantic Large Whale Disentanglement Network (ALWDN) members to document and respond to reports of entangled right whales. A whale disentanglement equipment cache will be housed and maintained at GDNR's Brunswick office. Disentanglement supplies will be carried aboard GDNR research boats when possible. GDNR will make disentanglement tools and staff available for disentanglement activities reported offshore of Georgia, South Carolina and Florida. Disentanglement response activities will be conducted by permitted GDNR staff (Clay George, Level 5 responder; Mark Dodd, Level 4 responder; Trip Kolkmeyer, Level 3 responder) with assistance from FWC, S2S and other GDNR staff. Fishing gear obtained from entangled right whales will be collected, documented and transferred according to NMFS protocols. Disentanglement activities will most likely occur during December 1, 2017 – March 31, 2018, but could occur at other times of year.

A GDNR WRD biologist will serve on the Atlantic Large Whale Take Reduction Team (ALWTRT) and attend ALWTRT meetings when possible. GDNR WRD staff will coordinate with NMFS, GDNR Coastal Resources Division and GDNR Law Enforcement Division staff to identify and mitigate fishing activities that pose a risk to right whales in the Southeast U.S.

GDNR and S2S will notify commercial, federal and military vessels about right whale collision risk by disseminating near-real-time whale sighting data as outlined in the EWS aerial survey protocols. Pilot boats, ships and other vessels may be notified directly when appropriate. This work will be conducted primarily when aerial surveys are being conducted, December 1, 2017 – March 31, 2018.

GDNR will cooperate with FWC, NMFS, S2S and the Southeast Marine Mammal Stranding Network to document and investigate reports of dead or injured right whales. All reports or sightings of dead or injured right whales offshore of Georgia will be verified when possible. Once verified, GDNR will notify NMFS immediately and an action plan will be implemented. In the event of a floating or stranded right whale carcass, GDNR will provide on-site stranding coordination if requested by NMFS, which may include carcass towing, necropsy and disposal. Stranding response may occur at any time of year, but would most likely occur December 1, 2017 – March 31, 2018.

Year 2, Job 5: Identify and Mitigate Impacts to Right Whales and Habitat

GDNR staff will review state, federal and private proposals and activities that have the potential to impact right whales and right whale habitat in the Southeast U.S. GDNR will provide comments and recommendations to NMFS, other government agencies, or other responsible parties with the goal of mitigating impacts to right whales.

GDNR and S2S will document and investigate activities and events that have the potential to impact right whales and habitat (e.g., emerging commercial fisheries, oil spills, boater harassment, etc.). GDNR will notify NMFS and submit relevant data in a timely manner.

Year 2, Job 6: Cooperate with NMFS and Other Organizations to Implement the Right Whale Recovery Plan

GDNR will cooperate with NMFS, FWC and other organizations to encourage right whale conservation in the Southeast U.S. GDNR staff will participate on the Southeast Implementation Team (SEIT) for Right Whale Recovery, attend the NARWC annual meeting and participate in other meetings and workshops as appropriate. GDNR staff will conduct right whale education and outreach via social media, GDNR's website, presentations and other methods.

YEAR 3 (September 1, 2018 – August 31, 2019):

Year 3, Job 1: Aerial Surveys

GDNR will conduct right whale aerial surveys through a contract with Sea to Shore Alliance (S2S) of Sarasota, FL. Aerial surveys will be conducted in parallel with an aerial survey project conducted by FWC staff. The primary objective of aerial surveys will be to collect right whale photo-identification data and other population monitoring data. Additional objectives include: 1) reducing vessel strikes by entering near-real-time whale sighting data into the Early Warning System (EWS) system, 2) monitoring right whale habitat, 3) documenting dead, injured and entangled whales, and 4) supporting boat surveys and other on-water research and monitoring efforts.

Aerial surveys will be flown December 1, 2018 – March 31, 2019. The survey area will include nearshore ocean waters offshore of Georgia, South Carolina and northeast Florida. Transect lines surveyed will change throughout the season in response to sea surface temperature, whale distribution and other factors. In the event of a sighting or report of an entangled or dead floating whale, the survey team may be temporarily redirected to an alternate location to assist with carcass recovery and/or disentanglement efforts. Surveys will be conducted aboard a NOAA AOC aircraft[3]. Surveys will be flown at a standard operational altitude of 1000 feet above sea level and not less than 750 feet. Operational survey airspeed will be 160 km/hr. Surveys will be flown only in safe operating conditions, under visual flight rules (VFR) flight conditions and in accordance with "NOAA Fisheries SER Minimum Aircraft and Crew Provisions for Right Whale Aerial Surveys." Aerial survey communications will be conducted in accordance with "EWS Aerial Survey Protocols." The survey crew will include at least 2 observers positioned on each side of the aircraft. An additional dedicated

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data recorder may be utilized. Observers will have previous experience conducting surveys for marine mammals and photographing marine mammals for photo-identification studies. At least one crewmember onboard the aircraft will be permitted by NMFS to conduct right whale aerial surveys. Additional scientific crew and/or non-scientific passengers (e.g., managers, media) may participate in surveys when approved in advance by GDNR and NMFS.

Photo-identification images, sighting data and survey effort data will be collected in accordance with North Atlantic Right Whale Consortium (NARWC) and EWS aerial survey protocols. GDNR and S2S will provide aerial survey data to NMFS promptly when requested to support real-time management needs (e.g., injured and entangled whales). Changes to EWS aerial survey protocols and other survey methods will be made cooperatively by GDNR, FWC, S2S and NMFS.

Year 3, Job 2: Boat Surveys and Biopsy Sampling

GDNR will conduct boat surveys and biopsy sampling in cooperation with the FWC boat survey team and FWC and S2S aerial survey teams. Objectives of boat surveys will include: 1) collecting biopsy samples from calves and other previously un-sampled right whales, 2) collecting high-resolution photo-identification images from individual whales and 3) documenting and responding to reports of entangled, injured and dead whales.

Boat surveys will be conducted during December 1, 2018 – March 31, 2019 as weather and whale availability permit. The survey area will include nearshore ocean waters offshore of Georgia, South Carolina and northeast Florida. Surveys will usually be conducted within the same spatial extent as aerial surveys, thereby enabling boat teams to respond to real-time reports of right whales observed by aerial survey teams. Surveys may be conducted off- or on-effort depending on various factors. Surveys will be conducted in small boats (typically 18-25 ft rigid hull inflatable boats) with a minimum of 2 experienced crewmembers. At least one crewmember onboard the boat will be permitted by NMFS to approach right whales and collect biopsy samples. At least one NOAA-certified small boat operator will be present any time that NOAA-owned boats are used.

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Photo-identification data may be collected using an Unmanned Aerial System (UAS, i.e., drone) if equipment, research permits and other authorizations become available during the project period. UAS technology may provide some advantages over current handheld camera methods, such as reducing harassment from close boat approaches. UAS methods would be implemented in coordination with NMFS and other agencies as appropriate. The timeline for UAS implementation is currently unknown.

Year 3, Job 3: Other Research and Monitoring Activities

GDNR and S2S may assist NMFS, FWC and other partners with additional research and monitoring efforts as management needs arise and as resources allow. Examples of such activities may include but not be limited to satellite tagging, acoustic monitoring and UAS research. All such activities will be coordinated with NMFS and FWC. Field activities would most likely occur during December 1, 2018 – March 31, 2019.

Year 3, Job 4: Reduce Mortality and Serious Injury

GDNR and S2S will coordinate with NMFS, FWC, Provincetown Center for Coastal Studies and other Atlantic Large Whale Disentanglement Network (ALWDN) members to document and respond to reports of entangled right whales. A whale disentanglement equipment cache will be housed and maintained at GDNR's Brunswick office. Disentanglement supplies will be carried aboard GDNR research boats when possible. GDNR will make disentanglement tools and staff available for disentanglement activities reported offshore of Georgia, South Carolina and Florida. Disentanglement response activities will be conducted by permitted GDNR staff (Clay George, Level 5 responder; Mark Dodd, Level 4 responder; Trip Kolkmeyer, Level 3 responder) with assistance from FWC, S2S and other GDNR staff. Fishing gear obtained from entangled right whales will be collected, documented and transferred according to NMFS protocols. Disentanglement activities will most likely occur during December 1, 2018 – March 31, 2019, but could occur at other times of year.

A GDNR WRD biologist will serve on the Atlantic Large Whale Take Reduction Team (ALWTRT) and attend ALWTRT meetings when possible. GDNR WRD staff will coordinate with NMFS, GDNR Coastal Resources Division and GDNR Law Enforcement Division staff to identify and mitigate fishing activities that pose a risk to right whales in the Southeast U.S.

GDNR and S2S will notify commercial, federal and military vessels about right whale collision risk by disseminating near-real-time whale sighting data as outlined in the EWS aerial survey protocols. Pilot boats, ships and other vessels may be notified directly when appropriate. This work will be conducted primarily when aerial surveys are being conducted, December 1, 2018 – March 31, 2019.

GDNR will cooperate with FWC, NMFS, S2S and the Southeast Marine Mammal Stranding Network to document and investigate reports of dead or injured right whales. All reports or sightings of dead or injured right whales offshore of Georgia will be verified when possible. Once verified, GDNR will notify NMFS immediately and an action plan will be implemented. In the event of a floating or stranded right whale carcass, GDNR will provide on-site stranding coordination if requested by NMFS, which may include carcass towing, necropsy and disposal. Stranding response may occur at any time of year, but would most likely occur December 1, 2018 – March 31, 2019.

Year 3, Job 5: Identify and Mitigate Impacts to Right Whales and Habitat

GDNR staff will review state, federal and private proposals and activities that have the potential to impact right whales and right whale habitat in the Southeast U.S. GDNR will provide comments and recommendations to NMFS, other government agencies, or other responsible parties with the goal of mitigating impacts to right whales.

GDNR and S2S will document and investigate activities and events that have the potential to impact right whales and habitat (e.g., emerging commercial fisheries, oil spills, boater harassment, etc.). GDNR will notify NMFS and submit relevant data in a timely manner.

Year 3, Job 6: Cooperate with NMFS and Other Organizations to Implement the Right Whale Recovery Plan

GDNR will cooperate with NMFS, FWC and other organizations to encourage right whale conservation in the Southeast U.S. GDNR staff will participate on the Southeast Implementation Team (SEIT) for Right Whale Recovery, attend the NARWC annual meeting and participate in other meetings and workshops as appropriate. GDNR staff will conduct right whale education and outreach via social media, GDNR's website, presentations and other methods.

YEAR 4 (September 1, 2019 – August 31, 2020):

Year 4, Job 1: Aerial Surveys

GDNR will conduct right whale aerial surveys through a contract with Sea to Shore Alliance (S2S) of Sarasota, FL. Aerial surveys will be conducted in parallel with an aerial survey project conducted by FWC staff. The primary objective of aerial surveys will be to collect right whale photo-identification data and other population monitoring data. Additional objectives include: 1) reducing vessel strikes by entering near-real-time whale sighting data into the Early Warning System (EWS) system, 2) monitoring right whale habitat, 3) documenting dead, injured and entangled whales, and 4) supporting boat surveys and other on-water research and monitoring efforts.

Aerial surveys will be flown December 1, 2019 – March 31, 2020. The survey area will include nearshore ocean waters offshore of Georgia, South Carolina and northeast Florida. Transect lines surveyed will change throughout the season in response to sea surface temperature, whale distribution and other factors. In the event of a sighting or report of an entangled or dead floating whale, the survey team may be temporarily redirected to an alternate location to assist with carcass recovery and/or disentanglement efforts. Surveys will be conducted aboard a NOAA AOC aircraft[4]. Surveys will be flown at a standard operational altitude of 1000 feet above sea level and not less than 750 feet. Operational survey airspeed will be 160 km/hr. Surveys will be flown only in safe operating conditions, under visual flight rules (VFR) flight conditions and in accordance with "NOAA Fisheries SER Minimum Aircraft and Crew Provisions for Right Whale Aerial Surveys." Aerial survey communications will be conducted in accordance with "EWS Aerial Survey Protocols." The survey crew will include at least 2 observers positioned on each side of the aircraft. An additional dedicated data recorder may be utilized. Observers will have previous experience conducting surveys for marine mammals and photographing marine mammals for photo-identification studies. At least one crewmember onboard the aircraft will be permitted by NMFS to conduct right whale aerial surveys. Additional scientific crew and/or non-scientific passengers (e.g., managers, media) may participate in surveys when approved in advance by GDNR and NMFS.

Photo-identification images, sighting data and survey effort data will be collected in accordance with North Atlantic Right Whale Consortium (NARWC) and EWS aerial survey protocols. GDNR and S2S will provide aerial survey data to NMFS promptly when requested to support real-time management needs (e.g., injured and entangled whales). Changes to EWS aerial survey protocols and other survey methods will be made cooperatively by GDNR, FWC, S2S and NMFS.

Year 4, Job 2: Boat Surveys and Biopsy Sampling

4 Right whale aerial survey implementation is contingent upon NMFS providing a NOAA AOC survey aircraft at no cost to GDNR and S2S. NMFS will provide GDNR with an estimate of available flight hours before surveys commence and will promptly convey any subsequent changes in flight hour estimates or aircraft availability to GDNR. GDNR and S2S will coordinate with NOAA AOC pilots to ensure that flight hour estimates are not exceeded. In the event that a NOAA aircraft is unavailable, GDNR and S2S will attempt to contract with a commercial aerial survey vendor if additional funds are available.

GDNR will conduct boat surveys and biopsy sampling in cooperation with the FWC boat survey team and FWC and S2S aerial survey teams. Objectives of boat surveys will include: 1) collecting biopsy samples from calves and other previously un-sampled right whales, 2) collecting high-resolution photo-identification images from individual whales and 3) documenting and responding to reports of entangled, injured and dead whales.

Boat surveys will be conducted during December 1, 2019 – March 31, 2020 as weather and whale availability permit. The survey area will include nearshore ocean waters offshore of Georgia, South Carolina and northeast Florida. Surveys will usually be conducted within the same spatial extent as aerial surveys, thereby enabling boat teams to respond to real-time reports of right whales observed by aerial survey teams. Surveys may be conducted off- or on-effort depending on various factors. Surveys will be conducted in small boats (typically 18-25 ft rigid hull inflatable boats) with a minimum of 2 experienced crewmembers. At least one crewmember onboard the boat will be permitted by NMFS to approach right whales and collect biopsy samples. At least one NOAA-certified small boat operator will be present any time that NOAA-owned boats are used.

Biopsy samples and photo-identification data will be collected and processed in accordance with NARWC protocols and as outlined in the relevant NMFS research permit. Skin samples will be split 3-ways when possible. Subsamples will be submitted to Trent University, Peterborough, ON for genetics analysis and to the NMFS Northeast Fisheries Science Center right whale tissue archive. The remaining skin subsample and blubber (if collected) will be archived at the GDNR Brunswick office or at another NMFS-approved facility. Photos of biopsy-sampled right whales will be shared with FWC and other partners immediately after each survey to ensure that no right whales are sampled twice.

Photo-identification data may be collected using an Unmanned Aerial System (UAS, i.e., drone) if equipment, research permits and other authorizations become available during the project period. UAS technology may provide some advantages over current handheld camera methods, such as reducing harassment from close boat approaches. UAS methods would be implemented in coordination with NMFS and other agencies as appropriate. The timeline for UAS implementation is currently unknown.

Year 4, Job 3: Other Research and Monitoring Activities

GDNR and S2S may assist NMFS, FWC and other partners with additional research and monitoring efforts as management needs arise and as resources allow. Examples of such activities may include but not be limited to satellite tagging, acoustic monitoring and UAS research. All such activities will be coordinated with NMFS and FWC. Field activities would most likely occur during December 1, 2019 – March 31, 2020.

Year 4, Job 4: Reduce Mortality and Serious Injury

GDNR and S2S will coordinate with NMFS, FWC, Provincetown Center for Coastal Studies and other Atlantic Large Whale Disentanglement Network (ALWDN) members to document and respond to reports of entangled right whales. A whale disentanglement equipment cache will be housed and maintained at GDNR's Brunswick office. Disentanglement supplies will be carried aboard GDNR research boats when possible. GDNR will make disentanglement tools and staff available for disentanglement activities reported offshore of Georgia, South Carolina and Florida. Disentanglement response activities will be conducted by permitted GDNR staff (Clay George, Level 5 responder; Mark Dodd, Level 4 responder; Trip Kolkmeyer, Level 3 responder) with assistance from FWC, S2S and other GDNR staff. Fishing gear obtained from entangled right whales will be collected, documented and transferred according to NMFS protocols. Disentanglement activities will most likely occur during December 1, 2019 – March 31, 2020, but could occur at other times of year.

A GDNR WRD biologist will serve on the Atlantic Large Whale Take Reduction Team (ALWTRT) and attend ALWTRT meetings when possible. GDNR WRD staff will coordinate with NMFS, GDNR Coastal Resources Division and GDNR Law Enforcement Division staff to identify and mitigate fishing activities that pose a risk to right whales in the Southeast U.S.

GDNR and S2S will notify commercial, federal and military vessels about right whale collision risk by disseminating near-real-time whale sighting data as outlined in the EWS aerial survey protocols. Pilot boats, ships and other vessels may be notified directly when appropriate. This work will be conducted primarily when aerial surveys are being conducted, December 1, 2019 – March 31, 2020.

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Year 4, Job 5: Identify and Mitigate Impacts to Right Whales and Habitat

GDNR staff will review state, federal and private proposals and activities that have the potential to impact right whales and right whale habitat in the Southeast U.S. GDNR will provide comments and recommendations to NMFS, other government agencies, or other responsible parties with the goal of mitigating impacts to right whales.

GDNR and S2S will document and investigate activities and events that have the potential to impact right whales and habitat (e.g., emerging commercial fisheries, oil spills, boater harassment, etc.). GDNR will notify NMFS and submit relevant data in a timely manner.

Year 4, Job 6: Cooperate with NMFS and Other Organizations to Implement the Right Whale Recovery Plan

GDNR will cooperate with NMFS, FWC and other organizations to encourage right whale conservation in the Southeast U.S. GDNR staff will participate on the Southeast Implementation Team (SEIT) for Right Whale Recovery, attend the NARWC annual meeting and participate in other meetings and workshops as appropriate. GDNR staff will conduct right whale education and outreach via social media, GDNR's website, presentations and other methods.

<u>YEAR 5 (September 1, 2020 – August 31, 2021):</u>

Year 5, Job 1: Aerial Surveys

GDNR will conduct right whale aerial surveys through a contract with Sea to Shore Alliance (S2S) of Sarasota, FL. Aerial surveys will be conducted in parallel with an aerial survey project conducted by FWC staff. The primary objective of aerial surveys will be to collect right whale photo-identification data and other population monitoring data. Additional objectives include: 1) reducing vessel strikes by entering near-real-time whale sighting data into the Early Warning System (EWS) system, 2) monitoring right whale habitat, 3) documenting dead, injured and entangled whales, and 4) supporting boat surveys and other on-water research and monitoring efforts.

Aerial surveys will be flown December 1, 2020 – March 31, 2021. The survey area will include nearshore ocean waters offshore of Georgia, South Carolina and northeast Florida. Transect lines surveyed will change throughout the season in response to sea surface temperature, whale distribution and other factors. In the event of a sighting or report of an entangled or dead floating whale, the survey team may be temporarily redirected to an alternate location to assist with carcass recovery and/or disentanglement efforts. Surveys will be conducted aboard a NOAA AOC aircraft[5]. Surveys will be flown at a standard operational altitude of 1000 feet above sea level and not less than 750 feet. Operational survey airspeed will be 160 km/hr. Surveys will be flown only in safe operating conditions, under visual flight rules (VFR) flight conditions and in accordance with "NOAA Fisheries SER Minimum Aircraft and Crew Provisions for Right Whale Aerial Surveys." Aerial survey communications will be conducted in accordance with "EWS Aerial Survey Protocols." The survey crew will include at least 2 observers positioned on each side of the aircraft. An additional dedicated data recorder may be utilized. Observers will have previous experience conducting surveys for marine mammals and photographing marine mammals for photo-identification studies. At least one crewmember onboard the aircraft will be permitted by NMFS to conduct right whale aerial surveys. Additional scientific crew and/or non-scientific passengers (e.g., managers, media) may participate in surveys when approved in advance by GDNR and NMFS.

Photo-identification images, sighting data and survey effort data will be collected in accordance with North Atlantic Right Whale Consortium (NARWC) and EWS aerial survey protocols. GDNR and S2S will provide aerial survey data to NMFS promptly when requested to support real-time management needs (e.g., injured and entangled whales). Changes to EWS aerial survey protocols and other survey methods will be made cooperatively by GDNR, FWC, S2S and NMFS.

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GDNR will conduct boat surveys and biopsy sampling in cooperation with the FWC boat survey team and FWC and S2S aerial survey teams. Objectives of boat surveys will include: 1) collecting biopsy samples from calves and other previously un-sampled right whales, 2) collecting high-resolution photo-identification images from individual whales and 3) documenting and responding to reports of entangled, injured and dead whales.

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Year 5, Job 3: Other Research and Monitoring Activities

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Year 5, Job 6: Cooperate with NMFS and Other Organizations to Implement the Right Whale Recovery Plan

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SCHEDULE:

Jobs will be conducted according to the schedule outlined in Table 1.

PROJECT MANAGEMENT:

This project will be coordinated and implemented by Clay George, principal investigator and wildlife biologist with the GDNR WRD based in Brunswick, GA. Assistance with project implementation will be provided by Trip Kolkmeyer (wildlife technician) and Mark Dodd (senior wildlife biologist) both with the GDNR WRD in Brunswick, GA. GDNR will hire a seasonal technician from December 1 to March 31 annually to assist with field work and data processing. Other GDNR staff may assist with field work as needed and during emergencies. Aerial survey activities will be implemented through a contract with Sea to Shore Alliance, a 501(c)(3) nonprofit based in Sarasota, FL. Cynthia Taylor will be the principal investigator of that contract. S2S will hire seasonal observers to aerial surveys from December 1 to March 31, annually. The S2S aerial survey team will be based at St. Simons Island, GA. GDNR staff will work closely with FWC Fish and Wildlife Research Institute staff based in St. Augustine and St. Petersburg, FL, including Thomas Pitchford, Katharine Jackson, Tim Gowan and seasonal staff. Assistance with grant management will be provided by Shirley Hall, administrative operations manager with the GDNR WRD based in Social Circle, GA. The NMFS liaison for this project will be Barb Zoodsma, southeast right whale recovery coordinator with NMFS SERO based in Fernandina Beach, FL.

DATA SUBMISSION AND DELIVERABLES:

This project will generate environmental data and information. Sighting, photo-identification, genetics, entanglement and mortality data generated by this project will be accessible to researchers and managers as outlined in the NARWC data access protocol: http://www.narwc.org/pdf/consortium_database.pdf. GDNR and S2S will submit all data and reports to NMFS and other cooperators accurately and in a timely manner as outlined below:

Weekly Aerial Survey Reports

The S2S aerial survey team will submit weekly reports to NMFS each Monday, summarizing aerial survey activities during the preceding Friday-Thursday, during the period of December 1 to March 31, annually. Barb Zoodsma (NMFS) will provide S2S with an email list of recipients prior to December 1 annually.

End of Season Aerial Survey Data

S2S will deliver all aerial survey effort and event data, including electronic data, sighting data sheets, etc., to Barb Zoodsma and Tim Gowan (FWC) by April 30, annually. FWC staff will check effort and event data for errors and submit cleaned datasets to the NARWC. S2S will submit all aerial photo-identification data to Barb Zoodsma and Philip Hamilton (New England Aquarium) by April 30, annually. S2S will deliver all aerial survey final report tables and text to Barb Zoodsma as outlined in the EWS aerial survey protocols by May 15, annually. Ms. Zoodsma will incorporate FWC and S2S aerial survey results into a comprehensive annual report that will be available for download on the NMFS SERO website.

Boat Survey Data and Biopsy Samples

Boat survey effort and event data will be archived at the GDNR Brunswick, GA office. GDNR will submit all boat photo-identification data to Barb Zoodsma and Philip Hamilton by April 30, annually. Biopsy skin samples for Trent University and NMFS NEFSC will be submitted to Lisa Conger (NMFS NEFSC) by April 30, annually.

Other Data

Images and data obtained from injured, dead and entangled whales will be submitted to NMFS, New England Aquarium and other recipients in a timely manner as requested. Fishing gear collected from entangled whales will be examined and transferred to NMFS in a timely manner as requested.

Progress Reports and Final Report

Project progress reports will be submitted to NMFS via NOAA Grant Online on March 31 and September 30, annually. A final report written in standard scientific format will be submitted 90 days after completion of the project.

Table 1. Project schedule summarized by job and year. See text for job descriptions.

		Year 1												Year 2												Year 3												Year 4												Year 5											
Job#	Job Title	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
1	Aerial surveys				X	X	X	X									X	X	X	X									X	X	X	X									X	X	X	X									X	X	X	X					
2	Boat surveys and biopsy sampling				X	X	X	X									X	X	X	X									X	X	X	X									X	X	X	X									X	X	X	X					
3	Other research and monitoring				X	X	X	X									X	X	X	X									X	X	X	X									X	X	X	X									X	X	X	X					
4	Reduce mortality and serious injury	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5	Protect habitat	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6	Help implement the right whale recovery plan	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

FORM **CD-451**
(REV. 11/18)

U.S. DEPARTMENT OF COMMERCE

AMENDMENT TO FINANCIAL ASSISTANCE AWARD

☒ GRANT ☐ COOPERATIVE AGREEMENT

FEDERAL AWARD ID NUMBER
NA16NMF4720323

CFDA NO. AND NAME
11.472 Unallied Science Program

PROJECT TITLE
Implement North Atlantic Right Whale Recovery Activities in the Southeast U.S.

RECIPIENT NAME
NATURAL RESOURCES, GEORGIA DEPARTMENT OF

AMENDMENT NUMBER
5

STREET ADDRESS
2 MARTIN LUTHER KING JR DR SE

EFFECTIVE DATE
05/01/2020

CITY, STATE, ZIP CODE
ATLANTA GA 30334-9000

EXTEND PERIOD OF PERFORMANCE TO (IF APPLICABLE)
N/A

COSTS ARE REVISED AS FOLLOWS:	PREVIOUS ESTIMATED COST	ADD	DEDUCT	TOTAL ESTIMATED COST
FEDERAL SHARE OF COST	$ $1,213,138.00	$ $58,200.00	$ $0.00	$ $1,271,338.00
RECIPIENT SHARE OF COST	$ $134,795.00	$ $6,467.00	$ $0.00	$ $141,262.00
TOTAL ESTIMATED COST	$ $1,347,933.00	$ $64,667.00	$ $0.00	$ $1,412,600.00

REASON(S) FOR AMENDMENT.

1. To provide additional funding for the project entitled "Implement North Atlantic Right Whale Recovery Activities in the Southeast U.S." per the recipient's supplemental application dated 04/07/2020, which is incorporated by reference.

2. To incorporate DOC Financial Assistance Standard Terms and Conditions

3. To revise NOAA Administrative Specific Award Conditions.

This Amendment Document (Form CD-451) signed by the Grants Officer constitutes an Amendment of the above-referenced Award, which may include an obligation of Federal funding. By signing this Form CD-451, the Recipient agrees to comply with the Amendment provisions checked below and attached, as well as previous provisions incorporated into the Award. If not signed and returned without modification by the Recipient within 30 days of receipt, the Grants Officer may unilaterally withdraw this Amendment offer and de-obligate any associated funds.

☒ **SPECIFIC AWARD CONDITION(S)**

☐ **LINE ITEM BUDGET**

☐ **OTHER(S):** ______________________

SIGNATURE OF DEPARTMENT OF COMMERCE GRANTS OFFICER
Alan Conway

DATE
04/27/2020

PRINTED NAME, PRINTED TITLE, AND SIGNATURE OF AUTHORIZED RECIPIENT OFFICIAL
Matt Elliott

DATE
05/22/2020

GEORGIA
DEPARTMENT OF NATURAL RESOURCES
COASTAL RESOURCES DIVISION
ONE CONSERVATION WAY • BRUNSWICK, GA 31520 • 912.264.7218
COASTALGADNR.ORG

MARK WILLIAMS
COMMISSIONER

DOUG HAYMANS
DIRECTOR

March 29, 2021

Ms. Kim Garvey, USACE SAS Chief of Planning
kimberly.l.garvey@usace.army.mil

RE: Brunswick Harbor Modification Study CZM Federal Consistency Extension of Time Request

Dear Ms. Garvey,

Staff of the Georgia Coastal Management Program received the updated Brunswick Harbor Modification Study Consistency Determination on February 10, 2021 and began our 60-day review per 15 CFR 930.41. We request a 15-day extension as provided by 15 CFR 930.41(b) to continue our review until April 26, 2021. This extension does not change the date you may take action, which is 90-days after our receipt of the Determination on May 11, 2021 per 15 CFR 41(c).

This does not preclude us from requesting an additional extension prior to April 26, 2021 considering the magnitude and complexity of this project. To date we have received over 1,500 public comments voicing concern of proposed modifications to operation and maintenance of the harbor.

Sincerely,

Doug Haymans
Director

cc: Dr. Jeffrey L. Payne, NOAA OCM Director, Jeff.Payne@noaa.gov
Kerry Kehoe, NOAA OCM Senior Policy Analyst, Kerry.Kehoe@noaa.gov
Lindy Betzhold, Sr. Coastal Management Specialist, Lindy.Betzhold@noaa.gov
Robin Leigh, Environment & Natural Resources Section Chief, Attorney General's Office, RLeigh@law.ga.gov
Kyle Pearson, GADNR Executive Counsel, Kyle.Pearson@gadnr.ga.gov
Jason Lee, GADNR/WRD WCP Director, Jason.Lee@dnr.ga.gov
Mark Dodd, GADNR/WRD WCP Wildlife Biologist, Mark.Dodd@dnr.ga.gov
Kelie Moore, GADNR/CRD Fed. Consistency Coordinator, Kelie.Moore@dnr.ga.gov

Moore, Kelie

From: Moore, Kelie
Sent: Tuesday, March 23, 2021 8:57 AM
To: Garvey, Kimberly L CIV USARMY CESAS (US)
Cc: Haymans, Doug; Andrews, Jill; Dodd, Mark; Lee, Jason
Subject: BHMS Federal Consistency Additional Information Request: Pre-Construction Risk Assessment & Annual Proposed Project List for Georgia

Under the 1997 SARBO, USACE retained flexibility, within defined seasonal dredging windows, to decide when and where project would occur and the equipment type used for a particular project. USACE SAD developed a *Risk Assessment and Risk Management Plan* to help guide the decision-making process and to address circumstances which may have contributed to incidental take. The Plan included documenting how required hopper dredging conditions were met, etc. (2020 SARBO page 69, Section 2.9.2.1 History of Adaptive Management). This Plan has been used post-project to inform the adaptive management process.

The 2020 SARBO **formalizes and expands** the risk assessment process by outlining a 4-step process that includes a **pre-project assessment** (2020 SARBO page 70, Section 2.9.2.2 SARBO Risk Assessment and Risk Management Process): Assessment Step 1: Determine the list of upcoming projects expected and pre-construction risk assessment. Each fiscal year, USACE and/or BOEM will compile a list of projects proposed for the next year and beyond (e.g. projects proposed for the next 1-5 years), **including relevant minimization measures based on the pre-construction risk assessment results**. The final project timing and risk assessment will be developed and **maintained** by USACE and/or BOEM. Timing of upcoming projects will minimize the risk of impacts to ESA-listed species by considering the risk to ESA-listed species proposed by particular projects based on **project-specific timing**, location, and equipment used. Suggested minimization measures consider when, where, and what equipment could be used to reduce take based on species use of an area.

We request a copy of the list of Georgia's upcoming projects and the pre-construction risk assessment, including the relevant minimization measures, for the Brunswick Harbor Modification Study/O&M dredging. Nothing has been provided to date that predicts risk to Georgia's Northern Recovery Unit Loggerhead sea turtles will be reduced, or at least not increased, by dredging outside the 'traditional' cold water dredge windows. If these items are not yet available, please let us know a timeframe when you expect them to be completed. If they have been completed but you prefer not to give us a copy, please provide justification. Thank you for your continued discussions on this project.

Kelie Moore
Federal Consistency Coordinator
Coastal Resources Division
(912) 264-7218 | (912) 262-2334
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Moore, Kelie

From: Moore, Kelie
Sent: Tuesday, March 30, 2021 3:06 PM
To: Garvey, Kimberly L CIV USARMY CESAS (US); Richards, Mary E CIV USARMY CESAS (USA)
Cc: Dodd, Mark; Haymans, Doug; Andrews, Jill; Lee, Jason
Subject: BHMS Federal Consistency Additional Information Request: Regional Dredging Contract
Attachments: Notification of Regional Dredging Contract.pdf

Good Afternoon Kim and Mary:

The Corps requested comments in May 2017 regarding the proposed solicitation of a pilot regional contract for maintenance dredging of 5 entrance channels in Georgia, South Carolina and North Carolina (refer to attached). Was a regional dredging contract ever awarded for this pilot project and/or were/are there subsequent reginal dredging contracts in place within the South Atlantic Division? Please provide a copy of the most recent regional dredging contract if one exists. Thank you.

Kelie Moore
Federal Consistency Coordinator
Coastal Resources Division
(912) 264-7218 | (912) 262-2334
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Moore, Kelie

From: Karla Reece - NOAA Federal <karla.reece@noaa.gov>
Sent: Wednesday, March 31, 2021 12:25 PM
To: Moore, Kelie
Cc: Garvey, Kimberly L CIV USARMY CESAS (US); Haymans, Doug; Andrews, Jill; Dodd, Mark; Lee, Jason; Bonine, Nicole CIV USARMY CESAD (US)
Subject: Re: BHMS Federal Consistency Additional Information Request: ESA Consultation Request Letter

CAUTION: This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Hi Kelie,
Your requests are more appropriate for the USACE to respond to because you are requesting USACE documents. Implementation of the 2020 SARBO is the responsibility of the USACE. The decisions about how they chose to implement their work under the 2020 SARBO are being documented through their risk assessments and are discussed at our monthly coordination meetings. Additionally, we have annual meetings where we review all actions that were carried out under SARBO, lessons learned, and how work going forward will be carried out based on what was learned.

Note that I have added Nicole Bonine to this email, for her awareness.

Thank you,
Karla

I am 100% Teleworking due to Covid-19. Please email any questions or concerns for the most efficient response.

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Karla Reece-
Section 7 Team Lead
Interagency Cooperation Branch
Protected Resources
NOAA Fisheries | U.S. Department of Commerce
Southeast Regional Office
National Marine Fisheries Service
Office: 727/824-5348
email: karla.reece@noaa.gov

Section 7 Guidance Webpage - UPDATED URL
Action Agencies, want your consultations quicker? Check out the Expedited process!

On Tue, Mar 30, 2021 at 2:37 PM Moore, Kelie <Kelie.Moore@dnr.ga.gov> wrote:

> Good Afternoon Kim and Karla:

The 2020 SARBO indicates that the Corps of Engineers specifically proposed to dredge six channels in warmer months (2020 SARBO at page 321) when they requested the ESA Section 7 consultation from NMFS, rather than that NMFS made the recommendation to the Corps to dredge certain channels outside the traditional cold water months. We request a copy of the original ESA consultation request letter USACE provided to NMFS which resulted in the 2020 SARBO. Any background information, in addition to the NMFS Request, on how these particular 6 channels were selected to be proposed for warm water dredging is also requested.

We request this information, along with the Pre-Construction Risk Assessment requested from USACE March 23rd, at your earliest convenience in order to avoid an Objection of the Brunswick Harbor Modification Study project as described in 15 CFR 930.43(b): "If the State agency's objection is based upon a finding that the Federal agency has failed to supply sufficient information, the State agency's response must describe the nature of the information requested and the necessity of having such information to determine the consistency of the Federal agency activity with the enforceable policies of the management program." Thank you.

Kelie Moore
Federal Consistency Coordinator
Coastal Resources Division
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