Final

Essential Fish Habitat 5-Year Review for Atlantic Highly Migratory Species

Atlantic Highly Migratory Species Management Division

2015

Table of Contents

List of Tables

List of Figures

List of Acronyms

ABT	Atlantic bluefin tuna
Amendment 1	Amendment 1 to the 2006 Consolidated Atlantic Highly Migratory Species Fishery Management Plan
Amendment 2	Amendment 2 to the 2006 Consolidated Atlantic Highly Migratory Species Fishery Management Plan
Amendment 3	Amendment 3 to the 2006 Consolidated Atlantic Highly Migratory Species Fishery Management Plan
Amendment 5a	Amendment 5a to the 2006 Consolidated Atlantic Highly Migratory Species Fishery Management Plan
AP	Advisory Panel
ASFA	Aquatic Sciences and Fisheries Abstracts
ASMFC	Atlantic States Marine Fisheries Commission
ATCA	Atlantic Tunas Convention Act
BAYS	bigeye, albacore, yellowfin, and skipjack tunas
BFT	bluefin tuna
C	Celsius
CFL	Curved Fork Length
CFMC	Caribbean Fishery Management Council
CLIOTOP	climate impacts on top ocean predators
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CPUE	catch per unit effort
DEIS	Draft Environmental Impact Statement
EEZ	exclusive economic zone
EFH	essential fish habitat
FADs	fish aggregating devices
FAO	Food and Agriculture Organization
FEIS	Final Environmental Impact Statement
FL	fork length
FR	Federal Register
FMP	Fishery Management Plan
GIS	geographic information system
GOM	Gulf of Mexico
GSMFC	Gulf States Marine Fisheries Commission
GULFSPAN	Cooperative Gulf of Mexico Shark Pupping and Nursery Project
HAPC	habitat area of particular concern
HMS	highly migratory species
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICES	International Council for the Exploration of the Sea
IPCC	Intergovernmental Panel on Climate Change
LCS	large coastal sharks
LNG	liquefied natural gas
MAFMC	Mid-Atlantic Fishery Management Council
Magnuson-Stevens Act	Magnuson-Stevens Fishery Conservation and Management Act
mt	metric ton
mtDNA	mitochondrial DNA
NEFMC	New England Fishery Management Council

NEFSC	Northeast Fisheries Science Center
nm	nautical mile
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NWA	Northwest Atlantic
PSAT	pop-up satellite tag
SAFMC	South Atlantic Fishery Management Council
SCRS	Standing Committee on Research and Statistics
SCS	small coastal sharks
SEDAR	Southeast Data, Assessment, and Review
SEFSC	Southeast Fishery Science Center
SRT	Status Review Team
SST	sea surface temperature
TAC	total allowable catch
TL	total length
ww	whole weight

1 INTRODUCTION

The Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) includes provisions concerning the identification and conservation of essential fish habitat (EFH) (16 U.S.C. 1801 et seq.). EFH is defined in National Marine Fisheries Service (NMFS) implementing regulations as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." (50 CFR § 600.10) NMFS must identify and describe EFH, minimize to the extent practicable the adverse effects of fishing on EFH, and identify other actions to encourage the conservation and enhancement of EFH (§ 600.815).

EFH maps are presented online in the NMFS EFH Mapper (http://www.habitat.noaa.gov/protection/efh/habitatmapper.html). Federal agencies that authorize, fund, or undertake actions that may adversely affect EFH must consult with NMFS as required by section 305(b)(2) of the Magnuson-Stevens Act and where a state or interstate fishing activity adversely affects EFH, NMFS will consider that action to be an adverse effect and will provide EFH Conservation Recommendations to the appropriate state or interstate fishery management agency on that activity (§ 600.815(c)).

In addition to identifying and describing EFH for managed fish species, a review of information available on EFH must be completed at least once every five years, and EFH provisions must be revised or amended, as warranted (§ 600.815(a)(10)). The EFH 5-year review should evaluate published scientific literature, unpublished scientific reports, information solicited from interested parties, and previously unavailable or inaccessible data.

This document is a final 5-year review of EFH for Atlantic highly migratory species (HMS). Atlantic HMS, as defined in the Magnuson-Stevens Act, include tunas (bluefin, bigeye, albacore, yellowfin, and skipjack), oceanic sharks, swordfish, and billfishes (blue marlin, white marlin, sailfish, roundscale spearfish, and longbill spearfish). The purpose of this review is to gather all new information and determine whether modifications to existing EFH descriptions and delineations are warranted. If we have determined in this review that such modifications are warranted, then an amendment to the 2006 Consolidated Atlantic HMS Fishery Management Plan (FMP) will be initiated.

1.1 Background

NMFS issued two separate FMPs in April 1999 for the Atlantic HMS fisheries. The 1999 FMP for Atlantic Tunas, Swordfish, and Sharks (1999 FMP), combined, amended, and replaced previous management plans for swordfish and sharks, and was the first FMP for tunas. It identified and described EFH for Atlantic tunas, swordfish, and sharks. Habitat Areas of Particular Concern (HAPCs) were also identified and described for sandbar sharks (*Carcharhinus plumbeus*). Amendment 1 to the Billfish FMP updated and amended a 1988 Billfish FMP and identified and described EFH for billfishes. In both the 1988 FMP and Amendment 1 to the Billfish FMP, there were some billfish species for which insufficient information prevented identification and description of EFH, and in those cases, text descriptions and maps were not provided.

In November 2003, NMFS issued Amendment 1 to the 1999 FMP, which, among other things, updated EFH for five shark species due to changes in stock status (blacktip shark, *C. limbatus,* which was no longer overfished; sandbar shark, for which overfishing was occurring; and finetooth shark, *C. isodon*, for which overfishing was occurring) and due to new information that had become available at that time (dusky shark, *C. obscurus*, and nurse shark, *Ginglymostoma cirratum*). The focus of Amendment 1 to the 1999 FMP was a comprehensive review of management measures for Atlantic sharks and did not consider any changes to the management of tunas, swordfish, or billfish. No new HAPCs were implemented at that time, and NMFS did not update EFH for any of the other species in the HMS management unit.

NMFS began the comprehensive review (referred to as Phase 1) of all HMS EFH as part of the 2006 Consolidated Atlantic HMS FMP, which was released on July 14, 2006 (71 FR 40096). In that document, NMFS presented new EFH information and data collected since 1999, including an evaluation of fishing gear impacts, and requested public comment on any additional data or information that needed to be included in the review. The purpose of the EFH review was to gather any new information and determine whether modifications to existing EFH descriptions and delineations were warranted. The 2006 Consolidated Atlantic HMS FMP included the first comprehensive review of all new information related to EFH that had been completed since 1999.

As part of the comprehensive review under Phase 1, NMFS searched for all new literature and information to assess habitat use and ecological roles of HMS EFH. Published and unpublished scientific reports, fishery dependent and independent datasets, and expert and anecdotal information detailing the habitats used by the managed species were evaluated and synthesized for inclusion in the review process and are described in Chapter 10 of the 2006 Consolidated Atlantic HMS FMP. Based on this evaluation, NMFS determined that modification to existing EFH for some species and/or life stages was warranted, and that any changes to EFH, including new HAPCs and potential measures to minimize fishing impacts, should be considered in a separate amendment (referred to as Phase 2). NMFS also conducted a comprehensive review of all federally- and non-federally managed fishing gears that formed the basis for further analysis on gear impacts.

Several HMS actions have directly identified EFH in the past five years, including Amendments 1 and 3 and an interpretive rule and final action on roundscale spearfish. All EFH text descriptions and maps previously provided in separate documents (e.g., the 1999 FMP, Amendment 1 to the Billfish FMP (1999), and Amendment 1 to the 1999 FMP (2003)) were combined in the 2006 Consolidated Atlantic HMS FMP. In 2009, NMFS completed Phase 2 of the 5-year review and update of EFH for Atlantic HMS in Amendment 1 to the 2006 Consolidated Atlantic HMS FMP (Amendment 1; June 12, 2009; 74 FR 28018). In Amendment 1, NMFS updated and revised existing identifications and descriptions of EFH for Atlantic HMS, designated a HAPC for bluefin tuna in the Gulf of Mexico, and analyzed fishing and non-fishing impacts on EFH pursuant to Section 305(b) of the Magnuson-Stevens Act.

Amendment 3 to the 2006 Consolidated HMS FMP (Amendment 3; June 1, 2010; 75 FR 30484) added the smoothhound shark management group to the Atlantic HMS management unit and designated EFH for the group. Details, including a map of the final EFH, are available in Chapter 11 of Amendment 3.

An interpretive rule and final action (September 22, 2010; 75 FR 57698) added roundscale spearfish (*Tetrapturus georgii*) to the Atlantic HMS management unit and defined its EFH. Roundscale spearfish and white marlin were previously managed as one species and historic data on habitat distribution likely included both species; therefore, the designation of roundscale spearfish EFH was the same as the designation of EFH for white marlin in Amendment 1.

On March 24, 2014, NMFS published a notice of initiation of 5-year EFH review and request for information (79 FR 15959). NMFS also solicited new information from HMS consulting parties, the HMS Advisory Panel (a group established by Magnuson-Stevens Act to advise the Secretary of Commerce on FMPs and plan amendments for HMS), and other interested parties. NMFS published a Federal Register notice announcing the availability of the draft EFH 5-year review for Atlantic HMS on March 5, 2015 (80 FR 11981), and requested public comment on the draft. The draft was also presented to, and discussed by, the HMS AP at the 2015 spring meeting.

This 5-year review considers environmental and management changes and new information since 2009. It evaluates and syntheses new information, including published and unpublished scientific reports, fishery dependent and independent datasets, public comments, and expert and anecdotal information detailing the habitats used by Atlantic HMS.

Table 1.1 Management History for Atlantic HMS Essential Fish Habitat

FMP or Amendment	EFH and Species
1999 FMP for Atlantic Tunas, Swordfish, and Sharks	EFH first identified and described for Atlantic tunas, swordfish and sharks; HAPCs designated sandbar sharks
1999 Amendment 1 to the Billfish FMP	EFH first identified and described for Atlantic billfish
2003 Amendment 1 to the FMP for Atlantic Tunas, Swordfish and Sharks	EFH updated for five shark species (blacktip, sandbar, finetooth, dusky, and nurse sharks)
2006 Consolidated Atlantic HMS FMP	Comprehensive review of EFH for all HMS. EFH for all Atlantic HMS consolidated into one FMP; no changes to EFH descriptions or boundaries
2009 Amendment 1 to the 2006 Consolidated Atlantic HMS FMP	EFH updated for all federally managed Atlantic HMS. HAPC for bluefin tuna spawning area designated in the Gulf of Mexico

2010 Amendment 3 to the 2006 Consolidated Atlantic HMS FMP	EFH first defined for smoothhound sharks
2010 White Marlin/ Roundscale Spearfish Interpretive Rule and Final Action	EFH first defined for roundscale spearfish (same as white marlin EFH designation in Amendment 1 to the 2006 Consolidated Atlantic HMS FMP)

Source: NMFS, 2014.

2 APPROACH

The results of the 2015 5-year Atlantic HMS EFH review are documented in this final report. The review included evaluating new information on Atlantic HMS EFH, recommendations for revisions to Atlantic HMS EFH, and identifying information gaps and research needs. New information, including, but not limited to, information on the biology, distribution, habitat requirements, life history characteristics, migratory patterns, spawning, pupping, and nursery areas of Atlantic HMS along with fishing and non-fishing impacts to EFH were taken into consideration in this review, and will be used to update EFH ranges and text descriptions in an upcoming amendment to the 2006 Consolidated HMS FMP. The review fulfills the regulatory requirement to complete a 5-year review of EFH. This report will be released to the public and posted to the Atlantic HMS Management Division website.

2.1 Steps Used to Complete and Document the EFH Review

1. Evaluation of new information: NMFS reviewed each of the mandatory 10 EFH components (as enumerated at 50 CFR 600.815(a)(1)-(10)) for new data and other information available since Amendment 1 (2009); Amendment 3 (2010); and the 2010 interpretive rule and final action that defined EFH for roundscale spearfish.
    a. NMFS HMS Management Division staff served as the lead evaluators
    b. NMFS Science Center staff and other qualified individuals, such as AP Members, aided in the evaluation through:
        i. Identification of data gaps and new information; and
        ii. Review of a draft version of the 5-year review document.
2. Request for information/scoping: On March 24, 2014, NMFS published (79 FR 15959) an announcement of its 5-Year Review of EFH for Atlantic HMS requesting submission of data on Atlantic HMS EFH, and the effects of HMS fishing gear on EFH that has become available since 2009. On April 3, 2014, NMFS presented its EFH 5-Year Review Plan to the HMS AP and public at the 2014 Spring AP meeting and requested new information to support the review. A Federal Register notice announcing the availability of the Draft EFH 5-Year Review for Atlantic HMS was published on March 5, 2015 (80 FR 11981), and requested public comment on the draft. The draft was also presented to, and discussed by, the HMS AP at the 2015 Spring meeting.
3. Preparation of the Draft HMS EFH 5-Year Review:

    Contents of the review include:

    a. Review of 10 EFH components (Table 2.1), documentation of how the review was conducted, and identification of new information available that relates to each component.
    b. Recommendations by section regarding future analyses or need for amending the 2006 Consolidated HMS FMP. Identification of any changes to the 10 EFH components will result in an assessment of whether development of an FMP amendment is necessary, depending, in part, on whether the change is a

substantive change (e.g., a change in EFH description), or a non-substantive or minor technical one (e.g., minor changes to life history information).

4. Intra-agency scientific review: Before publishing the draft review, internal NMFS scientists reviewed the document and provided information and updates that were included in the draft review.
5. Comments on the Draft 5-Year Review: The draft review was made available to the public and the HMS AP for comment. Commenters were invited to provide recommendations as to whether the individual species reviews are accurate and complete, and whether the available new information warrants revision to the EFH text in the 2006 Consolidated HMS FMP.
6. Final 5-Year Review: NMFS has addressed public and HMS AP comments on the Draft 5-Year Review and has determined that revisions to HMS EFH are warranted based on available information.

Table 2.1 HMS 5-year Review Plan for EFH Components as defined in the Contents of Fishery Management Plans (50 CFR 600.815)

EFH FMP Component	Review Plan
1. Description and Identification of EFH	Identify and evaluate new scientific literature and information from other relevant sources to see whether species-specific EFH description and identification, as written in the FMP, is correct. Suggest edits to the FMP text as appropriate.
2. Fishing activities that may adversely affect EFH	Review whether there have been changes in or newly available information on fishing activities that may adversely affect EFH. Identify sources of information that may influence analysis of the impact of these fishing activities.
3. Non-Magnuson-Stevens Act fishing activities that may adversely affect EFH	Review whether there have been changes in current Non-Magnuson-Stevens Act fishing (e.g., state water fisheries), compared to the EFH analysis. Identify sources of information that may influence analysis of the impact of these fishing activities.
4. Non-fishing related activities that may adversely affect EFH	Review whether there have been changes to or newly available information on non-fishing activities affecting habitat since the EFH analysis. Identify sources of information that may influence analysis of the impact of these fishing activities.
5. Cumulative impacts analysis	Review cumulative impacts discussion in FMPs and evaluate against new information.
6. Conservation and enhancement	Review EFH recommendations for fishing and non-fishing activities and evaluate against new information to see whether updates are warranted.
7. Prey species	Review prey species information and determine if updates are warranted.
8. Identification of HAPC	As appropriate, based on species-specific review of EFH, evaluators may suggest revisions to existing or new candidate HAPCs.

9. Research and information needs	Based on review of new information in Component 1, review research and information needs, and determine whether updates to EFH research needs identified in the FMP are warranted.
10. Review and revision of EFH components of FMPs	Final document represents EFH 5-Year Review.

2.2 Revision of EFH text and management measures

Upon completion of the Final 5-Year Review, we have determined that updates to HMS EFH are warranted and an amendment to the 2006 Consolidated Atlantic HMS FMP will be undertaken.

In our review of new information since 2009, some new data emerged for certain species, which warrants revision to those species' EFH. For other species, new data were either unavailable or we determined that the data did not warrant revisions to EFH. Please see Sections 4 through 11 for detailed species literature reviews. We will update EFH boundaries based on new observer, survey, and tag/recapture data collected since 2009 for all species.

We also determined through this process that the current EFH delineation methodology (Kernal Density Estimation / 95 Percent Volume Contour approach) is still appropriate to delineate Atlantic HMS EFH. The current EFH methodology was first applied in Amendment 1, but Atlantic HMS EFH has not been updated using this methodology. Therefore, it is unknown how data since 2009 that have been consistently collected over time (e.g., observer, survey, tag/recapture) will impact EFH boundaries. Therefore, we have decided to update all Atlantic HMS EFH to see how these data will impact EFH boundaries, even for species where there was limited or no new EFH data found in the literature review. Please see Section 15 for a detailed review of EFH delineation methodologies.

The upcoming amendment to the 2006 Consolidated HMS FMP will consider all ten EFH components, including individual species EFH descriptions, EFH conservation and enhancement recommendations for fishing and non-fishing effects on EFH, and identification of HAPCs, as well as scientific feedback and public comment. Where appropriate, text descriptions of life history and behavior will be updated in that amendment to include new information about these species in the high seas and territorial waters of other sovereign nations. However, NMFS only has legal authority to designate EFH in the EEZ of the United States. NMFS does not have the legal authority to designate EFH in the high seas or in the territorial waters of other sovereign nations.

3 RECENT ENVIRONMENT AND MANAGEMENT CHANGES

3.1 Environmental and Habitat Changes Since 2009

Since 2009, large-scale environmental and habitat changes have occurred that may have impacted HMS EFH.

3.1.1 Deepwater Horizon

On April 20, 2010, an explosion and subsequent fire damaged the Deepwater Horizon MC252 oil rig, which capsized and sank approximately 50 miles southeast of Venice, Louisiana. Oil flowed for 86 days into the Gulf of Mexico from a damaged wellhead on the seafloor. In response to the Deepwater Horizon MC252 oil spill, NMFS issued a series of emergency rules (75 FR 24822, May 6, 2010; 75 FR 26679, May 12, 2010; 75 FR 27217, May 14, 2010) closing a portion of the Gulf of Mexico exclusive economic zone (EEZ) to all fishing and analyzed the environmental impacts of these closures in an Environmental Assessment. Between May and November 2010, NMFS closed additional portions of the Gulf of Mexico to fishing. The maximum closure was implemented on June 2, 2010, when fishing was prohibited in approximately 37 percent of the Gulf of Mexico EEZ. Significant portions of state territorial waters in Alabama (40%), Florida (2%), Louisiana (55%), and Mississippi (95%) were closed to fishing (Upton, 2011). After November 15, 2010, approximately 0.4 percent (1,041 square miles) of the federal fishing area was kept closed immediately around the Deepwater Horizon wellhead through April 19, 2011, when the final oil spill closure area was lifted (NOAA 2011).

Water quality degradations from the oil and dispersants used in the clean-up could have impacted or could continue to impact HMS EFH. Available information indicates that Deepwater Horizon oil and/or dispersants may have impacted bluefin tuna. Muhling et al. (2012) studied the overlap between Atlantic bluefin tuna spawning grounds and observed Deepwater Horizon surface oil in the northern Gulf of Mexico, and their preliminary estimate of the effects of the spill on larval bluefin mortality concluded that less than 12% of larval bluefin were predicted to have been located within contaminated waters in the northern Gulf of Mexico, on a weekly basis. Studies also found that oil samples from the Deepwater Horizon spill had the potential to impact cardiac development in bluefin tuna embryos (Incardona et al. 2014) and the function of in vitro juvenile bluefin tuna heart cells (Brette et al. 2014).

NOAA continues to study and assess the impacts of the oil spill. For more information about Deepwater Horizon oil spill and restoration efforts, please visit http://www.restorethegulf.gov/. The Deepwater Horizon oil spill Natural Resource Damage Assessment Trustees (Trustees) released a draft plan on May 20, 2015, that proposes 10 early restoration projects across the Gulf of Mexico states at an estimated cost of $134 million. One project would reduce bycatch of pelagic fish across the Gulf of Mexico, two of the projects would enhance bird nesting habitat, four projects would improve nearshore and reef habitats, two projects would enhance recreational opportunities on federal lands, and one project would reduce sea turtle mortality. For more information about the Draft Plan, please visit www.gulfspillrestoration.noaa.gov.

3.1.2 Climate Change

Oceanographic changes resulting from climate change can result in subtle, ongoing changes to HMS distribution and EFH. Since HMS EFH is associated with water column conditions rather than benthic habitat, HMS may be particularly sensitive to changes in water temperature, current, and chemistry. For more information about climate change impacts to Atlantic HMS EFH, please see Chapter 13.

3.1.3 Seismic Surveys / Oil and Gas Exploration

NMFS has conducted the following recent EFH consultations on seismic research activities pursuant to requirements of the Magnuson-Stevens Act.

1) In response to a consultation request from Columbia's Lamont-Doherty Earth Observatory (LDEO) to conduct seismic survey research, the NMFS Office of Habitat Conservation determined in a June 18, 2014, letter that some level of adverse impact to EFH may occur as a result of seismic surveys proposed in research conducted in Atlantic EEZ waters off New Jersey. However, NMFS was unable to offer specific EFH conservation recommendations for fish and benthic organisms because most seismic testing research to date has been focused on marine mammals.

2) The Bureau of Ocean Energy Management (BOEM) issued a Final Programmatic Environmental Impact Statement (PEIS) in February 2014 that assessed potential environmental impacts associated with the authorization of geological and geophysical survey activity in the Mid- and South-Atlantic outer continental shelf regions and adjacent state waters. The final PEIS, and supporting documentation, can be found at the following website: http://www.boem.gov/Atlantic-G-G-PEIS/. The analysis in the PEIS included some Atlantic HMS in these regions (sharks and tunas but not billfish or swordfish) as part of an overall analysis of the effects on marine fisheries resources.

   NMFS and NOAA provided comments to BOEM regarding the PEIS (see pages 15-19 of the document located at: http://www.boem.gov/uploadedFiles/BOEM/Oil_and_Gas_Energy_Program/GOMR/AtlGGCommentsFedStaLoc.pdf.

   As of May 15, 2015, BOEM had received 10 applications for oil and gas exploration activities (including the use of seismic surveys). A list of current applications is available at the following website: http://www.boem.gov/Currently-submitted-Atlantic-OCS-Region-Permits/.

3) BOEM is in the process of developing a PEIS to assess potential environmental impacts associated with the authorization of geological and geophysical survey activity in the Gulf of Mexico outer continental shelf regions and adjacent state waters. Analysis documents are not currently published online. Scoping documents, a project schedule, and other resources may be found at the following website: http://www.boem.gov/Gulf-of-Mexico-Geological-and-Geophysical-Activities-Programmatic-EIS/. NMFS and/or NOAA will likely provide consultation and comment on this PEIS in the future.

For more information about seismic survey impacts to Atlantic HMS EFH, please see Chapter 13.

3.2 Management Changes

3.2.1 EFH Conservation Actions Since 2009

Since 2009, a number of actions were implemented across multiple levels of government to address EFH concerns. The following sections review EFH actions during that period.

States and Territories

Many individual states and territories in the Atlantic, Gulf of Mexico, and U.S. Caribbean take EFH into consideration when developing fishery management measures. Through the Atlantic States Marine Fisheries Commission (ASMFC), Atlantic states consider habitat impact under all Interstate FMPs. The ASMFC has a Habitat Committee that works to identify, enhance, and cooperatively manage vital fish habitat. At this time, the only coordinated HMS management under the ASMFC is for coastal sharks. The Coastal Sharks Interstate FMP was finalized in August 2008 but has been updated through three addendums in September 2009, May 2013, and October 2013. Under the 2008 Coastal Sharks Interstate FMP, a seasonal shark closure is required. Recreational and commercial fishermen are prohibited from possessing silky, tiger, blacktip, spinner, bull, lemon, nurse, scalloped hammerhead, great hammerhead, and smooth hammerhead sharks in the state waters of Virginia, Maryland, Delaware and New Jersey from May 15 through July 15, regardless of where the shark was caught. This closure was to protect sandbar sharks in nursery grounds.

The Gulf States Marine Fisheries Commission (GSMFC) provides recommendations to states along the Gulf of Mexico to help coordinate state fisheries management. At this time, the GSMFC has not recommended specific action to address HMS EFH.

Federal: Councils

Five Fishery Management Councils have jurisdiction overlapping with Atlantic HMS: the New England Fishery Management Council (NEFMC), the Mid-Atlantic Fishery Management Council (MAFMC), the South Atlantic Fishery Management Council (SAFMC), the Gulf of Mexico Fishery Management Council (GMFMC), and the Caribbean Fishery Management Council (CFMC). These councils manage federal non-HMS fisheries and sometimes develop habitat protection measures that can impact HMS EFH.

In 1998, the NEFMC prepared an Omnibus Habitat Amendment to designate EFH for species under their jurisdiction. The Amendment also examined ways to minimize adverse impacts to EFH caused by fishing activities and identifies other actions to encourage the conservation and enhancement of EFH for Council-managed species. The NEFMC is in the process of developing Omnibus Habitat Amendment 2, but the amendment has not yet been finalized.

In 2012, the MAFMC began development of Amendment 16 to the Atlantic Mackerel, Squid, and Butterfish FMP to protect deep sea corals and sponges from fishing gears that interact with benthic habitat. This Amendment has not yet been finalized. The Atlantic mackerel, squid, and butterfish fisheries sometimes use gear types that are also used when targeting HMS (e.g., gillnet), thus, the amendment could impact some HMS fisheries, but HMS EFH is unlikely to be affected because it does not alter conditions in the water column.

The SAFMC published a comprehensive Habitat Plan in 1998 for all species under its jurisdiction. Since then, the Council moved away from specific habitat and EFH plans, instead focusing on Fishery Ecosystem Plans. First published in 2009 and amended in 2011, the Fishery Ecosystem Plans take a holistic approach to management rather than focusing on individual species. As such, the plans include provisions to protect habitat and designate EFH for Council-managed species. The Council has also developed two FMPs that directly manage the removal of living habitat: corals and *Sargassum*. The Coral FMP was originally published in 1982 and has since been amended six times, most recently in 2010. Currently, the SAFMC is again amending the Coral FMP to expand several coral HAPCs. Within the coral HAPCs, the possession of coral species is prohibited, and the use of all bottom-damaging gear is prohibited, including bottom longline, trawl (bottom and mid-water), dredge, pot or trap, or the use of an anchor, anchor and chain, or grapple and chain by all fishing vessels. That amendment is not finalized. The SAFMC also implemented a *Sargassum* FMP, regulating the removal of sargassum for commercial use. *Sargassum* provides important habitat for a number of species, including HMS. The *Sargassum* FMP was published in 2002 and was amended in 2012.

The GMFMC has amended all EFH for species under their jurisdiction three times, most recently in 2005. Since then, the GMFMC completed a 5-year review of Council species' EFH in 2010. The Amendments and review describe EFH across different life stages for each species. They also analyze fishing impacts to EFH for Council-managed species and make recommendations to minimize impacts from non-fishing threats.

The CFMC finalized the EFH Generic Amendment in 2004 and completed a 5-year review in 2011. Similar to the other Councils, this Amendment and 5-year review designated EFH for Council-managed species and analyzed both fishing and non-fishing impacts.

Federal: HMS Management Division

Since finalizing Amendment 1 in 2009, NMFS designated smoothhound shark and roundscale spearfish EFH in two other actions. More information on these actions can be found in Section 1.1. More information about shark EFH can be found in Chapter 7. More information about billfish EFH can be found in Chapter 6.

Federal: National Ocean Policy

On July 19, 2010, President Obama signed Executive Order 13547 National Policy for the Stewardship of the Ocean, Our Coasts, and the Great Lakes. Recognizing the importance of ocean and Great Lakes resources to the country, the National Ocean Policy outlined broad initiatives for protection and remediation and ordered the development of the National Ocean Council. The National Ocean Council was tasked with translating the broad initiatives into action, culminating in the National Ocean Policy Implementation Plan, published in April 2013 (www.whitehouse.gov/sites/default/files/national_ocean_policy_implementation_plan.pdf). Several of the actions in the Implementation Plan could impact HMS EFH, in particular the Coastal and Ocean Resilience and Science and Information initiatives. The Coastal and Ocean Resilience initiative will protect and restore important habitats such as coastal wetlands and improve coastal water quality; both which support commercial fisheries. The Science and Information initiative will enhance our understanding of ocean and coastal systems through increased data collection and research. This enhanced understanding will support ecosystem-based management including EFH protection and designation. Although the National Ocean Policy does not currently provide information that necessitates a reexamination of HMS EFH, it could in the future.

3.3 Conclusions

At this time, environmental and management changes since 2009 are not cause for re-evaluating HMS EFH. Although the Deepwater Horizon oil spill event could have impacted bluefin tuna, impacts would have occurred in the larval stage and effects would not likely be evident until the affected cohort grows to later life stages. Any new information about impacts from the Deepwater Horizon oil spill and climate change will need to be monitored for information relevant to Atlantic HMS and the 2006 Consolidated HMS FMP. Similarly, management measures affecting HMS EFH will also need to be considered during any subsequent HMS 5-Year EFH Reviews.

3.4 Literature Cited

Brette F, Machado B, Cros C, Incardona JP, Scholz NL, Block BA. 2014. Crude oil impairs cardiac excitation-contraction coupling in fish. Science 343: 772-775.

Incardona JP, Gardner LD, Linbo TL, Brown TL, Esbaugh AJ, Mager EM, Stieglitz JD, French BL, Labenia JS, Laetz CA, et al. 2014. Deepwater Horizon crude oil impacts the developing hearts of large predatory pelagic fish. PNAS 111(15): 1510-1518. doi:10.1073/pnas.1320950111

Muhling, B.A., M.A. Roffer, J.T. Lamkin, G.W. Ingram Jr., M.A. Upton, G. Gawlikowski, F. Muller-Karger, S. Habtes, W.J. Richards. 2012. Overlap between Atlantic bluefin tuna spawning grounds and observed Deepwater Horizon surface oil in the northern Gulf of Mexico. Mar. Poll. Bull. 64(4): 679-687.

NOAA. 2011. NOAA: All federal waters of the Gulf of Mexico once closed to fishing due to spill now open. Press Release. Available at: http://www.noaanews.noaa.gov/stories2011/20110419_gulfreopening.html.

Upton HF. 2011. The Deepwater Horizon oil spill and the Gulf of Mexico fishing industry. Congressional Research Service (R41640; February 17, 2011).

.

4 ATLANTIC TUNAS

The following sections review and itemize new information (post-2009) on life history, behavior, distribution and habitat for Atlantic tunas managed by the Atlantic HMS Management Division of NMFS that could be used to update EFH boundaries and text descriptions. Unless otherwise noted, this information is intended to 1) supplement the text descriptions of life history, behavior, and EFH presented in Amendment 1; and 2) itemize possible new sources of data that could be incorporated into EFH updates for the species.

Original text descriptions of life history, behavior and essential fish habitat may be found in Chapter 5 of Amendment 1: http://www.nmfs.noaa.gov/sfa/hms/documents/fmp/am1/index.html.

4.1 Atlantic Bigeye Tuna, (*Thunnus obesus*)

The U.S. Atlantic bigeye tuna fisheries are managed under the 2006 Consolidated Atlantic HMS FMP. Implementing regulations are issued under the authority of the Magnuson-Stevens Act and Atlantic Tuna Convention Act (ATCA).

4.1.1 Summary of EFH Review

Recent Changes to Management Structure

Since Amendment 1, the Atlantic bigeye tuna stock was last assessed by ICCAT's SCRS in 2010. The 2010 stock assessment showed some improvement from previous assessments (B_{09}/B_{msy} median value was 1.01, up from B_{06}/B_{msy} median value of 0.92.). The SAFE reports from 2009 and in 2013 both consider the stock as not overfished (rebuilding) and overfishing not occurring. Information on the past stock assessment is available on the ICCAT SCRS website at: https://www.iccat.int/en/assess.htm. Domestic stock status information is available in the annual HMS SAFE Report at: http://www.nmfs.noaa.gov/sfa/hms/documents/safe_reports/index.html.

In 2009, ICCAT Recommendation 09-01 reduced the total allowable catch from 90,000 mt (Rec. 04-01) to 85,000 mt overall throughout the entire Atlantic. Subsequently in 2010 and 2011 ICCAT Recommendations 10-01 and 11-01 maintained the overall 85,000-mt total allowable catch. If this overall quota is exceeded, ICCAT may revisit and revise the current recommendation for Atlantic bigeye tuna. Also, Recommendation 11-01 included an expanded time/area closure in the Gulf of Guinea.

Summary of New Literature

- Zhu et al. (2013) studied bigeye tuna captured in the Chinese longline fishery in the central Atlantic Ocean and found that the growth rate in the central Atlantic is slightly higher than in the eastern Atlantic.

Recommendations for EFH based on new information

Although some updates to the life history information were found for Atlantic bigeye tuna, they were minor and do not support the need for any further review of EFH boundaries for any life stages of bigeye tuna. However, we will update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

4.1.2 Literature Cited

Zhu G, Xu L, Zhou Y, Chen X. 2013. Growth and mortality rates of bigeye tuna *Thunnus obesus* (Perciformes: Scombridae) in the central Atlantic Ocean. J Trop Biol, 57(1-2): 79-88.

4.2 West Atlantic Skipjack Tuna (*Katsuwonus pelamis*)

The U.S. West Atlantic skipjack tuna fisheries are managed under the 2006 Consolidated Atlantic HMS FMP. Implementing regulations are issued under the authority of the Magnuson-Stevens Act and ATCA.

4.2.1 Summary of EFH Review

Recent Changes to Management Structure

Since Amendment 1, the West Atlantic skipjack tuna stock was assessed by the ICCAT SCRS in 2014 and the biomass estimate was estimated as probably close to 1.3 B_{2013}/B_{msy} and fishing mortality estimate was estimated as probably close to 0.7. Information on this and past stock assessment results is available on the ICCAT SCRS website at: https://www.iccat.int/en/assess.htm. Domestic stock status information is available in the annual HMS SAFE Reports at: http://www.nmfs.noaa.gov/sfa/hms/documents/safe_reports/index.html

The West Atlantic skipjack tuna is not currently managed under a domestic quota. ICCAT has not adopted any management measures specifically designed for the West Atlantic skipjack tuna stock, including total allowable catch level. Even though no limits have been set on the harvest of West Atlantic skipjack tuna, the SCRS considers the current harvest of West Atlantic skipjack tuna below the maximum sustainable yield.

Summary of New Literature

- Dueri et al. (2014) used modeling to predict changes in abundance and spatial distribution of skipjack tuna throughout the world's oceans in response to climate change. Models predicted that the current distribution of skipjack tuna would shift northward or southward depending on the hemisphere. These shifts could cause a change to skipjack EFH, particularly spawning areas; however, these environmental changes may not occur for many years. The models also predicted that the abundance of skipjack tuna would increase within the first half of the next century but decline in the last half.
- Muhling et al. (2015) combined predictive habitat models with a downscaled climate model to examine potential impacts of climate change on adult and larval skipjack tuna (and bluefin tuna) in the Intra-Americas Seas (i.e., Caribbean Sea and Gulf of Mexico). The authors found that in contrast to bluefin tuna, habitat suitability for skipjack tended to increase as temperatures warmed. Skipjack models were also found to contain a higher degree of misclassification at higher temperatures, resulting in considerable uncertainty around future projections.
- Wang et al. (2012) conducted an analysis of fish aggregating devices (FADs) on the size structures of schools of skipjack tuna. This study found that open water schools of skipjack tended to be formed by fish of similar sizes. Conversely, schools around FADs tended to be formed of mixed size schools of skipjack. This may be important in fisheries in the Gulf of Mexico due to oil rigs. Targeting mixed schools can increase the mortality of juvenile individuals.

Recommendations for EFH based on new information

Although some updates to the life history and distribution information were found for West Atlantic skipjack tuna, they were minor and do not support any further review of EFH boundaries for any life stages for this species. However, we will update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

4.2.2 Literature Cited

Dueri S, Bopp LT, Maury O. 2014. Projecting the impacts of climate change on skipjack tuna abundance and spatial distribution. Global Chang Biol 20: 742-753.

Muhling, BA, Liu Y, Lee SK, Lamkin JT, Roffer MA, Muller-Karger F, Walter III JF. 2015. Potential impact of climate change on the Intra-Americas Sea: Part 2. Implications for Atlantic bluefin tuna and skipjack tuna adult and larval habitats. J Mar Sys 148(2015): 1-13.

Wang X, Xu L, Chen Y, Zhu G, Tian S, Zhu J. 2012. Impacts of fish aggregation devices on size structures of skipjack tuna *Katsuwonus pelamis*. Aquat Ecol. 46: 343-352.

4.3 North Atlantic Albacore Tuna (*Thunnus alalunga*)

The U.S. North Atlantic albacore tuna fisheries are managed under the 2006 Consolidated Atlantic HMS FMP. Implementing regulations are issued under the authority of the Magnuson-Stevens Act and ATCA.

4.3.1 Summary of EFH Review

Recent Changes to Management Structure

Since Amendment 1, there have been changes in the management of North Atlantic albacore tuna, specifically changes to the total allowable catch of north Atlantic albacore tuna.

The North Atlantic albacore tuna stock was last assessed by ICCAT SCRS in 2013, and NMFS has determined the stock is not overfished ($SSB_{current}/SSB_{MSY}$ value is 0.94; rebuilding status ranges from 0.74-1.14) and is not experiencing overfishing. Information on the past stock assessment result is available on the ICCAT SCRS website at: https://www.iccat.int/en/assess.htm. Domestic stock status information is available in the annual HMS SAFE Reports at: http://www.nmfs.noaa.gov/sfa/hms/documents/safe_reports/index.html

ICCAT Recommendation 09-05 was the first step ICCAT took to initiate a rebuilding plan for northern albacore. This recommendation included an overall total allowable catch of 28,000 mt for the North Atlantic stock, and it included a quota of 527 mt for U.S. fisheries. In 2013, ICCAT Recommendation 13-05 maintained the rebuilding plan for North Atlantic albacore through 2016.

Summary of New Literature

- Lezama-Ochoa et al. (2010) investigated the importance of prey presence in the Bay of Biscay for juvenile albacore tuna. An increase in the presence of anchovy caused a significant increase in the catch per unit effort (CPUE) of albacore tuna in the bay. The study also determined that the sea surface temperature had a large influence on the presence of albacore tuna in the bay. Climate change could play a role in the use of the

Bay of Biscay by albacore tuna. This aspect of climate change has been confirmed by research completed by Dufour (2010).

Recommendations for EFH based on new information

Although some updates to the life history for juvenile Atlantic albacore tuna were found, they were minor and do not support any further review of EFH boundaries for any life stages for this species. However, we will update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

4.3.2 **Literature Cited**

Dufour F, Arnizabalaga H, Irigoien X, Santiago J. 2010. Climate impacts on albacore and bluefin tunas migrations phenology and spatial distribution. Prog in Oceanog 86: 283-290.

Lezama-Ochoa A, Boyra G, Goni N, Arnizabalaga H, Bertrand A. 2010. Investigating relationships between albacore tuna (*Thunnus alalunga*) CPUE and prey distribution in the Bay of Biscay. Prog in Oceanog 86: 105-114.

4.4 Atlantic Yellowfin Tuna (*Thunnus albacares*)

The U.S. Atlantic yellowfin tuna fisheries are managed under the 2006 Consolidated Atlantic HMS FMP. Implementing regulations are issued under the authority of the Magnuson-Stevens Act and ATCA.

4.4.1 **Summary of EFH Review**

Recent Changes to Management Structure

Since Amendment 1, no changes in management have occurred for Atlantic yellowfin tuna.

The Atlantic yellowfin tuna stock was last assessed by ICCAT SCRS in 2011, and NMFS has determined that it is not overfished (B_{10}/B_{MSY} median value is 0.85; rebuilding status ranges from 0.61-1.12) with no overfishing occurring. Information on the past stock assessment result is available on the ICCAT SCRS website at: https://www.iccat.int/en/assess.htm

The Atlantic yellowfin tuna is currently not managed under a domestic quota. Under Recommendation 11-01, ICCAT has set a total allowable catch of 110,000 mt. If this overall quota is exceeded, ICCAT may revisit and revise the current recommendation for Atlantic yellowfin tuna.

Summary of New Literature

- Juan-Jorda et al. (2013) characterized the different life history patterns of some scombrids (including yellowfin tuna) and the traits explaining such variability. Results show that most species were ranked along a slow-fast continuum of life histories, explained by body size and time-related traits (such as longevity, growth rates, spawning duration). Yellowfin tuna was characterized by their large size, short-lived, and fast growing traits.
- Hoililhan et al. (2014) confirmed that yellowfin tuna in the Gulf of Mexico tend to make a higher number of vertical movements above the thermocline rather than below.

Yellowfin tuna were also observed making longer movements throughout the Gulf of Mexico.

- Weng et al. (2009) investigated the habitat use, behavior and movement patterns of yellowfin tuna using pop-up satellite archival tagging data in the Gulf of Mexico. The study found a diel pattern in depth distribution, with individuals remaining in the thermocline (mixed layer water) at night, and diving to deeper waters during the day, with individuals spending most of their time in water temperatures no more than ~6 degrees Celsius below the surface layer temperature and in waters shallower than 50 m.
- Kuo-We Lan et al. (2011) investigated the distribution of yellowfin tuna population in the equatorial Atlantic associated with environmental factors and fishing conditions. The study found the distribution of yellowfin tuna to be dependent on the vertical structure of the thermocline, with higher subsurface water temperatures resulting in a deeper thermocline and higher catch per unit effort for yellowfin tuna.
- Logan and Lutcavage (2012) investigated the trophic structure of tunas and billfish in the central North Atlantic Ocean using stable isotope analysis. Yellowfin tuna was found to have lower $\delta^{15}N$ values and are in a lower trophic level relative to other pelagic species. The study found that the use of both carbon and nitrogen stable isotope values of large pelagic fishes, including yellowfin tuna, can be used to trace large scale movements.
- Wexler et al. (2011) investigated the optimal temperature and oxygen ranges for survival, development, and growth of yellowfin eggs and yolk-sac and first-feeding larvae. Results show larval survival being restricted to temperatures between 21 degrees Celsius and 33 degrees Celsius, and dissolved oxygen greater than 2.2 mg O^2L^{-1}. Limiting oxygen levels may occur at depths greater than 30 m during the upwelling season and greater than 50 m during the reduced upwelling season.
- Logan et al. (2012) investigated the importance of cephalopod prey for large pelagic fish predators in the central North Atlantic Ocean. The study found that Ommastrephid squids followed by octopods, histioteuthids, and architeuthids and sargassum-associated fishes were identified as important prey for yellowfin tuna, with diet composition varying spatially and prey size positively correlated with predator size.
- Qiu et al. (2012) used both mitochondrial DNA (mtDNA) and microsatellite data reported on a population size discrepancy in five species of tuna, including yellowfin tuna. Results reveal that the size discrepancy could be a result of behavioral differences between the sexes, with tuna may be related to female-biased philopatry and male-biased dispersal.

Recommendations for EFH based on new information

Recent studies will be used to update the life history and distribution information for yellowfin tuna. We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

4.4.2 Literature Cited

Hoolihan JP, Wells RJD, Lou J, Falterman B, Prince E, Rooker JR. 2014. Vertical and horizontal movements of yellowfin tuna in the Gulf of Mexico. Mar Coast Fish Dynam Manag Ecosys Sci 6: 211-222.

Juan-Jorda MJ, Mosqueira I, Freire J, Dulvy NK. 2013. Life in 3-D: life history strategies in tunas, mackerels and bonitos. Rev Fish Biol Fisher 23: 135-155.

Kuo-Wei L, Lee MA, Lu HJ, Shie WJ, Lin WK, Kao SC. 2011. Ocean variations associated with fishing conditions for yellowfin tuna (*Thunnus albacares*) in the equatorial Atlantic Ocean. ICES J Mar Sci 68(6): 1063-1071.

Logan JM, Lutcavage ME. 2012. Assessment of trophic dynamics of cephalopods and large pelagic fishes in the central North Atlantic Ocean using stable isotope analysis. Deep Sea Res II 95: 63-73.

Logan J.M., Toppin R., Smith S., Galuardi B., Porter J., and Lutcavage M. 2013. Contribution of cephalopod prey to the diet of large pelagic fish predators in the central North Atlantic Ocean. Deep Sea Research II 95,74-82.

Qiu F., Kitchen A., Beerli P., Miyamoto M.M. 2013. A possible explanation for the population size discrepancy in tuna (genus Thunnus) estimated from mitochondrial DNA and microsatellite data. Molecular Phylogenetics and Evolution 66, 463-468.

Weng KC, Stokesbury MJW, Boustany AM, Seitz AC, Teo SLH, Miller SK, Block BA. 2009. Habit and behavior of yellowfin tuna *Thunnus albacares* in the Gulf of Mexico determined using pop-up satellite archival tags. J Fish Biol 74: 1434-1449.

Wexler JB. 2011. Temperature and dissolved oxygen requirements for survival of yellowfin tuna, *Thunnus albacares*, larvae. J Exp Mar Biol Ecol 404:63-72.

4.5 West Atlantic Bluefin Tuna (*Thunnus thynnus*)

The U.S. West Atlantic bluefin tuna fisheries are managed under the 2006 Consolidated Atlantic HMS FMP. Implementing regulations are issued under the authority of the Magnuson-Stevens Act and ATCA.

4.5.1 Summary of EFH Review

Recent Changes to Management Structure

Since Amendment 1, there have been several changes in the management for West Atlantic bluefin tuna as well as an FMP amendment. On April 5, 2011, NMFS published a final rule for the reduction of bluefin tuna bycatch in the Gulf of Mexico pelagic longline fishery (76 FR 18653). The final rule implemented measures to require the use of "weak hooks" in the fishery. Weak hooks allow incidentally hooked large bluefin tuna to escape capture because the hooks are more likely to straighten when a large fish is hooked. These requirements became effective May 5, 2011.

The final rule implementing Amendment 7 to the 2006 Consolidated HMS FMP (Amendment 7) was published on December 1, 2014 (79 FR 71509). It revised domestic quota allocations, increased reporting requirements, and restructured management of the pelagic longline fishery to include individual bluefin quotas, gear restricted areas, and increased reporting and monitoring requirements, among other management measures. Most management measures were effective January 2, 2015.

The Atlantic bluefin tuna stock was last assessed by ICCAT in 2014 (SCRS 2014), and based on these findings, NMFS determined that overfishing is not occurring on the West Atlantic stock, under either the high or low recruitment scenarios, and that the stock is not overfished under the low recruitment scenario but is overfished under the high recruitment scenario. Information on the past stock assessment result is available on the ICCAT SCRS website at: https://www.iccat.int/en/assess.htm

Summary of New Literature

- The two-stock (i.e., West and East Atlantic) hypothesis was supported by the Atlantic Bluefin Tuna Status Review Team (SRT), which NMFS convened in response to a petition to list bluefin tuna under the ESA. The SRT reviewed the ecological, physical, genetic and behavioral evidence for distinction of Atlantic bluefin tuna populations as required by the Endangered Species Act (ABT SRT 2011). The SRT acknowledged evidence suggesting that there may be two discrete populations within the Mediterranean, but did not have enough information to determine the significance of these populations to the species as a whole. Since the SRT determination, additional data from an archival tag study (Aranda et al. 2013) further supported two Mediterranean metapopulations.
- Amendment 7 reviewed the distribution of pelagic longline fishing activity for 2006 – 2012, and implemented gear restricted areas in the Gulf of Mexico and off Cape Hatteras, North Carolina (NMFS 2014) to reduce bycatch of bluefin tuna in the pelagic longline fishery.
- Bluefin tuna are highly migratory and in the Western Atlantic, generally ranging from 45°N to the equator, but have also supported short-term fisheries off Brazil and in the North Sea (Fromentin 2010). Fromentin et al. (2013) used ecological niche mapping to explain the expansion of bluefin tuna into the equatorial Atlantic off Brazil, and identified a temporary pathway of favorable habitat linking distributions in the North and South Atlantic. Based on this work, the authors hypothesized that changes in environmental conditions associated with climate change could result in a northerly (i.e., to 60°N) expansion of bluefin tuna distribution.
- Several recent studies found that some bluefin tuna of purported spawning size/age did not enter identified spawning areas in spring (Block et al. 2005, Galuardi et al. 2010, Lutcavage et al. 2012). These findings could support a paradigm shift from the assumption that mature western bluefin tuna follow an annual cycle of foraging off the eastern United States and Canadian coasts from June through March, and then migrate to spawning grounds in the Gulf of Mexico and Straits of Florida. Lutcavage et al. (2012) analyzed nine years of electronic tagging data, and found that smaller, likely mature bluefin did not enter the Gulf of Mexico with larger individuals to spawn, but were at times located in oceanographic conditions similar to known spawning areas. Galuardi et al. (2010) found that over 50 percent of tagged bluefin greater than 230cm did not enter identified spawning areas during the spring. Several hypotheses have been proposed to explain these findings, including the possibility some spawning areas are yet undescribed, and that bluefin tuna are not obligate annual spawners. Muhling et al. (2011a) described collection of larval bluefin tuna within and south of the Yucatan Channel, outside of documented Western Atlantic spawning grounds. The location and ambient currents suggested that they were spawned outside of the Gulf of Mexico. Recent satellite tagging studies on Southern bluefin tuna in the Tasman Sea (Evans et al. 2012) have also brought

into question the assumption that bluefin tuna are obligate annual spawners. A decadal scale decrease in somatic condition and lipid stores for Atlantic bluefin sampled in the Gulf of Maine was described by Golet et al. 2007, who hypothesized that their physiological condition may have impacted reproductive patterns and resulted in skipped spawning and changes in migratory behavior.

- Heinisch et al. (2014) presented evidence based on ratios of follicle stimulating hormone to luteinizing hormone that western Atlantic bluefin tuna mature at a much younger age and considerably smaller size (i.e., $\geq$ 134 cm curved fork length) than currently assumed (i.e., $\geq$ 185 cm curved fork length). The study showed that the maturity schedule for western Atlantic bluefin tuna is similar to that for Mediterranean spawners. A significant adjustment to the maturity schedule for western Atlantic bluefin tuna could have tremendous ripple effects to bluefin tuna life history analyses and management strategies.
- In a study analyzing archival tag data from 1999-2005, Lawson et al. (2010) described the movement of bluefin into western Atlantic foraging grounds of the Gulf of Maine, Canadian shelf, and nearby off-shelf waters, and their vertical distribution during occupancy. Throughout this study, bluefin spent most of their time in the upper 10m of the water column and occupied a relatively constant ambient temperature regime, with monthly median sea surface temperature (SST) between 16° and 19°C. In March through April, tagged fish arrived in the study region and occupied weakly stratified, off-shelf waters along the edge of the Gulf Stream. As shelf waters warmed into the summer, the fish shifted distribution shoreward onto the shelf. Dives were more frequent and faster in descent, but shorter in duration and shallower in the stratified shelf waters of summer and fall compared to dives in spring off-shelf waters. The fish departed shelf waters by November. The study showed strong correlation between diving behavior and the thermal structure of the water column. Based on physiological studies that showed that the capacity of the cardiac system to supply oxygen to the muscles is reduced in colder waters, the authors believed that their observations supported the hypothesis that bluefin use oscillatory diving behavior as a thermoregulatory strategy. They hypothesized that both the timing of the horizontal seasonal shift of bluefin tuna onto the continental shelf and diving behavior appeared to relate to a trade-off between thermal constraints and increased prey resources, and would likely vary in other regions depending upon regional factors.
- Walli et al. (2009) described the seasonal migrations and depth distribution for electronically tagged bluefin tuna in high use areas for purported western and transatlantic fish. High residence times were identified in four spatially confined regions on a seasonal scale, and fish size was significantly different between these regions. The regions identified included waters off North Carolina (late October to mid-May with highest residency December through March), Gulf of Maine, Georges Bank and south of Nova Scotia (early March – late December with peak residency June - October), Central North Atlantic, east of Flemish Cap (Northwest Corner) (April - December with peak residency in June), and the Western coast of Spain, where fish were consistently present with peaks from September - December and in May).
- Golet et al. (2013) studied distribution of commercial sized (>185 cm) bluefin tuna schools in the Gulf of Maine. They constructed a 28-year (1979-2005) time series of commercial bluefin tuna catches and sightings from fishermen's logbooks, which showed a gradual eastward shift of commercial sized bluefin tuna school distribution towards

offshore and Canadian waters. The authors associated this shift in size distribution to the changes in size and abundance of Atlantic herring.

- Wilson and Block (2009) classified daily vertical profiles of archival and/or PSAT tagged bluefin tuna into three types, with the goal of inferring habitat use from diving behavior. V-shaped profiles, the most abundant of the three, were associated with unproductive regions, and purported to be used for transiting or searching for prey. U-shaped profiles were associated with putative foraging behavior, and geographically distributed across known productive feeding grounds, including the Gulf of Maine, Grand Banks, and Flemish Cap. The dive characteristics (e.g., length and depth of dive) were shown to vary between region, likely because of oceanographic features or prey distribution. The authors hypothesized that two other areas in which a great number of U-shaped dives were found (Florida/Bahamas, Northeast Atlantic) may be important for feeding or satisfying other physiological needs. The third profile type occurred in shallow coastal areas or colder northern regions, and those dives were considered to be restricted due to water depth or temperature profile.
- Galuardi and Lutcavage (2012) developed and deployed mini pop-up satellite archival tags (PSAT) on juvenile bluefin tuna (aged 2-5) captured in coastal recreational fisheries off Cape Cod from 2005-2009, and described vertical and horizontal movement of tagged juveniles. Natal origins of tagged fish had not been determined at the time of publication, and may have included some eastern fish, although none showed trans-Atlantic movement during the study. Summer distributions of tagged fish were more constricted, and restricted to coastal areas, the Gulf Stream margin and shelf break north of Cape Hatteras to the southern Gulf of Maine. Fall months showed a southern migration along the shelf break to the South Atlantic bight and northern Bahamas, and an increase in spatial dispersal, while spring months showed the reverse trend. Core use areas were most dispersed in winter. Winter and spring distribution in the South Atlantic bight was coincident with the Gulf Stream position. PSAT tagged juveniles experienced a wide range of sea temperatures (4°-26°C) and showed seasonal patterns of temperature preference and variability. They spent the majority of time at relatively shallow depth (<20m), although maximum recorded depth was 800m. From January – May, average depth distribution was greater with increased variability than summer months. Two core use areas were identified for winter (January through March) centered around100 m (12°C) and 40 m (21°C). In summer, tagged fish were primarily found near the surface at temperatures from 15-20°C. Spring and fall temperature and depth were transitional between summer and winter findings.
- Teo and Block (2010) analyzed NMFS pelagic observer program data in an attempt to further refine their description of putative breeding locations, and found that bluefin CPUE in the Gulf of Mexico tended to increase in areas with cyclonic eddies.
- Muhling et al. (2010) created a model from a time series of larval distribution data in the Gulf of Mexico to define associations between larval bluefin catch locations and environmental variables. The authors defined favorable habitat for bluefin larvae as moderately warm waters (i.e., they were most commonly collected in 23.5-28°C) outside the Loop Current and Loop Current eddies, and outside of cooler, higher chlorophyll continental shelf waters. The authors noted larval bluefin may be well adapted to nutrient poor waters, since larval tuna have been found to target appendicularians, which are well adapted to oligotrophic open oceans. The authors hypothesized that larvae were likely to

be present in the same water mass into which they were spawned. They also proposed that the Loop Current was likely unsuitable for both spawning and larval habitat because the high temperatures would be stressful for adults and larvae would quickly be advected out of the Gulf of Mexico. The resolution of sampling locations was low, so the authors were not able to correlate larval occurrence with finer habitat features such as fronts and frontal eddies

- Muhling et al. (2015) updated their 2011 study that projected climate change impacts to BFT spawning habitat. The updated study accounted for the importance of regional scales as indicated in Liu et al. (2012). Results showed marked temperature induced habitat loss for both adult and larval BFT in the spawning grounds in the northern Gulf of Mexico, further supporting their previous conclusions; however, habitat loss was somewhat mitigated by the slowing of the Caribbean Current-Loop Current system.
- Muhling et al. (2011) used climate model simulations to predict the potential average temperature increase in the upper waters of the Gulf of Mexico, and subsequent suitability for bluefin tuna spawning activity. The researchers predicted that areas of suitable temperature during the late spring, when bluefin tuna currently spawn, could be reduced by over 90 percent by the end of the 21st century, and that early spring could become more suitable for bluefin tuna spawning activity
- Muhling et al. (2012) studied the overlap between Atlantic bluefin tuna spawning grounds and observed Deepwater Horizon surface oil in the northern Gulf of Mexico, and their preliminary estimate of the effects of the spill on larval bluefin mortality concluded that less than 12 percent of larval bluefin were predicted to have been located within contaminated waters in the northern Gulf of Mexico, on a weekly basis.
- Liu et al. (2012) used a downscaled high-resolution ocean model to look at potential changes to the Loop Current induced by climate change. The current effect of the Loop Current is to warm the Gulf of Mexico; however, in this study, volume transport by the Loop Current was projected to be considerably reduced (20-25 percent) as a result of climate induced reductions to the Atlantic Meridional Overturning Circulation. The reduction in the Loop Current would reduce its warming effect in the Gulf of Mexico, particularly in the northern basin. This reduction in warming was underestimated by the low resolution model used by Muhling et al. (2011).
- Recent studies found that oil from the Deepwater Horizon spill had the potential to impact cardiac development in bluefin tuna embryos (Incardona et al. 2014) and the function of in vitro juvenile bluefin tuna heart cells (Brette et al. 2014).
- Butler et al. (2010) found that menhaden (*Brevoortia brevoortia*) comprised almost 95 percent (by weight) of the diet of sampled bluefin tuna off the North Carolina coast during the winters of 2006-2009. Pleizier et al. (2012) found that pelagic schooling fish such as herring (*Clupea harengus*) and mackerel (*Scomber scombrus*) dominated the diet of bluefin tuna caught of Nova Scotia during the fall of 2010. Butler et al. (2015) assessed the diet of bluefin on the Gulf of Mexico spawning grounds and nutritional status of spawning fish during April through June of 2012. They found that bluefin tuna were actively feeding, and that the energetic value of the prey was inferior to that consumed in studies on feeding grounds, although the bluefin tuna sampled did not show evidence of nutritional stress.

- Logan et al. (2011) found that juvenile bluefin tuna (60-150 cm CFL) fed mainly on zooplanktivorous fishes and crustaceans. In this study, sand lance was the main prey of young bluefin in the mid-Atlantic bight.
- Golet et al. (2013) showed a positive correlation between bluefin tuna school positions with the amount of herring captured in fishery independent surveys.

Recommendations for EFH based on new information

Recent research topics for bluefin tuna (i.e., since publication of Amendment 1 in 2009) include electronic tagging studies reviewing vertical and horizontal distribution of juvenile and adult bluefin tuna, review of egg and larval distribution during the Deepwater Horizon oil spill, and aspects of bluefin life history. In addition, the Final Environmental Impact Statement (FEIS) for Amendment 7 reviewed the distribution of pelagic longline effort in recent years, and analyzed impacts for two gear restricted areas (Gulf of Mexico, off Cape Hatteras). Because previous EFH designations were based in part on distribution of fishing catch and effort, a thorough review of the overlap of these new observer, survey, and tag/re-capture data with the previous EFH designations in Amendment 1 is warranted and will be included in EFH updates for West Atlantic bluefin tuna.

4.5.2 Literature Cited

Aranda G, Abascal FJ, Varela JL, Medina A. 2013. Spawning behavior and post-spawning migration patterns of Atlantic Bluefin Tuna (*Thunnus thynnus*) ascertained from satellite archival tags. PLoS ONE. 8(10): e76445.

Atlantic Bluefin Tuna Status Review Team (ABT SRT). 2011. Status review report of Atlantic bluefin tuna (*Thunnus thynnus*). Report to National Marine Fisheries Service, Northeast Regional Office, Gloucester, MA, March 22, 2011. 104 pp.

Block BA, Teo SLH, Walli A, Boustany A, Stokesbury MJW, Farwell CJ, Weng KC, Dewar H, Williams TD. 2005. Electronic tagging and population structure of Atlantic bluefin tuna. Nature. 434: 1121-1127.

Brette F, Machado B, Cros C, Incardona JP, Scholz NL, Block BA. 2014. Crude oil impairs cardiac excitation-contraction coupling in fish. Science 343: 772-775.

Butler CM, Rudershausen PJ, Buckel JA. 2010. Feeding ecology of Atlantic bluefin tuna (*Thunnus thynnus*) in North Carolina: diet, daily ration, and consumption of Atlantic menhaden (*Brevoortia tyrannus*). Fish Bull. 108: 56-69.

Butler CM, Logan JM, Provaznik JM, Hoffmayer ER, Staudinger MD, Quattro JM, Roberts MA, Ingram GW, Pollack AG, Lutcavage ME. 2015. Atlantic Bluefin tuna *Thunnus thynnus* feeding ecology in the northern Gulf of Mexico: a preliminary description of diet from the western Atlantic spawning grounds. J Fish Biol. 86(1): 365-374. doi:10.1111/jfb.12556.

Evans K, Patterson TA, Reid H, Harley SJ. 2012. Reproductive schedules in Southern bluefin tuna: are current assumptions appropriate? PLoS ONE 7(4): e34550. doi: 10.1371/journal.pone.0034550.

Fromentin JM. 2010. Atlantic bluefin tuna. In: International Commission for the Conservation of Atlantic Tunas (ICCAT). 2006-2009. *ICCAT Manual.* International Commission for the Conservation of Atlantic Tuna**.** p. 93-111. http://www.iccat.int/en/ICCATManual.htm

Fromentin JM, Reygondeau G, Bonhommeau SG, Beaugrand G. 2013. Oceanographic changes and exploitation drive the spatio-temporal dynamics of Atlantic bluefin tuna. Fish Oceanogr. 23(2): 147-156.

Galuardi B and Lutcavage M. 2012. Dispersal routes and habitat utilization of juvenile Atlantic bluefin tuna, *Thunnus thynnus*, tracked with mini PSAT and archival tags. PLoS ONE 7(5): e37829. doi:10.1371/journal.pone.0037829.

Galuardi B, Royer F, Golet W, Logan J, Neilson J, Lutcavage M. 2010. Complex migration routes of Atlantic bluefin tuna (Thunnus thynnus) question current population structure paradigm. Can J Fish Aquat Sci. 67: 966-976.

Goldstein J, Heppell SA, Cooper AB, Brault S, Lutcavage M. 2007. Reproductive status and body condition of Atlantic bluefin tuna in the Gulf of Maine. Mar Biol. 151(6): 2063-2075. doi:10.1007/s00227-007-063-8.

Golet WJ, Cooper AB, Campell R, Lutcavage M. 2007. Decline in condition of northern bluefin tuna (*Thunnus thynnus*) in the Gulf of Maine. Fish Bull. 105: 390-395.

Golet WJ, Galuardi B, Cooper AB, Lutcavage ME. 2013. Changes in the Distribution of Atlantic bluefin tuna (*Thunnus thynnus*) in the Gulf of Maine 1979-2005. PLoS ONE 8(9): e75480. doi:10.1371/journal.pone.0075480.

Heinisch G, Rosenfeld H, Knapp JM, Gordin H, Lutcavage ME. 2014. Sexual maturity in western Atlantic bluefin tuna. Sci Rep 4:7205. doi:10.1038/srep07205.

Incardona JP, Gardner LD, Linbo TL, Brown TL, Esbaugh AJ, Mager EM, Stieglitz JD, French BL, Labenia JS, Laetz CA, et al. 2014. Deepwater Horizon crude oil impacts the developing hearts of large predatory pelagic fish. PNAS 111(15): 1510-1518. doi:10.1073/pnas.1320950111

Lawson GL, Castleton MR, Block BA. 2010. Movements and diving behavior of Atlantic bluefin tuna *Thunnus thynnus* in relation to water column structure in the northwestern Atlantic. Mar Ecol Prog Ser. 400: 245-265.

Liu Y, Lee S-K, Muhling BA, Lamkin JT, Enfield DB. 2012. Significant reduction of the Loop Current in the 21st century and its impact on the Gulf of Mexico. J Geophys Res. 117: C5039. doi:10.1029/2011JC007555.

Logan JM, Rodriguez-Marin E, Goni N, Barreiro S, Arrizabalaga H, Golet W, Lutcavage M. 2011. Diet of young Atlantic bluefin tuna (*Thunnus thynnus*) in eastern and western Atlantic foraging grounds. Mar Biol. 158: 73-85.

Lutcavage ME, Galaurdi B, Lam TC. 2012. Predicting potential Atlantic spawning grounds of Western Atlantic bluefin tuna based on electronic tagging results, 2002-2011. ICCAT SCRS/2012/157. 7 p.

Muhling BA, Lamkin JT, Roffer MA. 2010. Predicting the occurrence of Atlantic bluefin tuna (Thunnus thynnus) larvae in the northern Gulf of Mexico: building a classification model from archival data. Fish Oceanogr 19(6): 526-539.

Muhling BA, Lamkin JT, Quattro JM, Smith RH, Roberts MA, Roffer MA, Ramirez K. 2011a. Collection of larval bluefin tuna (*Thunnus thynnus*) outside documented western Atlantic spawning grounds. Bull Mar Sci. 87(3): 687-694. http://dx.doi.org/10.5343/bms.2010.1101.

Muhling BA, Lee S-K, Lamkin JT, Liu Y. 2011. Predicting the effects of climate change on bluefin tuna (*Thunnus thynnus*) spawning habitat in the Gulf of Mexico. ICES J Mar Sci. 68(6): 1051-1062.

Muhling, B.A., M.A. Roffer, J.T. Lamkin, G.W. Ingram Jr., M.A. Upton, G. Gawlikowski, F. Muller-Karger, S. Habtes, W.J. Richards. 2012. Overlap between Atlantic bluefin tuna spawning grounds and observed Deepwater Horizon surface oil in the northern Gulf of Mexico. Mar Poll Bull. 64(4): 679-687.

Muhling, BA, Liu Y, Lee SK, Lamkin JT, Roffer MA, Muller-Karger F, Walter III JF. 2015. Potential impact of climate change on the Intra-Americas Sea: Part 2. Implications for Atlantic bluefin tuna and skipjack tuna adult and larval habitats. J Mar Sys 148(2015): 1-13. National Marine Fisheries Service (NMFS). 2014. Final Amendment 7 to the 2006 Consolidated Atlantic Highly Migratory Species Fishery Management Plan. 757 p.

Pleizier NK, Campana SE, Schallert RJ, Wilson SG, Block BA. 2012. Atlantic bluefin tuna (*Thunnus thynnus*) diet in the Gulf of St. Lawrence and on the Eastern Scotian Shelf. J Northw Atl Fish Sci. 44: 67-76. http://journal.nafo.int/44/pleizier/6-pleizier.html.

Standing Committee on Research and Statistics (SCRS). 2014. Report of the 2014 Atlantic Bluefin Tuna Stock Assessment Session. International Commission for the Conservation of Atlantic Tunas. Madrid, Spain, September 22-27, 2014. http://www.iccat.int/Documents/Meetings/Docs/2014_BFT_ASSESS-ENG.pdf

Teo SL, Block BA. 2010. Comparative influence of ocean conditions on yellowfin and Atlantic bluefin tuna catch from longlines in the Gulf of Mexico. PLoS ONE 5(5): e10756. doi:10.1371/journalo.pone.0010756

Walli A, Teo SL, Boustany A, Farwell CJ, Williams T, Dewar H, Prince E, Block BA. 2009. Seasonal movements, aggregations and diving behavior of Atlantic BFT (TT) revealed with archival tags. PLoS ONE 4(7): e6151

Wilson SG, Block BA. 2009. Habitat use in Atlantic bluefin tuna Thunnus thynnus inferred from diving behavior. Endang Species Res. 10: 355-367. doi: 10.3354/esr00240

5 ATLANTIC SWORDFISH

The following sections review and itemize all new literature (post-2009) on life history, behavior, distribution and habitat for Atlantic swordfish managed by the Atlantic HMS Management Division of NMFS that could be used to update EFH boundaries and text descriptions. Unless otherwise noted, this information is intended to 1) supplement the text descriptions of life history, behavior, and essential fish habitat presented in Amendment 1; and 2) itemize possible new sources of data that could be incorporated into EFH updates for the species.

Original text descriptions of life history, behavior and essential fish habitat may be found in Chapter 5 of Amendment 1: http://www.nmfs.noaa.gov/sfa/hms/documents/fmp/am1/index.html.

5.1 Atlantic Swordfish (*Xiphias gladius*)

The U.S. North and South Atlantic swordfish fisheries are managed under the 2006 Consolidated HMS FMP. Implementing regulations are issued under the authority of the Magnuson-Stevens Act and ATCA.

5.1.1 Summary of EFH Review

Recent Changes to Management Structure

Since Atlantic swordfish EFH was described and designated in Amendment 1 to the 2006 Consolidated HMS FMP in 2009, there have been substantial changes to the management structure.

On August 10, 2011, NMFS published a final rule (76 FR 49368) that modified the permitting requirements and retention limits for Atlantic HMS that are incidentally-caught in Atlantic trawl fisheries. The action reduced regulatory dead discards of incidentally-caught Atlantic swordfish in the *Illex* squid trawl fishery by establishing an Incidental HMS Squid Trawl permit for all valid *Illex* squid moratorium permit holders. The Incidental HMS Squid Trawl permit allows up to 15 swordfish per trip to be retained.

On July 31, 2012, NMFS published a final rule to adjust the 2012 North and South Atlantic swordfish quota specifications and implemented other management measures, which became effective August 30, 2012 (77 FR 45273). For Atlantic swordfish fisheries, the final rule implemented, among other things, a 25-inch cleithrum to caudal keel measurement as a commercial and recreational minimum size and allowed the existing 47-inch lower jaw fork length measurement to apply to swordfish without a bill, as long as the bill is removed forward of anterior tip of the lower jaw and the head is naturally attached.

On August 21, 2013, NMFS published a final rule (78 FR 52012) implementing Amendment 8 to the 2006 Consolidated HMS FMP. The final rule established a commercial fishing vessel permit (the Swordfish General Commercial permit) that allows permit holders to retain and sell a limited number of swordfish caught on rod and reel, handline, harpoon, greenstick, or bandit gear. Other management measures included the modification of HMS Charter/Headboat permit regulations to allow for the commercial retention of swordfish on non-for-hire trips, regional swordfish retention limits for the new and modified permits, gear authorizations, and reporting requirements.

The status of the North and South Atlantic swordfish stocks was recently assessed in September 2013. Summarized information regarding the stock assessment results can be found on the ICCAT SCRS website at: https://www.iccat.int/en/assess.htm. Domestic stock status information can be found in the annual HMS SAFE Reports at http://www.nmfs.noaa.gov/sfa/hms/documents/safe_reports/index.html.

Summary of New Literature

- Lerner et al. (2013) described diel and migration patterns of swordfish. The study found that swordfish migration behavior was correlated to lunar illumination, with swordfish depth preference increasing with increasing lunar illumination. The study also updated the depth where swordfish can be found to up to 1,448 m.
- Dewar et al. (2011) described Atlantic diel vertical movement pattern, indicating the presence of periodic daytime basking events and deeper diving depths during the day.
- Fenton (2012: Thesis) described movement of juvenile swordfish, which found diurnal movements of juvenile swordfish to be much greater than their lunar movements.
- Abecassis et al. (2012) described habitat use of swordfish by finding that in the absence of daytime basking by swordfish, most fish remained within a narrow range of light level during both day and night to potentially forage.
- Neilson et al. (2013) provided a comprehensive summary of aspects of the biology of Atlantic swordfish relative to other large pelagic species to look at the resilience of the species and its ability to recover from an over-exploited state in relation to management actions from different Regional Fishery Management Organizations; however, the study does not provide new information.

Recommendations for EFH based on new information

Recent studies on Atlantic swordfish provide updates to existing life history information. However, these studies do not provide new and/or substantial information that warrants reconsideration of EFH boundaries for swordfish. However, we will update EFH boundaries based on new observer, survey, and tag/recapture data since 2009

5.1.2 **Literature Cited**

Abecassis M, Dewar H, Hawn D, Polovina J. 2012. Modeling swordfish daytime vertical habitat in the North Pacific Ocean from pop-up archival tags. Mar Ecol Prog Ser. 452: 219-236.

Dewar H, Prince ED, Musyl MK, Brill RW, Sepulveda C, Luo J, Foley D, Orbesen ES, Domeier M, Nasby-Lucas N, Snodgrass D, Laurs RM, Hoolihan JP, Block BA, Mcnaughton LM. 2011. Movements and behaviors of swordfish in the Atlantic and Pacific Oceans examined using pop-up satellite archival tags. Fish Oceanog. 20(3): 219-241.

Fenton J. 2012. Post-Release Survival and Habitat Utilization of Juvenile Swordfish in the Florida Straits [thesis]. [Fort Lauderdale (FL)]: Nova Southeastern University.

Lerner JD, Kerstetter DW, Prince ED, Talaue-McManus L, Orbesen ES, Mariano A, Snodgrass D, Thomas GL. 2013. Swordfish vertical distribution and habitat use in relation to diel and lunar cycles in the western north Atlantic. Trans Am Fish Soc. 142(1): 95-104.

6 NEILSON J, AROCHA F, CAS-CALAY S, MEJUTO J, ORTIZ M, SCOTT G, SMITH C, TRAVASSOS P, TSERPES G, ANDRUSHCHENKO I. 2013. THE RECOVERY OF ATLANTIC SWORDFISH: THE COMPARATIVE ROLES OF THE REGIONAL FISHERIES MANAGEMENT ORGANIZATION AND SPECIES BIOLOGY. REV FISH SCI. 21(2): 59-97.ATLANTIC BILLFISHES

The following sections review and itemize all new literature (post-2009) on life history, behavior, distribution and habitat for Atlantic billfishes managed by the Atlantic HMS Management Division of NMFS that could be used to update EFH boundaries and text descriptions. Unless otherwise noted, this information is intended to 1) supplement the text descriptions of life history, behavior, and essential fish habitat presented in Amendment 1; and 2) itemize possible new sources of data that could be incorporated into EFH updates for these species.

Original text descriptions of life history, behavior and essential fish habitat may be found in Chapter 5 of Amendment 1: http://www.nmfs.noaa.gov/sfa/hms/documents/fmp/am1/index.html.

The 2006 Consolidated Atlantic HMS FMP and Amendment 1 (2009) identify Atlantic billfishes as blue marlin (*Makaira nigricans*), white marlin (*Tetrapturus albidus*), longbill spearfish (*Tetrapturus pfluegeri*), and western Atlantic sailfish (*Istiophorus platypterus*). A paper by Shivji et al. (2006) confirmed a new species, roundscale spearfish, which was previously unconfirmed and thought to be the same as white marlin. As a result of DNA testing and other identifying factors, the genus of Atlantic white marlin was changed in 2008 from *Tetrapturus* to *Kajikia* and was adopted by the Integrated Taxonomic Information System, of which NOAA is a partner, and by the American Fisheries Society. In 2010, NMFS published an interpretive rule (Sept. 22, 2010, 75 FR 57698) that added roundscale spearfish to the definition of terms in the implementing regulations of the Magnuson-Stevens Act and the Atlantic HMS regulations and recognized the change of the genus of white marlin from *Tetrapturus* to *Kajikia* in the implementing regulations of the Magnuson-Stevens Act and the Atlantic HMS regulations to reflect the recent taxonomic change. Morphological differences between white marlin and roundscale spearfish were described in Amendment 1, and a comprehensive description of billfish management measures prior to 2009 was given in the 2010 interpretive rule.

Recent Management Activities and Changes to the Management Structure of Billfishes

In November 2012, ICCAT adopted Recommendation 12-04 which, for the first time, sets country-specific quotas for landings of blue marlin and white marlin/spearfish. These quotas are in line with scientific advice and will reduce the number of fish that may be caught by ICCAT Contracting Parties. This recommendation includes the adoption of Atlantic-wide minimum sizes that are equivalent to those that are currently in place in the United States for Atlantic blue and white marlin. This binding measure also includes a ban on all sales of recreationally caught marlins, as well as measures to improve data collection in artisanal fisheries and a requirement for all Contracting Parties to report on implementation of this recommendation in 2013.

Summary of New Literature Pertinent to all Billfishes

- Salcedo-Bojorquez and Arreguin-Sanchez (2011) characterized reproduction and life history parameters of billfishes using literature from databases such as ASFA, EBSCOhost, FishBase, and theses and dissertations, which are summarized for Atlantic billfishes in Table 6.1 below.

Table 6.1 Summary of Life History Parameters of Billfishes and Swordfish from Salcedo-Bojorquez and Arreguin-Sanchez (2011).

	Maximum			Mature		
Species	Length (cm)	Weight (kg)	Age (yr)	Length (cm)	Weight (kg)	Age (yr)
Istiophorus platypterus	***260***	***60***	12	***185.6***	***28***	***5***
Makaira nigricans	457	541	17	213	***108***	4
[Kajikia] albidus	210	67.1	9	***156.12***	***(22***	1.5
Tetrapturus georgii	***200***	***24***	***5***	***155***		***2***
Tetrapturus pfluegeri	***194***	***45***	***5***	***150***	***19***	***2***
Xiphias gladius	351	506	16	166	75	4.6

Bold italic values indicate those that differ from, or were not available in, the life history description of the respective species in Amendment 1.

- Rooker et al. (2012) examined the larval abundance of billfishes and swordfish in mesoscale features of the northern Gulf of Mexico. The authors determined that the presence of billfish larvae is strongly linked to the physiochemical attributes (e.g., frontal zones, areas proximal to the Loop Current, lower sea surface temperature, and higher salinity) of the water in which they were found. The prevalence of these larvae (sailfish n=2,033; blue marlin n=722; white marlin n=133; swordfish n=264) in the sampling area in June and July highlights the importance of the northern Gulf of Mexico as habitat for early life development of billfishes and swordfish.

6.1.1 Literature Cited

Rooker JR, Simms JR, David Wells RJ, Holt SA, Holt GJ, Graves JE, Furey NB. 2012. Distribution and habitat associations of billfish and swordfish larvae across mesoscale features in the Gulf of Mexico. PloSOne, 7(4):e34180.

Salcedo-Bojorquez S, Arreguin-Sanchez F. 2011. An exploratory analysis to identify reproductive strategies of billfishes. J Fish Aquat Sci. 6(6): 578-591.

Shivji MS, Magnussen JE, Beerkircher LR, Hinteregger G, Lee DW, Serafy JE, Prince ED. 2006. Validity, identification, and distribution of the roundscale spearfish, *Tetrapturus georgii* (Teleostei: Istiophoridae): morphological and molecular evidence. Bull Mar Sci. 79(3):483-491.

6.2 Atlantic Blue Marlin (*Makaira nigricans*)

6.2.1 Summary of EFH Review

Recent Changes to Management Structure

Changes to the management structure for blue marlin (e.g., country-specific quotas) are outlined in the introduction to this section.

Summary of New Literature

- Sponaugle (2014) analyzed otolith microstructure to determine that oceanographic features and the abundance of certain prey types influence the growth of larval and juvenile blue marlin. Variable patterns of larval growth in the Florida Straits were examined, and revealed that blue marlin grew more rapidly in the western Straits than did those in the eastern Straits, and determined that it was primarily due to higher percentages of *Farranula* copepods in their diet. An early ontogenetic shift to piscivory was observed to enhance survival, as it enhanced growth rates.
- Logan et al. (2013) found that fishes were the sole dominant prey group for blue marlin.
- Kraus et al. (2011) used pop-up satellite archival tags (PSATs) to examine the movements of mature Atlantic blue marlin in the Gulf of Mexico, revealing seasonal differences in distribution corresponding with sea surface temperature and chlorophyll, but that the Gulf of Mexico provides spatially dynamic habitat that is most often utilized through seasonal movements year-round.
- Stramma et al. (2011) used climate model predictions and observations to examine the expansion of oxygen minimum zones' effect on habitat restrictions for billfishes and tunas, whose physiologies demand large amounts of oxygen. A decrease in dissolved oxygen between 1960 and 2010 resulted in a habitat loss of 15 percent. An electronic tagging study on blue marlin was also conducted to validate habitat compression by monitoring horizontal and vertical movements of 47 individuals. Researchers indicate concern for greater vulnerability to overfishing by surface gear for the affected species as these zones expand from the eastern tropical Atlantic.
- Prince et al. (2010) found that below-surface oxygen minimum zones in the eastern Atlantic concentrate sailfish and blue marlin into the upper, near-surface portion of the water column. This concentration could make them more vulnerable to overexploitation by surface gears.
- Wells et al. (2010) quantified $\delta^{13}C$ and $\delta^{18}O$ stable isotopes of blue marlin otoliths (collected from 1981 to 2007) to examine the regional variation of their population structures in the western North Atlantic (Gulf of Mexico, Straits of Florida, Caribbean Sea, and U.S. Atlantic). Results indicate that blue marlin migration out of the Gulf of Mexico basin is limited.
- Richardson et al. (2009) describes the importance of the Florida Straits as a spawning ground for blue marlin.

Recommendations for EFH based on new information

EFH boundaries should be amended to include distribution of blue marlin in the northern Gulf of Mexico throughout their lifecycle. Research indicates that the northern Gulf of Mexico provides important habitat to spawning and early life stages of blue marlin, and for seasonal migrations of adults. These studies will also be used to update the life history description of the species. We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

6.2.2 Literature Cited

Kraus RT, Wells RJD, Rooker JR. 2011. Horizontal movements of Atlantic blue marlin (*Makaira nigricans*) in the Gulf of Mexico. Mar Biol 158: 699-713.

Logan JM, Toppin R, Smith S, Guluardi B, Porter J, Lutcavage M. 2013. Contributions of cephalopod prey to the diet of large pelagic fish predators in the central North Atlantic Ocean. Deep-Sea Res Pt II. 95: 74-82.

Prince ED, Luo J, Goodyear CP, Hoolihan JP, Snodgrass D, Orbesen ES, Serafy JE, Ortiz M, Schirripa M. 2010. Ocean scale hypoxia-based habitat compression of Atlantic istiophorid billfishes. Fish Oceanogr. (19)6: 448-462.

Richardson DE, Llopiz JK, Leaman KD, Vertes PS, Muller-Karger FE, Cowen RK. 2009. Sailfish (*Istiophorus platypterus*) spawning and larval environment in a Florida Current frontal eddy. Prog Oceangr 82:252-264.

Sponaugle S. 2014. Early life history of Atlantic reef & pelagic fishes: using otolith microstructure to reveal ecological & oceanographic processes. Bull Fish Res Agen (2014)38:75-80.

Stramma L, Prince ED, Schmidtko S, Luo J, Hoolihan JP, Visbeck M, Wallace DWR, Brandt P, Kortzinger A. 2011. Expansion of oxygen minimum zones may reduce available habitat for tropical pelagic fishes. Nat Clim Change. (2)1: 33-37.Wells RJD, Rooker JR, Prince ED. 2010. Regional variation in the otolith chemistry of blue marlin (*Makaira nigricans*) and white marlin (*Tetrapturus albidus*) from the western North Atlantic Ocean. Fish Res. 106: 430-435.

6.3 Atlantic White Marlin (*Kajikia albidus*)

6.3.1 Summary of EFH Review

Recent Changes to Management Structure

In September 2010, NMFS published a rule that recognized the taxonomic change in the genus of Atlantic white marlin from *Tetrapturus* to *Kajikia* (Sept. 22, 2010, 75 FR 57698). NMFS adopted the genus change for white marlin with no effect on the management of Atlantic white marlin. Additional changes to the management structure of white marlin (e.g., country-specific quotas) are outlined in the introduction to this section.

Summary of New Literature

- Logan et al. (2013) found that the mean weight of stomach contents in white marlin sampled in the central North Atlantic was highest for fishes (~74 percent), followed by cephalopods (~24 percent; consisting primarily of *Teuthoidea*).
- Logan and Lutcavage (2012) conducted stable isotope analyses on liver and muscle tissue samples of white marlin (n=25) and on the beaks of their cephalopod prey to examine their trophic structures in the central North Atlantic. White marlin were found between

34 and 37 degrees N latitude, and was one of several species that made up an intermediate trophic position. It was found that larger cephalopods occupy a similar trophic position to their fish predators.

- Snodgrass et al. (2011) published an update to the U.S. Conventional Tagging Database for Atlantic White Marlin, including 51,969 tagged individuals and 1,014 reported recaptures between 1954 and 2008 (1.95 percent). Recapture data indicated that three individuals made north to south trans-equatorial crossings (0.29 percent) and seven made trans-Atlantic crossings (0.69 percent). Snodgrass et al. (2010) details these movements.
- S. Salcedo-Bojorquez and F. Arreguin-Sanchez (2011) characterized reproduction in white marlin by "rapid growth, an early age at first maturity with respect to maximum age, and high values of reproductive variables (e.g., spawning duration and frequency, annual fecundity, and relative fecundity)."
- Wells et al. (2010) quantified $\delta^{13}C$ and $\delta^{18}O$ stable isotopes of white marlin otoliths (collected from 1981 to 2007) to examine the regional variation of their population structures in the western North Atlantic (Gulf of Mexico, Straits of Florida, and U.S. Atlantic). Classification success of white marlin was low due to high isotope variability, supporting previous tagging data and a study (Graves and McDowell 2003) that demonstrated, using molecular markers, that white marlin move significantly among the regions sampled.

Recommendations for EFH based on new information

These studies will be used to update the life history description of the species. EFH should be amended to include cephalopod *Teuthoidea* in the description of prey species, revise the length at first maturity to 156 cm (from 130 cm), per the S. Salcedo-Bojorquez and F. Arreguin-Sanchez (2011) paper (Table 6.1), include larval presence in the Gulf of Mexico, and update several life history parameters found in Table 6.1. We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

6.3.2 Literature Cited

Graves JE, McDowell JR. 2003. Stock structure of the world's istiophorid billfishes: a genetic perspective. Mar Freshwater Res 54:287-298.

Logan JM, Toppin R, Smith S, Guluardi B, Porter J, Lutcavage M. 2013. Contributions of cephalopod prey to the diet of large pelagic fish predators in the central North Atlantic Ocean. Deep-Sea Res II. 95: 74-82.

Logan JM, Lutgavage ME. 2012. Assessment of trophic dynamics of cephalopods and large pelagic fishes in the central North Atlantic Ocean using stable isotope analysis. Deep-Sea Res II. 95:63-73.

Snodgrass D, Orbesen ES, Hoolihan JP, Prince ED. 2011. The U.S. conventional tagging database updates for Atlantic white marlin (1954-2008). SCRS/2010/041. Col Vol Sci Pap ICCAT. 66(4): 1760-1766.

Salcedo-Bojorquez S, Arreguin-Sanchez F. 2011. An exploratory analysis to identify reproductive strategies of billfishes. J Fish Aquat Sci. 6(6): 578-591.

Wells RJD, Rooker JR, Prince ED. 2010. Regional variation in the otolith chemistry of blue marlin (*Makaira nigricans*) and white marlin (*Tetrapturus albidus*) from the western North Atlantic Ocean. Fish Res 106 (3): 430-435.

6.4 Roundscale Spearfish (*Tetrapturus georgii*)

6.4.1 Summary of EFH Review

Recent Changes to Management Structure

In September 2010, NMFS published a rule that added roundscale spearfish to the Atlantic billfish management unit and adopted regulations for this newly recognized species identical to those currently in place for white marlin (Sept. 22, 2010, 75 FR 57698).

Summary of New Literature

- Bernard et al. (2013) used mitochondrial DNA analysis to examine the broad geographic distribution of roundscale spearfish (n=14) in the western Atlantic, concluding that it extends from the central North Atlantic at least as far as 37°41'N to much of the western South Atlantic at least as far as 28°52'S latitude.
- Snodgrass et al. (2011) published an update to the U.S. Conventional Tagging Database for Atlantic White Marlin, including 51,969 tagged individuals and 1,014 reported recaptures between 1954 and 2008 (1.95 percent). This paper recognized the historical misidentification of roundscale spearfish as white marlin as a potential issue in the historical tagging data.
- Salcedo-Bojorquez and Arreguin-Sanchez (2011) characterized reproduction in *T. georgii* as rapid growth, high age at first maturity vs. maximum age (Tm/Tmax) ratios and Batch Fecundity (BF) values and low Sd values.

Recommendations for EFH based on new literature

Due to previously data-limited description of species separate from white marlin, we will update reproduction and life history parameters per the Salcedo-Bojorquez and Arreguin-Sanchez (2011) paper and modify the description of several life history parameters as indicated in Table 6.1. We will also propose to update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

6.4.2 Literature Cited

Bernard AM, Shivji MS, Domingues RR, Hazin FHV, de Amorim AF, Domingo A, Arocha F, Prince ED, Hoolihan JP, Hilsdorf AWS. 2013. Broad geographic distribution of roundscale spearfish (*Tetrapturus georgii*) (Teleostei, Istiophoridae) in the Atlantic revealed by DNA analysis: Implications for white marlin and roundscale spearfish management. Fish Res 139: 93-97.

Snodgrass D, Orbesen ES, Hoolihan JP, Prince ED. 2011. The U.S. conventional tagging database updates for Atlantic white marlin (1954-2008). SCRS/2010/041. Col. Vol. Sci. Pap. ICCAT, 66(4): 1760-1766.

Salcedo-Bojorquez S, Arreguin-Sanchez F. 2011. An exploratory analysis to identify reproductive strategies of billfishes. J Fish Aquat Sci. 6(6): 578-591.

6.5 Longbill Spearfish (*Tetrapturus pfluegeri*)

6.5.1 Summary of EFH Review

Recent Changes to Management Structure

Longbill spearfish remains a prohibited species, and there have been no changes to the management structure since 2009.

Summary of New Literature

- Logan and Lutcavage (2012) conducted stable isotope analyses on the cephalopod prey of longbill spearfish to examine their trophic structure. Cephalopoda collected from stomach contents of longbill spearfish included family Ommastriphidae.

Recommendations for EFH based on new information

Recent studies will be used to update the life history description of the species, including areas which were previously described as data-limited. EFH will be updated to include the cephalopod family Ommastiphidae in description of prey species, which was previously data-limited, and include previously-missing life history parameters indicated in Table 6.1. We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009

6.5.2 Literature Cited

Logan JM, Lutgavage ME. 2013. Assessment of trophic dynamics of cephalopods and large pelagic fishes in the central North Atlantic Ocean using stable isotope analysis. Deep-Sea Res II 95:63-73.

6.6 Sailfish (*Istiophorus platypterus*)

6.6.1 Summary of EFH Review

Recent Changes to Management Structure

There have been no changes to the management of sailfish since 2009.

Summary of New Literature

- Domenici et al. (2014) described the use of the sailfish bill to capture prey, inserting it into a school of sardines undetected, and tapping or slashing through the school with one of the highest accelerations of movement recorded in aquatic vertebrates.
- Hoolihan et al. (2011) deployed PSATs (n=63) to track vertical habitat use in the western North Atlantic, eastern tropical Atlantic, and eastern tropical Pacific, and found greater use of deeper strata in the Atlantic compared to the hypoxia-based habitat compressed regions in the eastern tropical Atlantic and Pacific. A preference for warmer, near-surface depth was found in comparison with the preferences of other billfishes. Sailfish were found to remain at the surface for most of the day (~82 percent of daylight hours). This activity is associated with foraging. The low temperature threshold was found to be 8°C, and the maximum depth recorded in the study was 340 m.
- Kerstetter et al. (2011) characterized habitat utilization and movements of sailfish (n=16) in the southern Gulf of Mexico and Florida Straits tagged with PSATs between 2005 and 2007. The study found that sailfish are primarily associated with the upper 20 m of surface waters (34 percent of their time in upper 10m and 41 percent of their time

between 10 and 20m depth), and take numerous short-duration vertical descents to depths of 50 to 150 m. It was presumed that these dives were to forage due to their characteristic diel patterns (short-term dives more numerous in the daytime). The maximum depth recorded in this study was 463.9 m.

- Simms et al. (2010) examined the distribution, growth, and mortality of sailfish larvae in the northern Gulf of Mexico during the months of May through September in 2005 and 2006. Otolith microstructure of the larvae indicated that they hatched 4 to 24 days prior to time of collection. The study concluded that the Gulf of Mexico is likely important spawning and nursery habitat for sailfish.
- Orbesen et al. (2010) published an update to the U.S. conventional tagging database for Atlantic sailfish with data from 1955-2008, examining the tag and release patterns and recapture results for 92,201 tagged individuals primarily in the western north Atlantic. The recapture rate was the highest of all billfishes, at 2.05 percent (n=1,896), and trans-Atlantic and trans-equatorial movement remains undocumented, supporting the assumption that sailfish have a preference for coastal habitat and minimal mixing with eastern and southern Atlantic populations.
- Richardson et al. (2009) describes the importance of the Florida Straits as a spawning ground for sailfish.
- Prince and Goodyear (2007) described the effect that hypoxia-induced constrained habitat for tropical pelagic fishes in the eastern Atlantic could have on the western Atlantic stocks, including the restriction of depth distribution of sailfish.
- Prince and Goodyear (2006) described the compressed acceptable physical habitat for marlins, sailfish, and tunas to ~25 m, underneath which is a barrier of cold hypoxic water. Prince and Goodyear explain that compression of habitat may increase foraging opportunities for sailfish by putting them in closer proximity to their prey, a proposed explanation for the greater size of eastern Atlantic sailfish in these hypoxic areas when compared to those in the western Northern Atlantic, where dissolved oxygen is not limiting and the boundary is much deeper or not present. Further, the compression of habitat could increase vulnerability of these fish to over-exploitation by surface fishing gears.

Recommendations for EFH based on literature review

These studies will be used to update the life history description of Atlantic sailfish. EFH will be revised to include sardines in the prey list, include PSAT-documented deep dive depths of over 400 m and temperature of 8° C, and update several life history parameters as indicated in Table 6.1. We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009

6.6.2 Literature Cited

Domenici P, Wilson ADM, Kurvers RHJM, Marras S, Herbert-Read JE, Steffensen JF, Krause S, Viblanc PE, Couillaud P, Krause J. 2014. How sailfish use their bills to capture schooling prey. Proc R Soc B. 281(1784):20140444.

Hoolihan JP, Luo J, Goodyear CP, Orbesen ES, Prince ED. 2011. Vertical habitat use of sailfish (*Istiophorus platypterus*) in the Atlantic and eastern Pacific, derived from pop-up satellite archival tag data. Fish Oceanogr. 20(3): 192-205.

Kerstetter DW, Bayse SM, Fenton JL, Graves JE. 2011. Sailfish habitat utilization and vertical movements in the southern Gulf of Mexico and Florida Straits. Mar Coast Fish Dynam Manag Ecosys Sci. 3(1): 353-365. doi: 10.1080/19425120.2011.623990

Orbesen ES, Snodgrass D, Hoolihan JP, Prince ED. 2010. Updated U.S. conventional tagging database for Atlantic sailfish (1955-2008), with comments on potential stock structure. SCRS/2009/047. Col. Vol. Sci. Pap. ICCAT, 65(5): 1692-1700.

Prince ED, Goodyear CP. 2007. Consequences of ocean scale hypoxia constrained habitat for tropical pelagic fishes. Gulf Caribb Res. 19(2):17-20.

Prince ED, Goodyear CP. 2006. Hypoxia-based habitat compression of tropical pelagic fishes. Fish Oceanogr. 15 (6): 451-464.Richardson DE, Llopiz JK, Leaman KD, Vertes PS, Muller-Karger FE, Cowen RK. 2009. Sailfish (*Istiophorus platypterus*) spawning and larval environment in a Florida Current frontal eddy. Prog Oceangr 82:252-264.

Simms JR, Rooker JR, Holt SA, Holt GJ, Bangma J. 2010. Distribution, growth, and mortality of larval *Istiophorus platypterus* in the northern Gulf of Mexico. Fish Bull. 108:478-490.

7 LARGE COASTAL SHARKS

The following sections review and itemize all new literature (post-2009) on life history, behavior, distribution and habitat for large coastal sharks (LCS) managed by the Atlantic HMS Management Division of NMFS that could be used to update EFH boundaries and text descriptions. Unless otherwise noted, this information is intended to 1) supplement the text descriptions of life history, behavior, and essential fish habitat presented in Amendment 1; and 2) itemize possible new sources of data that could be incorporated into EFH updates for these species.

Original text descriptions of life history, behavior and essential fish habitat may be found in Chapter 5 of Amendment 1: http://www.nmfs.noaa.gov/sfa/hms/documents/fmp/am1/index.html.

7.1 Blacktip Shark (*Carcharhinus limbatus*)

7.1.1 Summary of EFH Review

Recent Changes to Management Structure

The first stock assessment for the Gulf of Mexico blacktip shark population was conducted in 2012 (SEDAR 29). The results of that assessment indicated that the stock is not overfished and overfishing is not occurring. Summarized information regarding the stock assessment results can be found in the Amendment 5a FEIS. SEDAR 29 stock assessment documents can be found on the SEDAR website at: http://www.sefsc.noaa.gov/sedar/Sedar_Workshops.jsp?WorkshopNum=29

As a result of the SEDAR 29 stock assessment NMFS implemented Amendment 5a, which created a TAC and quota for Gulf of Mexico blacktip sharks, and a specific commercial quota group for blacktip sharks landed in the Gulf of Mexico region. In the Atlantic, blacktip sharks were included in the aggregated large coastal shark management group. The peer review panel for the 2006 stock assessment for Atlantic blacktip sharks concluded that, while the methods were scientifically sound, the assessment model did not provide reliable estimates of abundance, biomass, or exploitation rates. As a result, NMFS determined the stock status of Atlantic blacktip sharks to be unknown. There is no previous stock assessment for blacktip sharks on which to appropriately base a species-specific TAC or quota. NMFS had no new information to inform a separate quota or TAC. Therefore, NMFS decided to maintain Atlantic blacktip sharks in the aggregated LCS management group. When NMFS has a peer reviewed and approved stock assessment for Atlantic blacktip sharks NMFS will reconsider this decision.

Summary of New Literature

- New literature was presented at the SEDAR 29 stock assessment for blacktip sharks (see assessment archives at http://www.sefsc.noaa.gov/sedar/Sedar_Workshops.jsp?WorkshopNum=29)
- McCallister et al. (2013) sampled estuarine areas on the northeast coast of Florida using bottom longline and captured 95 blacktip sharks, which made up 15.3 percent of the sharks caught in this survey. Over half (n=53) of the blacktip sharks caught were considered to be young of the year. Analysis of blacktip presence/absence and

environmental data with logistic regression and GLM modeling suggested that blacktip sharks were associated with warmer temperatures, slightly lower dissolved oxygen, and deeper water with a salinity of 30‰ or greater.
- Baremore and Passerotti (2013) looked at reproductive and age data for blacktip sharks in the Gulf of Mexico and found length at 50 percent maturity to be 105.8 and 119.2 cm fork length for males and females, respectively. They also calculated age at 50 percent maturity to be 4.8 years for males and 6.3 years for females, gestation time to be 12 months, average fork length of near term pups to be 38 cm and litter size of over 4 pups.
- Drymon et al. (2010) compared data from inshore and offshore fishery-independent surveys off the Alabama coast. Catch per unit effort for blacktip sharks was significantly higher at shallow depths, and there was a significant bias towards females at shallow depths.
- Bubley and Carlson (2012) developed relative abundance indexes for juvenile blacktip sharks from multiple fishery-independent surveys in the western Gulf of Mexico.
- Froeschke et al. (2010) compared blacktip distribution with environmental variable data collected in the Texas Parks and Wildlife coastwide fisheries gill net monitoring program. They noted that fitted functions for blacktip were most strongly influenced by salinity, inlet distance, depth, and temperature suggesting a preference for warm waters near tidal inlets of moderate salinities that are proximate to deeper waters.
- Bethea et al. (2014) in a comprehensive study of 10 geographic areas in the northeastern Gulf of Mexico found juvenile blacktip shark did not appear to be restricted to any specific nursery area and are abundant in all habitats despite differences in habitats.
- Swinsburg et al. (2012) and Swinsburg (2013) analyzed tag and recapture data for blacktip sharks in the Atlantic and Gulf of Mexico and calculated survival estimates. No blacktip sharks moved from the Gulf of Mexico to the Atlantic or Caribbean Sea. Furthermore, there was no evidence that sharks tagged in the western half of the Gulf of Mexico moved to the eastern half (and vice versa). Sharks were primarily distributed within the 200m depth contour. Some sharks moved from U.S. territorial waters to Mexican territorial waters.
- Ward-Paige et al. (2014) examined data from a fishery-independent gillnet survey to predict EFH features for juvenile sharks and found that blacktip shark preferred higher temperature (>30 °C) and mid-depth (~5.5 m) among a suite of environmental and habitat factors. Although Driggers et al (2012), which looked at the feeding chronology of six Carcharhinid shark species, including blacktip sharks, could indicate that surveys that do not sample during all hours of the day do not accurately reflect true distribution, especially if those surveys are done over a small spatial scale.

Recommendations for EFH based on new information

Because NMFS has determined that there are two stocks of blacktip sharks (Atlantic and Gulf of Mexico) and EFH is currently designated only for one joint stock, EFH will be delineated for each individual stock. We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

7.1.2 Literature Cited

Baremore IE, Passerotti MS. 2013. Reproduction of the Blacktip Shark in the Gulf of Mexico. Mar Coast Fish Dynam Manag Ecosys Sci. 5(1), 127-138.

Bethea DM, Carlson JK, Grace MA. 2012. Tag and recapture data for blacktip shark, *Carcharhinus limbatus*, in the Gulf of Mexico: 1999-2010. SEDAR29-WP-07, SEDAR Working Paper, SEDAR 29: HMS Gulf of Mexico Blacktip Shark, Charleston, SC.

Bethea DM, Ajemian MJ, Carlson JK, Hoffmayer ER, Imhoff JL, Grubbs RD, Peterson CT, Burgess GH. 2014. Distribution and community structure of coastal sharks in the northeastern Gulf of Mexico. Environ Biol Fish DOI: 10.1007/s10641-014-0355-3

Bubley W, Carlson JK. 2012. Relative abundance of blacktip shark based on a fishery-independent gillnet survey off Texas. SEDAR 29-WP-12. SEDAR, North Charleston, SC.

Carlson JK, Bethea D, Tyminski J, Hueter R. 2012. Relative abundance of blacktip shark, *Carcharhinus limbatus*, from the eastern Gulf of Mexico. SEDAR29-WP-01, SEDAR Working Paper, SEDAR 29: HMS Gulf of Mexico Blacktip Shark, Charleston, SC.

Drymon, JM, Powers SP, Dindo J, Dzwonkowski B, Henwood TA. 2010. Distributions of sharks across a continental shelf in the northern Gulf of Mexico. Mar Coast Fish Dynam Manag Ecosys Sci. 2(1): 440-450.

Driggers WB III, Campbell MD, Hoffmayer ER, Ingram Jr. GW. 2012. Feeding chronology of six species of carcharhinid sharks in the western North Atlantic Ocean as inferred from longline capture data. Mar Ecol Prog Ser. 465: 185–192.

Froeschke J, Stunz GW, Wildhaber ML. 2010. Environmental influences on the occurrence of coastal sharks in estuarine waters. Mar Ecol Prog Ser 407:279-292. doi: 10.3354/meps08546

McCallister M, Ford R, Gelsleichter J. 2013. Abundance and Distribution of Sharks in Northeast Florida Waters and Identification of Potential Nursery Habitat. Mar Coast Fish Dynam Manag Ecosys Sci, 5(1), 200-210.

SEDAR. 2012. SEDAR 29 Stock Assessment Report: Gulf of Mexico Blacktip Sharks. SEDAR, 4055 Faber Place Drive, Suite 201, North Charleston, SC 29405. 415p.

Swinsburg W. 2013. Survival of the Blacktip Shark, *Carcharhinus limbatus* [thesis]. [Kingston (RI)]: University of Rhode Island.

Swinsburg W, Kohler NE, Turner PA, McCandless CT. 2012. Mark/Recapture Data for the Blacktip Shark, *Carcharhinus limbatus*, in the Gulf of Mexico from NEFSC Cooperative Shark Tagging Program. SEDAR29-WP16. SEDAR, North Charleston, SC.

Ward-Paige CA, Britten GL, Bethea DM, Carlson J K. 2014. Characterizing and predicting essential habitat features for juvenile coastal sharks. Mar Ecol. doi: 10.1111/maec.12151

7.2 Bull Shark (*Carcharhinus leucas*)

7.2.1 Summary of EFH Review

Recent Changes to Management Structure

There have been no new stock assessments for bull sharks. Because of TAC and quota management measures implemented in Amendment 5a to the 2006 Consolidated Atlantic HMS FMP for scalloped hammerhead and Gulf of Mexico blacktip sharks, bull sharks are now in the aggregated large coastal shark management groups in both the Atlantic and Gulf of Mexico regions.

Summary of New Literature

- Life history parameters (age and growth estimates) for bull shark were updated in Natanson et al. (2014). Specifically, mean back-calculated size at birth was estimated at 60.8 cm FL for males and 62.2 cm FL for females (overall mean size at birth was estimated at 61.5 cm FL). Age at maturity was estimated at 15-17 years for males and 15 years for females. Maximum age for males and females was 25 and 27 years of age, respectively. The study noted that bull sharks in the western North Atlantic and the Gulf of Mexico have similar growth and maturation rates, but that there were sex-related differences in growth rates.
- Popup satellite tags were deployed on 18 bull sharks in coastal regions of the U.S., Gulf of Mexico, and off the southeastern U.S. (Carlson et al., 2010). Usable data was extracted from 15 tags and probable long-distance track estimates were derived for two sharks. Most remained in coastal waters where they were tagged, with an average movement rate of 5-6km/day. Some offshore-onshore movement was noted, and may have been due to response to environmental conditions (these movements were noted in areas adjacent to freshwater input, e.g., the Mississippi, Apalachicola, Caloosahatchee rivers). Shark location data were consistent with previously described EFH for adult bull sharks.
- Brunnschweiler et al. (2010) deployed PSATs on 6 bull sharks in the Bahamas. In general, the sharks did not perform large-scale horizontal movements away from tagging sites, except for one shark which moved across the Blake Plateau from the Bahamas to coastal habitats off Florida at the mouth of the Indian River Lagoon (considered a nursery for bull sharks). Most sharks stayed in shallow waters.
- Streich and Peterson (2011) found evidence that a bull shark nursery area exists in the Altamaha River Estuary in Georgia state waters.
- Froeschke et al. (2012) analyzed fishery independent data from gillnet surveys in Texas coastal waters and found that bull shark abundance has been increasing in those areas.
- Froeschke et al. (2010) used gillnet survey data in nine major Texas bay systems to determine if these areas met criteria for potential bull shark nursery habitat. Matagorda Bay met these criteria for young-of-the-year bull sharks and Matagorda Bay and San Antonio Bays did for juvenile bull sharks.
- Karl et al. (2011) examined genetic variation of bull sharks in the western Atlantic, and noted that structure exists between the Brazilian and all northern populations at the mtDNA control region. Results were congruent with restricted maternal gene flow between populations caused by female site fidelity to nursery areas. This study also estimates an effective population size for northwest Atlantic bull sharks at 221,000 animals.
- Hammershlag et al. (2012) tracked 16 bull sharks in the Florida Keys with SPOT tags and analyzed their movements and abundance levels to movements and abundance levels of Atlantic tarpon in the same area and time period. Bull shark abundance in the area seemed higher in winter months (December – January).
- Curtis et al (2011) reported shallow freshwater creeks, power plant outfalls, ocean inlets, and seagrass habitats with temperatures greater than 20°C, salinities of 10–30‰, and

dissolved oxygen concentrations between 4 and 7 mg/L most influenced the distribution of juvenile bull shark.

- Using long-term fisheries independent gill net surveys conducted in Texas estuaries from 1975 to 2006 habitat use models for bull shark found that the central region along the Texas coast contains the most important estuarine bull shark habitat characterized by warm temperatures, moderate salinities, and abundant tidal inlets. Bull sharks also extended into low salinity estuaries (Froeschke et al. 2010).
- Naylor et al. (2012) summarized genetic research completed from 24 specimens collected from around the world. The genetic analysis grouped together three subclusters of bull sharks from the western Atlantic (including specimens from Florida and Alabama), South Africa, and Borneo.

Recommendations for EFH based on new information

New tagging papers did not provide evidence of new EFH (i.e., bull sharks were tracked in locations previously described as EFH for the species), but research identifying a nursery area in Georgia state waters warrant changes to bull shark EFH. We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

7.2.2 Literature Cited

Brunnschweiler JM, Queiroz N, Sims DW. 2010. Oceans apart? Short-term movements and behavior of adult bull sharks *Carcharhinus leucas* in Atlantic and Pacific Oceans determined from pop-off satellite archival tagging. J Fish Biol. 77:1343-1358.

Carlson JK, Ribera MM, Conrath CL, Heupel MR, Burgess GH. 2010. Habitat use and movement patterns of bull sharks *Carcharhinus leucas* determined using pop-up satellite archival tags. J Fish Biol. doi:10.1111/j.1095-8649.2010.02707.x

Curtis TH, Adams DH, Burgess GH. 2011. Seasonal distribution and habitat associations of bull sharks in the Indian River lagoon, Florida: A 30-Year Synthesis. Trans Am Fish Soc. 140: 1213–1226. doi: 10.1080/00028487.2011.618352

Froeschke J, Stunz G, Sterba-Boatwright B, Wildhaber M. 2010. An empirical test of the ‘shark nursery area concept’ in Texas bays using a long-term fisheries-independent data set. Aquat Biol. 11, 65-76.

Froeschke J, Stunz GE, Wildhaber ML. 2010. Environmental influences on the occurrence of coastal sharks in estuarine waters. Mar Ecol Prog Ser. 407:279-292. doi: 10.3354/meps08546

Froeschke JT, Froeschke BF, Stinson CM. 2012. Long-term trends of bull shark (*Carcharhinus leucas*) in estuarine waters of Texas, USA. Can J Fish Aquat Sci. 70(1), 13-21.

Hammerschlag N, Jiangang L, Irschick DJ, Ault JS. 2012. A comparison of spatial and movement patterns between sympatric predators: bull shark (*Carcharhinus leucas*) and Atlantic tarpon (*Megalops atlanticus*). PloS One. doi: 10.1371/journal.pone.0045958.

Karl SA, Castro ALF, Lopez JA, Charvet P, Burgess GH. 2011. Phylogeography and conservation of the bull shark (*Carcharhinus leucas*) inferred from mitochondrial and microsatellite DNA. Conserv Gen. 12(2), 371-382.

Natanson LJ, Adams DH, Winton MV, Jasmine RM. 2014. Age and Growth of the Bull Shark in the Western North Atlantic Ocean, Trans Amer Fish Soc. 143:3, 732-743, doi: 10.1080/00028487.2014.892537

Naylor, GJP, Caira JN, Jensen K, Rosana KAM, White WT, Last PR. 2012. A DNA sequence-based approach to the identification of shark and ray species and its implications for global elasmobranch diversity and parasitology. Bull. Am. Mus. Nat. His. No. 367. http://digitallibrary.amnh.org/dspace/handle/2246/6183

Streich MK, Peterson DL. 2011. Evidence of a Bull Shark Nursery in the Altamaha River Estuary, Georgia. In: Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies. 65: 83-88.

7.3 Great Hammerhead (*Sphyrna mokarran*)

7.3.1 Summary of EFH Review

Recent Changes to Management Structure

There has not been a SEDAR stock assessment conducted specifically for great hammerheads, but management measures have changed for great hammerheads due to their similar appearance to scalloped hammerheads. Jiao et al. (2011) compared modeling approaches for the data poor hammerhead complex, and completed an assessment of the hammerhead complex (including great hammerhead) using a Bayesian hierarchical model. Results indicate that the population of great hammerhead likely became overfished in the mid-1980s and overfishing occurred periodically from 1983 to 1997. However, the risk of overfishing was very low after 2001. In 2013, Amendment 5a to the 2006 Consolidated HMS FMP was finalized, and included management measures to end overfishing and rebuild scalloped hammerheads. This included setting total allowable catches and quotas for scalloped hammerheads, but because of identification issues between great, scalloped, and smooth hammerheads, all three species were grouped into the hammerhead shark complex. Management measures for hammerheads include separate commercial quotas in the Gulf of Mexico and Atlantic regions, and a minimum size for retention in the recreational fishery of 78 inches fork length. Great hammerhead underwent a status review for consideration of listing under the Endangered Species Act in 2014. Please see the status report for additional information on this species (Miller et al. 2014), which can be found at:
http://www.nmfs.noaa.gov/pr/species/Status%20Reviews/great_hammerhead_shark_sr_2014.pdf

Fishermen participating in ICCAT-related fisheries are subject to regulations implementing ICCAT Recommendation 10-08, which prohibits commercial retention of hammerhead (great, scalloped, and smooth) in these ICCAT fisheries. U.S. fishermen that are not fishing in an ICCAT fishery that is authorized to harvest sharks, such as the commercial bottom longline shark fishery, are not bound by this restriction. Hammerhead are also listed in Appendix II of CITES (effective September 14, 2014), which makes international trade of these species subject to additional regulation (e.g., permitting for importing/exporting great hammerhead sharks).

Summary of New Literature

- An age and growth study of great hammerhead in the Gulf of Mexico and Northwest Atlantic by Piercy et al. (2010) estimated maximum length for males at 264.2 cm FL and 307.8 cm FL for females.
- Passerotti et al. (2010) estimated maximum age for females and males at 44 and 42 years, respectively.
- In 2014, Calich (unpublished data) investigated great and scalloped hammerhead distribution in the west subtropical Atlantic Ocean and Gulf of Mexico by using satellite tags and tracking their movements. Great hammerheads were tracked along both the Atlantic and Gulf of Mexico coasts of Florida. In particular, shares were tracked moving along the continental shelf break on the east coast of Florida and along the Florida Keys. In contrast, great hammerhead tracked along the west coast of Florida were generally located inshore of the edge of the continental shelf. High point densities were observed in the northern Florida Keys.
- Hoffmayer et al. (2014) tracked the movements of great hammerhead in the northern Gulf of Mexico using satellite tags from 2012-2014.
- Gallagher et al. (2014a) investigated the survival of great hammerheads and found that they were inherently vulnerable to capture stress and mortality resulting from fisheries interactions.
- Hammerschlag et al. (2011) tracked a great hammerhead for 62 days in 2010 using a satellite tag and recorded data points approximately 1,200 km apart, from the Florida Keys to approximately 500 km off New Jersey.
- Miller et al. (2014) evaluated recent literature pertaining to great hammerheads in a status review report, which was used to determine that listing great hammerhead under the Endangered Species Act was not warranted.

Recommendations for EFH based on new information

We will update EFH for great hammerhead sharks based on results of new tagging studies, specifically from PSAT data. New life history information (e.g., maximum size and maximum age) will be updated accordingly. We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

7.3.2 Literature Cited

Calich, H. Unpublished data. Great and scalloped hammerhead distribution in the western subtropical Atlantic Ocean & Gulf of Mexico.

Gallagher AJ, Serafy JE, Cooke SJ, Hammerschlag N. 2014. Physiological stress response, reflex impairment, and survival of five sympatric shark species following experimental capture and release. Mar Ecol Prog Ser. 496:207-218

Hammerschlag N, Gallagher AJ, Lazarre DM, Slonim C. 2011. Range extension of endangered great hammerhead shark *Sphyrna mokarran* in the Northwest Atlantic: Preliminary data and significance for conservation. Endanger Species Res. 13: 111–116

Hoffmayer E, Falterman B, McKinney J. Unpublished data. Great hammerhead movements in the northern Gulf of Mexico from 2012-2014.

Miller MH, Carlson JK, Hogan L, Kobayashi D. 2014. Status review report: great hammerhead shark (*Sphyrna mokarran*). Final Report to National Marine Fisheries Service, Office of Protected Resources. June 2014. 116 pp.

Passerotti MS, Carlson JK, Piercy AN, Campana SE. 2010. Age validation of great hammerhead shark (*Sphyrna mokarran*), determined by bomb radiocarbon analysis. Fish Bull. 108: 346–351.

Piercy AN, Carlson JK, Passerotti MS. 2010. Age and growth of the great hammerhead shark, *Sphyrna mokarran*, in the north-western Atlantic Ocean and Gulf of Mexico. Mar Freshw Res. 61:992–998

7.4 Lemon Shark (*Negaprion brevirostris*)

7.4.1 Summary of EFH Review

Recent Changes to Management Structure

There have been no new stock assessments for lemon sharks, but because of TAC and quota management measures implemented in Amendment 5a for scalloped hammerhead and Gulf of Mexico blacktip sharks, lemon sharks are now in the aggregated large coastal shark management groups in both the Atlantic and Gulf of Mexico regions.

Summary of New Literature

- Reyier et al. (2014) tracked juvenile lemon sharks off the east coast of Florida using passive acoustic telemetry to assess factors that influence site fidelity. Fifty four lemon sharks tagged with acoustic transmitters were monitored on an extensive acoustic array for three years, showing a high degree of wintertime site fidelity to the Cape Canaveral region except under extreme decreases in water temperature (when sharks would be displaced to the south). Tagged lemon sharks moved northward to summer habitats off northeastern Florida, Georgia and the Carolinas.
- A possible wintertime nursery area off of the Cape Canaveral in the Atlantic was identified by Reyier et al. (2008) and further supported in Reyier et al. (2014) based on acoustic tagging data.
- McKenzie (2013) identified a possible nursery area off the Chandeleur Islands in the Gulf of Mexico.
- Reyier et al. (2014) investigated the mortality rate of lemon sharks which show strong site philopatry to the area off Jupiter, FL.
- Kessel et al. (2014) used acoustic tags to track adult lemon sharks off the southeast coast of Florida and suggests that there is a temperature driven "migration-residency" model for mature lemon shark distribution across the U.S. eastern seaboard.
- Newman et al. (2012) researched lemon shark ontogenetic diet shifts and prey utilization.
- Stump (2013) investigated the impact of habitat loss on juvenile lemon sharks.

Recommendations for EFH based on new information

We will update lemon shark EFH based on results of new tagging studies, specifically to the neonate and juvenile life stages. The current northern extent of juvenile lemon shark EFH ends at the FL/GA border (per Amendment 1 designations of EFH for juvenile lemon sharks).

We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

7.4.2 Literature Cited

Hearn M. Unk. Using acoustic telemetry to estimate lemon shark, *Negaprion brevirostris*, mortality rates in south eastern Florida [dissertation]. [Cardiff (Wales, UK)]: School of Earth and Ocean Sciences, Cardiff University.

Kessel S.Chapman DD, Franks BR, Gedamke T, Gruber SH, Newman JM, White ER, Perkins RG. 2014. Predictable temperature regulated residency, movement and migration in a large, highly-mobile marine predator (*Negaprion brevirostris*). Mar Ecol Prog Ser. 514:175-190.

McKenzie JF. 2013. Occurrence and genetic diversity of lemon sharks (*Negaprion brevirostris*) at a nursery ground at the Chandeleur Islands, Louisiana [dissertation]. [New Orleans (LA)]: Department of Earth and Environmental Sciences, University of New Orleans. Paper 1653.

Newman SP, Handy RD, Gruber SH. 2012. Ontogenetic diet shifts and prey selection in nursery bound lemon sharks, *Negaprion brevirostris,* indicate a flexible foraging tactic. Environ Biol Fish. 95(1): 115-126.

Reyier EA, Adams DH, Lowers RH. 2008. First evidence of a high density nursery ground for the lemon shark, *Negaprion brevirostris,* near Cape Canaveral, Florida. Florida Scientist, 71(2), 134.

Reyier EA, Franks BR, Chapman DD, Scheidt DM, Stolen ED, Gruber SH. 2014. Regional-Scale Migrations and Habitat Use of Juvenile Lemon Sharks (*Negaprion brevirostris*) in the U.S. South Atlantic. PLoS ONE 9(2): e88470. doi:10.1371/journal.pone.0088470

Stump K. 2013.The Effects of Nursery Habitat Loss on Juvenile Lemon Sharks, *Negaprion brevirostris* [dissertation]. [Miami (FL)]: Department of Marine Biology and Fisheries, University of Miami. Paper 1063.

7.5 Nurse Shark (*Ginglymostoma cirratum*)

7.5.1 Summary of EFH Review

Recent Changes to Management Structure

There have been no new stock assessments for nurse sharks. Because of TAC and quota management measures implemented in Amendment 5a for scalloped hammerhead and Gulf of Mexico blacktip sharks, nurse sharks are now in the aggregated large coastal shark management groups in both the Atlantic and Gulf of Mexico regions.

Summary of New Literature

- Hannan et al (2012) investigated nurse shark distribution in the Gulf of Mexico found that nurse sharks are broadly distributed along the Gulf continental shelf from the Florida Keys to Louisiana, but are rarely observed in the western Gulf of Mexico.
- Hendon et al. (2013) documented the first catch of a nurse shark in the Mississippi Sound.

- Karl et al. (2012) conducted a population genetics study for nurse sharks in the Western Atlantic. Mitochondrial DNA suggested three populations offshore of Brazil, and geographically proximate populations off Florida and in the Bahamas; however microsatellite data indicated that sharks from Brazil, the Bahamas and Florida constitute a single group.

Recommendations for EFH based on new information

We will update nurse shark EFH based on the report of a nurse shark inhabiting the Mississippi Sound, and will consider new genetics information. We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

7.5.2 Literature Cited

Hannan KM, Driggers III WB, Hanisko DS, Jones LM, Canning AB. 2012. Distribution of the nurse shark, *Ginglymostoma cirratum*, in the northern Gulf of Mexico. Bull Mar Sci. 88(1):73-80.

Hendon JM, Hoffmayer ER, Driggers III WB. 2013. First record of a nurse shark, *Ginglymostoma Cirratum*, within the Mississippi Sound. Gulf Caribb Res. 25: 137-139.

Karl SA, Castro AL, Garla RC. 2012. Population genetics of the nurse shark (*Ginglymostoma cirratum*) in the western Atlantic. Mar Biol. 159(3): 489-498.

7.6 Sandbar Shark (*Carcharhinus plumbeus*)

7.6.1 Summary of EFH Review

Recent Changes to Management Structure

The latest stock assessment for sandbar sharks was completed through the SEDAR 21 process in 2011. The stock assessment provides an update from the 2005/2006 assessment on the status of the stock. Based on the 2005/2006 assessment, sandbar sharks were determined to be overfished and experiencing overfishing, and a rebuilding plan is currently in place for this species with a rebuilding date of 2070. The SEDAR 21 assessment found that the stock is still overfished but overfishing is no longer occurring. Summarized information regarding the stock assessment results can be found in the Amendment 5a FEIS. SEDAR 29 stock assessment documents can be found on the SEDAR website at: http://www.sefsc.noaa.gov/sedar/Sedar_Workshops.jsp?WorkshopNum=21

The SEDAR 21 stock assessment indicated that reducing the TAC from the current 220 mt ww to 178 mt ww would provide a 70 percent chance of rebuilding the stock by the year 2066, a reduction of four years from the current rebuilding timeframe. But because the current TAC already provides a greater than 70 percent probability of rebuilding, and because overfishing is not occurring and the stock status is improving, changes to the sandbar shark TAC were not made in Amendment 5a.

Summary of New Literature

- A sizeable amount of new literature was presented at the SEDAR 21 stock assessment for sandbar sharks (see assessment archives at http://www.sefsc.noaa.gov/sedar/Sedar_Workshops.jsp?WorkshopNum=21)

- A working paper for the SEDAR 21 assessment by Baremore and Hale (2009) analyzed sandbar shark reproduction using fishery-dependent and –independent data.
- A working paper for the SEDAR 21 assessment by Bethea and Carlson (2009) analyzed tag-recapture data.
- NMFS received suggestions from the public to investigate potential nursery habitats off Brownsville, Texas. NMFS may update text and life history descriptions, and sandbar EFH, to include a Brownsville, Texas coastal nursery habitat if appropriate references or datasets are found.

Recommendations for EFH based on new information

Recent studies may support updating sandbar shark EFH for neonate or juvenile life stages off Brownsville, Texas. We will update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

7.6.2 Literature Cited

Baremore IE, Hale LF. 2012. Reproduction of the sandbar shark *Carcharhinus plumbeus* in the US Atlantic Ocean and Gulf of Mexico. SEDAR 21-DW-06, SEDAR 21 Working Papers. http://www.sefsc.noaa.gov/sedar/download/S21_DW_06_Sandbar_repro.pdf?id=DOCUMENT

Baremore IE, Hale LF. 2012. Reproduction of the sandbar shark in the western North Atlantic Ocean and Gulf of Mexico. Mar Coast Fish Dynam Manag Ecosys Sci. 4(1): 560-572.

Bethea DM, Carlson JK. 2009. Tag and recapture data for blacknose, *Carcharhinus acronotus*, sandbar, *C. plumbeus*, and dusky shark, *C. obscurus*, as kept in the NOAA Fisheries Southeast Fisheries Science Center Elasmobranch Tagging Management System, 1999-2009. SEDAR21-DW-20, SEDAR 21 Working Papers.

7.7 Scalloped Hammerhead (*Sphyrna lewini*)

7.7.1 Summary of EFH Review

Recent Changes to Management Structure

In October 2009, Hayes et al. (2009) published a stock assessment of the Atlantic population of scalloped hammerhead in U.S. waters. The stock assessment utilized a surplus production model, an approach commonly used in data poor scenarios, and incorporated commercial and recreational landings, fisheries dependent data, fisheries independent data from NMFS observer programs, and scientific surveys. NMFS reviewed this paper and concluded that: the assessment is complete; the assessment is an improvement over a 2008 aggregated species assessment for hammerhead; and the assessment is appropriate for U.S. management decisions (76 FR 23794; April 28, 2011). Based on the results of this paper, NMFS determined on April 28, 2011 that scalloped hammerhead were overfished and experiencing overfishing (76 FR 23794).

As a result of this stock assessment, in 2013, Amendment 5a to the 2006 Consolidated HMS FMP was finalized. The Amendment included management measures to end overfishing and rebuild scalloped hammerhead, such as setting total allowable catches and quotas for scalloped hammerhead sharks, and adjusting the recreational minimum size for hammerhead to 78 inches fork length.

In response to a petition submitted by WildEarth Guardians and Friends of Animals, NMFS issued a final determination to list the Central and Southwest Atlantic Distinct Population Segment (DPS) and the Indo-West Pacific DPS of scalloped hammerhead as threatened species under the Endangered Species Act (ESA), and the Eastern Atlantic DPS and Eastern Pacific DPS of scalloped hammerhead as endangered species under the ESA (79 FR 38213; July 3, 2014). The Central and Southwest Atlantic DPS includes U.S. territorial waters in Puerto Rico and the U.S. Virgin Islands, and NMFS intends to consider critical habitat for this DPS in an upcoming rulemaking.

Fishermen participating in ICCAT-related fisheries are subject to regulations implementing ICCAT Recommendation 10-08, which prohibits commercial retention of hammerheads (great, scalloped, and smooth) in ICCAT fisheries. Hammerheads are also listed in Appendix II of CITES (effective September 14, 2014), which makes international trade of these species subject to additional regulation (e.g. permitting for importing/exporting scalloped hammerhead sharks).

Summary of New Literature

- Quattro et al. (2013) described a new species known as the Carolina hammerhead (*Sphyrna gilberti*). The Carolina hammerhead is considered a cryptic species of scalloped hammerhead (*S. lewini*), as the two species are morphologically separable only in the number of precaudal vertebrae. Scientifically, Carolina and scalloped hammerheads have been described as different species, but, at this time, NMFS has not made a distinction between scalloped and Carolina hammerheads for management purposes and they are currently both managed as scalloped hammerheads.
- Hoffmayer et al. (2013) tracked a female scalloped hammerhead in the northern Gulf of Mexico using a satellite tag and showed that this individual performed numerous dives at night to deep depths (up to 964 m) over a 27 day period of time, but also showed that the shark spent almost 72 percent of its time at or near the surface of the water.
- Hoffmayer et al. (2014) tracked the movements of 14 scalloped hammerhead sharks in the northern Gulf of Mexico using satellite tags from 2012-2014.
- Calich (2014) investigated great and scalloped hammerhead distribution in the west subtropical Atlantic Ocean and Gulf of Mexico by using satellite tags and tracking their movements. Scalloped hammerheads were largely tracked along the shelf break of the Atlantic and the Gulf of Mexico off the Florida coast, and through the Straits of Florida. In the eastern Gulf of Mexico, scalloped hammerheads were tracked further offshore than great hammerheads.
- Bejarano-Alvarez et al. (2010) looked at the reproductive biology of scalloped hammerheads off southwest Mexico.
- McCallister et al. (2013) collected samples in estuarine areas on the northeast coast of Florida using bottom longline and captured 22 scalloped hammerheads, which made up 5.8 percent of the sharks caught in this survey. The majority of the scalloped hammerheads caught were considered to be juveniles (n=17).
- Temperature and salinity were the two most influential factors determining juvenile scalloped hammerhead shark occurrence, where occurrence increased with both

temperature (>30°C) and salinity (>35 PSU) (Ward-Paige et al. 2014)A foraging ecology study of juvenile scalloped hammerhead sharks in northwest Florida by Bethea et al. (2011) found that there was little diet overlap between scalloped hammerhead and bonnethead.

- Bethea et al. (2014) in a comprehensive study of 10 geographic areas in the northeastern Gulf of Mexico found juvenile scalloped hammerheads were restricted to specific nursery area based primarily on salinity and water clarity. Gulak et al. (in press) found that at-vessel mortality rates for scalloped hammerheads were high on bottom longline gear (62.9 percent) and that 50 percent mortality was predicted on sets with a soak time of 3.5 hours.

Recommendations for EFH based on new information

We will determine if the Carolina hammerhead should be considered individually for management purposes instead of being included under current management for scalloped hammerheads. If so, we will define EFH for the Carolina hammerhead. EFH will be updated for scalloped hammerhead EFH based on results of new tagging studies. We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

7.7.2 Literature Cited

Bejarano-Alvarez M, Galvan-Maga-a F, Ochoa-Baez RI. 2010. Reproductive biology of the scalloped hammerhead shark *Sphyrna lewini* (Chondrichthyes: Sphyrnidae) off south-west Mexico. Aqua Int J Ichthyol. 17: 11-22.

Bethea DM, Carlson JK, Hollensead LD, Papastamatiou YP, Graham BS. 2011. A comparison of the foraging ecology and bioenergetics of the early life-stages of two sympatric hammerhead sharks. Bull Mar Sci. 87(4): 873-889.

Bethea DM, Ajemian MJ, Carlson JK, Hoffmayer ER, Imhoff JL, Grubbs RD, Peterson CT, Burgess GH. 2014. Distribution and community structure of coastal sharks in the northeastern Gulf of Mexico. Environ Biol Fish. doi 10.1007/s10641-014-0355-3

Calich H. Unpublished data. Great and Scalloped Hammerhead Distribution in the Western Subtropical Atlantic Ocean and Gulf of Mexico.

Hammerschlag N, Gallagher AJ, Lazarre DM, Slonim C. 2011. Range extension of endangered great hammerhead shark *Sphyrna mokarran* in the Northwest Atlantic: Preliminary data and significance for conservation. Endang Species Res. 13: 111–116.

Hayes CG, Jiao Y, Cortes E. 2009. Stock assessment of scalloped hammerheads in the western North Atlantic Ocean and Gulf of Mexico. N Am J Fish Manage. 29:1406-1417.

Hoffmayer ER, Franks JS, Driggers WB, Howey PW. 2013. Diel vertical movements of a scalloped hammerhead, *Sphyrna lewini*, in the northern Gulf of Mexico. Bull Mar Sci. 89(2): 551-557.

Hoffmayer ER, Falterman B, McKinney J. unpublished data. Scalloped hammerhead movements in the northern Gulf of Mexico from 2012-2014.

McCallister M, Ford R, Gelsleichter J. 2013. Abundance and Distribution of Sharks in Northeast Florida Waters and Identification of Potential Nursery Habitat. Mar Coast Fish Dynam Manag Ecosys Sci. 5(1): 200-210.

Quattro JM, Driggers WB III, Grady JM. 2013. *Sphyrna gilberti* sp. nov., a new hammerhead shark (Carcharhiniformes, Sphyrnidae) from the western Atlantic Ocean. Zootaxa. 3702: 159-178.

Ward-Paige CA, Britten GL, Bethea DM, Carlson JK. 2014. Characterizing and predicting essential habitat features for juvenile coastal sharks. Mar Ecol. doi: 10.1111/maec.12151

7.8 Silky Shark (*Carcharhinus falciformis*)

7.8.1 Summary of EFH Review

Recent Changes to Management Structure

There have been no new stock assessments for silky sharks, but because of TAC and quota management measures implemented in Amendment 5a for scalloped hammerhead and Gulf of Mexico blacktip sharks, silky sharks are now in the aggregated large coastal shark management groups in both the Atlantic and Gulf of Mexico regions. Fishermen participating in ICCAT-related fisheries are subject to regulations implementing ICCAT Recommendation 11-08, which prohibits commercial retention of silky sharks.

Summary of New Literature

- Hoffmayer and Franks (2010) used popup satellite archival tags to quantify the short-term movements of silky sharks in the northern Gulf of Mexico. The silky sharks were all tagged along the continental shelf edge and remained within 150 km of the initial tagging locations.

Recommendations for EFH based on new information

Recent studies do not support updating silky shark EFH based on new literature. However, we will update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

7.8.2 Literature Cited

Hoffmayer ER, Franks JS. 2010. A cooperative approach to the investigation of essential fish habitat of dusky, *Carcharhinus obscurus*, and silky, *Carcharhinus falciformis*, sharks in the northern Gulf of Mexico using pop-up satellite archival tag (PSAT) technology. Final Report. National Oceanic and Atmospheric Administration, Cooperative Research Program, 78p.

7.9 Smooth Hammerhead (*Sphyrna zygaena*)

7.9.1 Summary of EFH Review

Recent Changes to Management Structure

There has not been a stock assessment conducted specifically for smooth hammerhead sharks, but management measures have changed for smooth hammerhead due to their similar appearance to scalloped hammerhead. In 2013, Amendment 5a to the 2006 Consolidated HMS FMP was finalized, and included management measures to end overfishing and rebuild scalloped hammerhead. This included setting TACs and quotas for scalloped hammerhead, but because of identification issues between great, scalloped, and smooth hammerhead all three species were consolidated into the hammerhead complex. Management measures for hammerheads include a commercial quota in the Gulf of Mexico and Atlantic regions, and a minimum size for retention in the recreational fishery of 78 inches fork length.

Fishermen participating in ICCAT-related fisheries are subject to regulations implementing ICCAT Recommendation 10-08, which prohibits commercial retention of hammerheads (great, scalloped, and smooth) in ICCAT fisheries. Hammerhead are also listed in Appendix II of CITES (effective September 14, 2014), which makes international trade of these species subject to additional regulation (e.g., permitting for importing/exporting smooth hammerhead sharks).

Summary of New Literature

- Coelho et al. (2011) conducted an age and growth study on smooth hammerhead in the eastern equatorial Atlantic Ocean.
- Updated distribution records are available on this species (e.g., Castro 2011, Ebert and Stehmann 2013).

Recommendations for EFH based on new information

Recent studies support updating smooth hammerhead age and growth information in the smooth hammerhead life history profile. We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

7.9.2 Literature Cited

Castro JI. 2011. The sharks of North America. Oxford University Press, New York, NY. ISBN: 9780195392944

Coelho R, Fernandez-Carvalho J, Amorim S, Santos MN. 2011. Age and growth of the smooth hammerhead shark, *Sphyrna zygaena*, in the Eastern Equatorial Atlantic Ocean, using vertebral sections. Aquat Living Resour. 24: 351–357.

Ebert DA, Stehmann MFW. 2013. Sharks, batoids, and chimaeras of the North Atlantic. FAO Species Catalogue for Fishery Purposes. No 7. Rome. FAO. 523 pp. http://www.fao.org/docrep/017/i3178e/i3178e.pdf

7.10 Spinner Shark (*Carcharhinus brevipinna*)

7.10.1 Summary of EFH Review

Recent Changes to Management Structure

There have been no new stock assessments for spinner sharks. Because of TAC and quota management measures implemented in Amendment 5a for scalloped hammerhead and Gulf of Mexico blacktip sharks, spinner sharks are now in the aggregated large coastal shark management groups in both the Atlantic and Gulf of Mexico regions.

Summary of New Literature

- Carlson et al. (2012), using bottom longline commercial fishery observer data, found a 14 percent increase in relative abundance of spinner sharks.
- Bethea et al. (2014) analyzed fishery-independent gillnet survey data in the Gulf of Mexico and found that the majority of spinner sharks captured were juveniles in two general areas off northwest Florida.

Recommendations for EFH based on new information

Recent studies do not support updating spinner shark EFH based on new literature. However, we will update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

7.10.2 Literature Cited

Bethea DM, Ajemian MJ, Carlson JK, Hoffmayer ER, Imhoff JL, Grubbs RD, Peterson C, Burgess GH. 2014. Distribution and community structure of coastal sharks in the northeastern Gulf of Mexico. Environ Biol Fish. doi 10.1007/s10641-014-0355-3.

Carlson JK, Hale LF, Morgan A, Burgess GH. 2012. Relative abundance and size of coastal sharks derived from commercial shark longline catch and effort data. J Fish Biol. 80(5): 1749-1764.

7.11 Tiger Shark (*Galeocerdo cuvier*)

7.11.1 Summary of EFH Review

Recent Changes to Management Structure

There have been no new stock assessments for tiger sharks, but because of TAC and quota management measures implemented in Amendment 5a for scalloped hammerhead and Gulf of Mexico blacktip sharks, tiger sharks are now in the aggregated large coastal shark management groups in both the Atlantic and Gulf of Mexico regions.

Summary of New Literature

- Hammerschlag et al. (2012) presents horizontal movement, site fidelity, and additional essential habitat requirements for tiger sharks in the western North Atlantic Ocean.
- Hoffmayer et al. (2014) tracked the movements of 14 tiger sharks in the northern Gulf of Mexico using satellite tags from 2012-2014.
- Vaudo et al. (2014) tagged 14 tiger sharks with PSATs to investigate the vertical habitat use and diving behavior and observed a great deal of intraspecific variability in vertical habit use and that they spent the majority of their time making yo-yo dives within the upper 50 m of the water column.

Recommendations for EFH based on new information

We will re-evaluate tiger shark EFH based on new tagging data. We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

7.11.2 Literature Cited

Hammerschlag N, Gallagher AJ, Wester J, Lou J, Ault JS. 2012. Don’t bite the hand that feeds: assessing ecological impacts of provisioning ecotourism on an apex marine predator. Funct Ecol. 26: 567-576.

Hoffmayer E, Falterman B, McKinney J. Unpublished data. Tiger shark movements in the northern Gulf of Mexico from 2012-2014.

Vaudo J, Wetherbee B, Harvey G, Nemeth R, Aming C, Burnie N, Howey-Jordan L, Shivji M. 2014. Intraspecific variation in vertical habitat use by tiger sharks in the western North Atlantic. Ecol Evol. 4: 1768-1786.

8 SMALL COASTAL SHARKS

The following sections review and itemize all new literature (post-2009) on life history, behavior, distribution and habitat for Small Coastal Sharks managed by the Atlantic HMS Management Division of NMFS that could be used to update EFH boundaries and text descriptions. Unless otherwise noted, this information is intended to 1) supplement the text descriptions of life history, behavior, and EFH presented in Amendment 1; and 2) itemize possible new sources of data that could be incorporated into procedures to delineate EFH for the species.

Original text descriptions of life history, behavior and essential fish habitat may be found in Chapter 5 of Amendment 1: http://www.nmfs.noaa.gov/sfa/hms/documents/fmp/am1/index.html.

8.1 Atlantic Sharpnose Shark (*Rhizoprionodon terraenovae*)

8.1.1 Summary of EFH Review

Recent Changes to Management Structure

Atlantic sharpnose sharks recently underwent a stock assessment (SEDAR 34). Genetic information presented at the assessment indicated the need to split the stock into separate Atlantic and Gulf of Mexico stocks; however, due to lack of time to complete benchmark assessments for two new stocks, a "standard" assessment of a single unit stock was completed to provide management advice to NMFS. The assessment indicated that this single unit stock status was not overfished and overfishing was not occurring. However, based on the results of the assessment and scientific recommendations from assessment participants and reviewers, NMFS decided to split the single Atlantic sharpnose stock into Atlantic and Gulf of Mexico stocks, both of which are not overfished and not experiencing overfishing.

Summary of New Literature

- A sizeable amount of new literature was presented at the SEDAR 34 stock assessment for blacknose sharks (see assessment archives at http://www.sefsc.noaa.gov/sedar/Sedar_Workshops.jsp?WorkshopNum=34)
- Coastal nursery habitats of Atlantic sharpnose shark have been identified in northeastern Florida (McCallister et al., 2013). Mature sharks were found in these nursery areas between May and June. Age-0 individuals were found throughout the summer (primarily in July and August). Juveniles were found in northeastern Florida habitats between June and October.
- The species is considered abundant in Chesapeake Bay and in coastal Virginia waters (Latour et al. 2013).
- Ward-Paige et al. (2014) developed habitat suitability models and found temperature and depth most influenced the occurrence of Atlantic sharpnose shark, increasing with both factors within each site across the sampled range
- Tagging studies suggest little to no movement between the Gulf of Mexico and the Atlantic (Bethea and Grace 2013; Hendon et al. 2013; Kohler et al. 2013; Tyminski et al. 2013). Bethea and Grace (2013) noted that most tag recaptures occurred in the same bodies of water from which tagged sharpnose sharks were released.

- Bethea et al. (2014) analyzed fishery-independent gillnet survey data in the Gulf of Mexico and found that Atlantic sharpnose was the most commonly caught shark species and were caught consistently across all sampling areas. Males were more abundant than females. Adult male and juvenile Atlantic sharpnose sharks do not appear to be restricted to any specific areas throughout the northeastern Gulf of Mexico. However, adult females are generally only found offshore and newborn sharks are found only in certain coastal areas near the Mississippi delta
- Hoffmayer et al. (2013) identified mature spermatozoa in male sharks from March to November, with a peak time of March through May for spermatogenesis. This study also found that a large number of sexually mature, gravid females were found outside of the known mating season described in Parsons (1983). Maximum estimated longevity of Atlantic sharpnose sharks in the western North Atlantic Ocean was determined by Frazier et al. (2014) to be 19.8 years through tag-recapture data and 18.5 years through direct age estimates
- A preliminary review of post-release live-discard mortality was compiled for Atlantic sharpnose by Courtney (2013) for the SEDAR 34 assessment; hook and line fisheries were estimated to have 10 percent post-release live-discard mortality, and gillnet and bottom longline fisheries were estimated to have a 35 percent post-release live-discard mortality.

Recommendations for EFH based on new information

Because we determined that there are two stocks of Atlantic sharpnose (Atlantic and Gulf of Mexico) and EFH is currently designated only for one joint stock, EFH will be delineated for each individual stock. We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

8.1.2 Literature Cited

Bethea DM, Ajemian MJ, Carlson JK, Hoffmayer ER, Imhoff JL, Grubbs RD, Peterson C, Burgess GH. 2014. Distribution and community structure of coastal sharks in the northeastern Gulf of Mexico. Environ Biol Fish. DOI 10.1007/s10641-014-0355-3.

Bethea DM, Grace MA. 2013. Tag and recapture data for Atlantic sharpnose, *Rhizoprionodon terraenovae*, and bonnethead shark, *Sphyrna tiburo*, in the Gulf of Mexico and US South Atlantic: 1998- 2011. SEDAR34-WP-04. SEDAR, North Charleston, SC. 19 pp.

Frazier BS, Loefer JK. 2013. Update to maximum observed age of Atlantic sharpnose sharks (*Rhizoprionodon terraenovae*) in the western North Atlantic Ocean based on a direct age estimate of a long term recapture. SEDAR34-WP-06. SEDAR, North Charleston, SC. 5 pp

Frazier BS, Driggers III WB, Ulrich GF. 2014. Longevity of Atlantic sharpnose sharks *Rhizoprionodon terraenovae* and blacknose sharks *Carcharhinus acronotus* in the western North Atlantic Ocean based on tag-recapture data and direct age estimates. F1000Research 3:190. doi: 10.12688/f1000research.4767.1

Hendon JM, Hoffmayer ER, Parsons GR. 2013. Tag and recapture data for Atlantic sharpnose, *Rhizoprionodon terraenovae*, and bonnethead, *Sphyrna tiburo*, sharks caught in the northern Gulf of Mexico from 1998-2011. SEDAR34-WP-33. SEDAR, North Charleston, SC. 6 pp.

Hoffmayer ER, Hendon JM, Driggers III WB, Jones LM, Sulikowski JA. 2013. Variability in the reproductive biology of the Atlantic sharpnose shark in the Gulf of Mexico. Mar Coast Fish Dynam Manag Ecosys Sci. 5(1): 139-151.

Kohler NE, Bailey D, Turner PA, McCandless C. 2013. Mark/Recapture Data for the Atlantic Sharpnose Shark (*Rhizoprionodon terraenovae*), in the Western North Atlantic from the NEFSC Cooperative Shark Tagging Program. SEDAR, North Charleston, SC. 23 pp.

Latour RJ, Bonzek CF, Gartland J. 2013. Size composition and indices of relative abundance of the Atlantic sharpnose shark (*Rhizoprionodon terraenovae*) in coastal Virginia waters. SEDAR34-WP-24. SEDAR, North Charleston, SC. 20 pp.

McCallister M, Ford R, Gelsleichter J. 2013. Abundance and Distribution of Sharks in Northeast Florida Waters and Identification of Potential Nursery Habitat. Mar Coast Fish Dynam Manag Ecosys Sci. 5(1): 200-210. doi: 10.1080/19425120.2013.786002

[SEDAR] Southeast Data, Assessment and Review. 2013. SEDAR 34 Stock Assessment Report: Atlantic Sharpnose Sharks. SEDAR, North Charleston, SC.

Tyminski JP, Hueter RE, Morris J. 2013. Tag-recapture results of bonnethead (*Sphyrna tiburo*) and Atlantic sharpnose (*Rhizoprionodon terraenovae*) sharks in the Gulf of Mexico and Florida Coastal Waters. SEDAR34-WP-31. SEDAR, North Charleston, SC. 12 pp.

Ward-Paige CA, Britten GL, Bethea DM, Carlson JK. 2014. Characterizing and predicting essential habitat features for juvenile coastal sharks. Mar Ecol. doi: 10.1111/maec.12151.

8.2 Blacknose Shark (*Carcharhinus acronotus*)

8.2.1 Summary of EFH Review

Recent Changes to Management Structure

Blacknose sharks were last assessed during the 2010 SEDAR 21 stock assessment. Because we determined that there are two stocks of Atlantic blacknose (Atlantic and Gulf of Mexico) and EFH is currently designated only for one joint stock, EFH will be delineated for each individual stock.

Summary of New Literature

- A sizeable amount of new literature was presented at the SEDAR 21 stock assessment for blacknose sharks (see assessment archives at http://www.sefsc.noaa.gov/sedar/Sedar_Workshops.jsp?WorkshopNum=21)
- Potnoy et al. (2014) found barriers to gene flow within blacknose sharks in the U.S. Atlantic and Gulf of Mexico and genetic testing suggested that there are five genetic groups in the region (western Gulf, eastern Gulf, Atlantic, Mexico, and the Bahamas).
- The size at which 50 percent of male sharks are mature was found to be 79.5 cm FL in the northern Gulf of Mexico (Driggers et al. 2010). The size at which 50 percent of females reach maturity was 84.8 cm FL (Driggers et al. 2010). Maximum estimated longevity of blacknose sharks in the western North Atlantic Ocean was determined by Frazier et al. (2014) to be 22.8 years through tag-recapture data and 20.5 years through direct age estimates. Litter size ranges from 1 to 5 pups in the Gulf of Mexico (Driggers et al. 2010).

- Hendon et al. (2014) reported the size at 50 percent maturity for blacknose sharks in the Gulf of Mexico to be 800 and 822 cm FL for males and females, respectively. The observed maximum age was 15.5 and 19.5 for males and females, respectively. The average brood size was 3.63 and ranged from 1 to 6 embryos.
- Bethea et al. (2014) analyzed fishery-independent gillnet survey data in the Gulf of Mexico and found that blacknose sharks seemed to be restricted to specific areas generally with areas of higher salinity and seagrass coverage (Bethea et al. 2014).
- Research has shown that turtle excluder devices (TEDs) have the potential to substantially reduce bycatch of blacknose and bonnethead sharks (Raborn et al. 2010).
- Drymon et al. (2010, 2013) showed a discrete depth preference of 10–30 m for blacknose shark.

Recommendations for EFH based on new information

We have determined that there are two stocks of Atlantic blacknose (Atlantic and Gulf of Mexico), and will delineate EFH for each stock. We will also update EFH boundaries for these stocks based on new literature, observer, survey, and tag/recapture data since 2009.

8.2.2 **Literature Cited**

Bethea DM, Ajemian MJ, Carlson JK, Hoffmayer ER, Imhoff JL, Grubbs RD, Peterson C, Burgess GH. 2014. Distribution and community structure of coastal sharks in the northeastern Gulf of Mexico. Environ Biol Fish. doi: 10.1007/s10641-014-0355-3.

Driggers III WB, Carlson JK, Frazier B, Ingram GW, Quattro JM, Sulikowski JA, Ulrich GF. 2010. Life history and population structure of blacknose sharks, *Carcharhinus acronotus*, in the western North Atlantic Ocean. SEDAR Working Document, SEDAR 21- DW-36.

Drymon JM, Powers S, Dindo J, Dzwonkowski B, Henwood T. 2010. Distributions of sharks across a continental shelf in the northern Gulf of Mexico. Mar Coast Fish Dynam Manag Ecosys Sci. 2: 440-450.

Drymon JM, Carassou L, Powers S, Grace M, Dindo J, Dzwonkowski B. 2013. Multiscale analysis of factors that affect the distribution of sharks throughout the northern Gulf of Mexico. Fish Bull. 111: 370-380.

Frazier BS, Driggers III WB, Ulrich GF. 2014. Longevity of Atlantic Sharpnose Sharks *Rhizoprionodon terraenovae* and Blacknose Sharks *Carcharhinus acronotus* in the western North Atlantic Ocean based on tag-recapture data and direct age estimates. F1000Research 3:190 doi: 10.12688/f1000research.4767.1

Hendon J, Higgs J, Sulikowski J. 2014. A cooperative approach to updating and investigating anomalies in critical life history parameters of two exploited shark species, Blacknose and Finetooth sharks in the northern Gulf of Mexico. NOAA/NMFS Cooperative Research Program Final Report, 31 pp.

Portnoy DS, Hollenbeck CM, Belcher CN, Driggers III WB, Frazier BS, Gelsleichter J, Gold JR. 2014. Contemporary population structure and post-glacial genetic demography in a migratory marine species, the blacknose shark, *Carcharhinus acronotus*. Mol Ecol, 23(22): 5480-5495.

Raborn SA, Andrews KI, Gallaway BJ, Cole JG, Gazey WJ. 2010. Effects of turtle excluder devices (TEDs) on the bycatch of small coastal sharks in the Gulf of Mexico penaeid shrimp fishery. SEDAR Supplemental Document, SEDAR 21-DW-05.

8.3 Bonnethead Shark (*Sphyrna tiburo*)

8.3.1 Summary of EFH Review

Recent Changes to Management Structure

Bonnethead sharks recently underwent a stock assessment in 2013 (SEDAR 34). Genetic information presented at the assessment indicated the need to split the stock into separate Atlantic and Gulf of Mexico stocks, however, due to lack of time to complete benchmark assessments for two new stocks, a “standard” assessment of a single unit stock was completed to provide management advice to NMFS. The assessment found the status of the single unit stock to be not overfished and not experiencing overfishing. However, based on the results of the assessment and scientific recommendations from assessment participants and reviewers, NMFS decided to split the single bonnethead shark stock into Atlantic and Gulf of Mexico stocks and determined the status of each stock as “unknown.”

Summary of New Literature

- A sizeable amount of new literature was presented at the SEDAR 34 stock assessment for bonnethead sharks (see assessment archives at http://www.sefsc.noaa.gov/sedar/Sedar_Workshops.jsp?WorkshopNum=34)
- The FY10-GULFSPAN Shark Nursery Ground and Essential Fish Habitat survey noted important coastal bonnethead shark habitats between the Florida panhandle and Tarpon Springs, FL and in Mississippi Sound off of Alabama. Associations with environmental variables (e.g., temperature, salinity, depth, substrate) are summarized by region and sample locations (Bethea et al., 2011). Some interannual variability is likely to occur between GULFSPAN reports for different years, however, bonnethead sharks are consistently one of the top species caught by number.
- Bethea et al. (2014) analyzed coastal shark community dynamics (including bonnethead sharks) in relation to environmental variables. Bonnethead sharks comprised a greater proportion of the sampled shark community in coastal Florida waters than elsewhere in the Gulf of Mexico.
- Ward-Paige et al. (2014) developed habitat suitability models for several coastal sharks, including bonnethead. Bonnethead shark occurrence was primarily correlated with warmer temperatures (>30ºC) and salinity between 30-35 ppt.
- Bethea and Grace (2013) reviewed tagging data for 901 bonnethead sharks, 9 of which were recaptured. Most recaptures occurred in close proximity to release locations. Tagging data were consistent with current EFH.
- Kohler et al. (2013) review a tagging program conducted by the NEFSC in which 4,123 bonnetheads were released and 172 were recaptured. Most sharks were recaptured in close proximity to release locations with a few exceptions. Tagging data were consistent with current EFH.
- Belcher and Jennings (2010) correlated the presence of subadult sharks in coastal Georgia estuaries with environmental variables. Bonnethead sharks were the second most prevalent species caught. The presence of bonnethead sharks was associated with depth,

salinity, and dissolved oxygen levels. Bonnethead sharks were sampled from locations either within or adjacent to (i.e., in estuaries) previously defined EFH.

- McCallister et al. (2013) evaluated habitat and environmental associations of sharks in northeastern Florida estuaries. Bonnethead sharks were the third most prevalent species caught, and presence was associated with dissolved oxygen levels. Tagging results indicate that bonnethead sharks do not travel far from release locations. Bonnethead sharks were sampled from locations either within or adjacent to (i.e., in estuaries) previously defined EFH.
- Frazier et al. (2014) used biological samples from bonnethead sharks collected from Onslow Bay, North Carolina, south to West Palm Beach, Florida to estimate length and age at 50 percent maturity for females (819 mm FL, 6.7 years) and males (618 mm; 3.9 years).
- Driggers et al. (2014) conducted a tag-recapture study of bonnethead sharks of off South Carolina and found strong site fidelity to specific estuaries and hypothesize that these areas are utilized as seasonal feeding grounds.
- Froeschke et al. (2010) developed spatially explicit estuarine habitat use models for three coastal shark species (bull, blacktip, and bonnethead sharks) from long-term fisheries independent gillnet surveys conducted in Texas estuaries and showed that bonnethead sharks were restricted to areas near tidal passes with moderate salinities.
- Bethea et al. (2014) in a comprehensive study of 10 geographic areas in the northeastern Gulf of Mexico found bonnetheads were only consistently captured at the highest rates in the eastern part of the northern Gulf of Mexico and areas dominated by seagrass and higher salinities.

Recommendations for EFH based on new information

Because we determined that there are two stocks of bonnethead sharks (Atlantic and Gulf of Mexico) and EFH is currently designated only for one joint stock, EFH will be delineated for each individual stock. We will also update EFH boundaries based on new literature, observer, survey, and tag/recapture data since 2009.

8.3.2 Literature Cited

Belcher CN, Jennings CA. 2010. Utility of mesohabitat features for determining habitat associations of subadult sharks in Georgia's estuaries. Environ Biol Fish. 88: 349-359

Bethea DM, Smith K, Carlson JK, Ajemian MJ, Grubbs RD, Imhoff J. 2011. Shark nursery grounds and essential fish habitat studies. GULFSPAN Survey-FY10 Sustainable Fisheries Div. Contrib. PCB-11/01. NOAA Fisheries, Highly Migratory Species Div.

Bethea DM, Grace MA. 2013. Tag and recapture data for Atlantic sharpnose, *Rhizoprionodon terraenovae*, and bonnethead shark, *Sphyrna tiburo*, in the Gulf of Mexico and US South Atlantic: 1998- 2011. SEDAR34-WP-04. SEDAR, North Charleston, SC. 19 pp.

Bethea DM, Ajemian MJ, Carlson JK, Hoffmayer ER, Imhoff JL, Grubbs RD, Peterson C, Burgess GH. 2014. Distribution and community structure of coastal sharks in the northeastern Gulf of Mexico. Environ Biol Fish. doi:10.1007/s10641-014-0355-3.

Driggers III WB, Frazier BS, Adams DH, Ulrich GF, Jones CM, Hoffmayer ER, Campbell MD. 2014. Site fidelity of migratory bonnethead sharks *Sphyrna tiburo* (L. 1758) to specific estuaries in South Carolina, USA. J Exp Mar Biol Ecol. 459: 61-69.

Frazier BS, Driggers III WB, Adams DH, Jones CM, Loefer JK. 2014. Validated age, growth and maturity of the bonnethead Sphyrna tiburo in the western North Atlantic Ocean. J Fish Biol. 85(3): 688-712.

Froeschke J, Stunz GW, Wildhaber ML. 2010. Environmental influences on the occurrence of coastal sharks in estuarine waters. Mar Ecol Prog Ser. 407: 279-292.

Kohler NE, Sawicki E, Turner PA, McCandless C. 2013. Mark/Recapture Data for the Bonnethead (*Sphyrna tiburo*), in the Western North Atlantic from the NEFSC Cooperative Shark Tagging Program. SEDAR, North Charleston, SC. 15 pp.

McCallister M, Ford R, Gelsleichter J. 2013. Abundance and Distribution of Sharks in Northeast Florida Waters and Identification of Potential Nursery Habitat. Mar Coast Fish Dynam Manag Ecosys Sci. 5(1): 200-210. doi: 10.1080/19425120.2013.786002

Ward-Paige CA, Britten GL, Bethea DM, Carlson JK. 2014. Characterizing and predicting essential habitat features for juvenile coastal sharks. Mar Ecol. 1-13. doi: 10.1111/maec.12151

8.4 Finetooth Shark (*Carcharhinus isodon*)

8.4.1 Summary of EFH Review

Recent Changes to Management Structure

There have been no changes to the management structure of finetooth sharks since the publication of Amendment 1 to the 2006 Consolidated HMS FMP.

Summary of New Literature

- Spatial and temporal variability in distribution has been observed for this species between the Atlantic and Gulf of Mexico (Carlson et al. 2007; Driggers and Hoffmayer 2009; Driggers and Hoffmayer 2009; Hendon et al. 2014).
- Drymon et al. (2010) noted that finetooth sharks tended to be found in shallower waters in a study of shark distribution across the continental shelf of the northern Gulf of Mexico. Many of the sharks sampled for research conducted by Hendon et al. (2014) came from coastal waters inshore of the Mississippi Sound barrier islands (Mississippi), around Dauphin Island and Mobile Bay (Alabama), and in Chandeleur Sound (eastern Louisiana).
- Crear (2012) identified nursery habitat was identified in Mississippi Sound.
- Hendon et al. (2014) noted the observed maximum male and female age to be 5.5 years, and 8.5 years, respectively, in the northern Gulf of Mexico. This study also noted the size at 50 percent maturation for male and female finetooth sharks of the northern Gulf of Mexico were 956 mm TL and 1035 mm TL, respectively; that litter size in the Gulf of Mexico ranged from one to nine pups; and that spermatogenesis in the northern Gulf of Mexico peaks in April, and corresponds with female ovulation in May.
- The reproductive cycle is biennial in the South Atlantic Bight (Castro 1993); both annual and biennial reproductive cycles have been observed in sharks from the northern Gulf of Mexico (Driggers and Hoffmayer 2009).
- Ward-Paige et al. (2014) analyzed a fishery independent gillnet survey from the northern Gulf of Mexico to describe distribution patterns and habitat associations of juvenile

coastal sharks with habitat suitability modeling. In comparison to other sharks, Ward-Paige et al. noted that finetooth sharks were associated more often with low salinity habitats (< 20 PSU) and moderate depths (~4 meters).

Finetooth sharks were only consistently captured at the highest rates over a select group of bays (i.e., Mobile Bay to Apalachicola Bay) throughout the northeast Gulf of Mexico, generally those with lower salinities (Bethea et al. 2014).

Recommendations for EFH based on new information

While there is some new literature that suggests separate life history characteristics in the Gulf of Mexico and Atlantic and provides more refined estimates of life history parameters in the Gulf of Mexico, because there is only one defined finetooth shark stock at this time, EFH will not be updated specifically based on this new literature. However, we will update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

8.4.2 Literature Cited

Bethea DM, Ajemian MJ, Carlson JK, Hoffmayer ER, Imhoff JL, Grubbs RD, Peterson C, Burgess GH. 2014. Distribution and community structure of coastal sharks in the northeastern Gulf of Mexico. Environ Biol Fish. doi: 10.1007/s10641-014-0355-3.

Carlson JK, Drymon JM, Neer JA. 2007. Life history parameters for finetooth sharks, *Carcharhinus isodon*, from the United States South Atlantic Ocean and northern Gulf of Mexico. SEDAR 13-DW-11. SEDAR, Charleston SC. http://www.sefsc.noaa.gov/sedar/download/SEDAR13-DW-11.pdf?id=DOCUMENT

Castro JI, 1993. The biology of the finetooth shark, *Carcharhinus isodon*. Environ Biol Fish. 36:219-232.

Crear D. 2012. Assessing the variability in distribution of four shark species within the Mississippi Sound [Thesis]. University of New England. http://dune.une.edu/theses/14/

Driggers III WB, Hoffmayer ER. 2009. Variability in the reproductive cycle of finetooth sharks, *Carcharhinus isodon*, in the northern Gulf of Mexico. Copeia. 2009(2):390-393.

Drymon JM, Powers SP, Dindo J, Dzwonkowski B, Henwood T. 2010. Distribution of sharks across a continental shelf in the northern Gulf of Mexico. Mar Coast Fish Dynam Manag Ecosys Sci. 2: 440-450.

Hendon JM, Higgs J, Sulikowski J. 2014. A cooperative approach to updating and investigating anomalies in critical life history parameters of two exploited shark species, blacknose and finetooth sharks in the Gulf of Mexico. Final Report-Cooperative Research Program, National Marine Fisheries Service, NOAA. Grant # NA11NMF4540117

Ward-Paige CA, Britten GL, Bethea DM, Carlson JK. 2014. Characterizing and predicting essential habitat features for juvenile coastal sharks. Mar Ecol. doi: 10.1111/maec.12151.

9 PELAGIC SHARKS

The following subsections review and itemize all new literature (post-2009) on life history, behavior, distribution and habitat for pelagic sharks managed by the Atlantic HMS Management Division of NMFS that could be used to update EFH boundaries and text descriptions. Unless otherwise noted, this information is intended to 1) supplement the text descriptions of life history, behavior, and EFH presented in Amendment 1; and 2) itemize possible new sources of data that could be incorporated into procedures to delineate EFH for the species.

Original text descriptions of life history, behavior and essential fish habitat may be found in Chapter 5 of Amendment 1:
http://www.nmfs.noaa.gov/sfa/hms/documents/fmp/am1/index.html.

9.1 Blue Shark (*Prionace glauca*)

9.1.1 Summary of EFH Review

Recent Changes to Management Structure

There have been no changes to the management structure of blue sharks since the publication of Amendment 1 to the 2006 Consolidated HMS FMP. ICCAT assessed North Atlantic blue sharks in 2008 and found the species to be not overfished with no overfishing occurring.

Summary of New Literature

- Queiroz et al. (2012) noted fidelity of female blue sharks to localized high-productivity regions along thermal fronts, suggesting that once prey resources are found the sharks may remain in those areas for some time.
- Diel vertical migrations in sharks located along shelf-breaks, possibly also related to tracking food resources that make similar vertical migrations through the water column (Campana et al. 2011; Queiroz et al. 2012) Campana et al. (2011) noted that blue sharks initiated mean diel vertical migrations of over 300 meters during the day, perhaps following migrations of teleost and squid prey.
- Howey (2010) tagged blue sharks off of New England using satellite tags and found that blue sharks stayed in shallow continental shelf areas and showed shallow diving behavior during the summer months.
- Vandeperre et al. (2014) tracked blue sharks tagged off the Azores belonging to different life stages for up to 952 days. This study found a potential central North Atlantic nursery with juvenile residence of up to two years.
- Vandeperre et al. (2014) analyzed fishery independent data and observer data to characterize population structure and abundance of blue shark around the Azores Archipelago in the central North Atlantic.

Recommendations for EFH based on new information

Recent studies do not support amending the existing blue shark EFH. However, we will update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

9.1.2 Literature Cited

Campana SE, Dorey A, Fowler M, Joyce W, Wang Z, Wright D, Yashayaev I. 2011. Migration pathways, behavioral thermoregulation and overwintering grounds of blue sharks in the northwest Atlantic. PLoS ONE. 6: e16854.

Howey L. 2010. Seasonal movement patterns, migratory behavior, and habitat utilization of the blue shark in the western North Atlantic [thesis]. [Fort Lauderdale (FL)]: Nova Southeastern University.

Queiroz N, Humphries NE, Noble LR, Santos AM, Sims DW. 2012. Spatial Dynamics and Expanded Vertical Niche of Blue Sharks in Oceanographic Fronts Reveal Habitat Targets for Conservation. PLoS ONE 7(2): e32374. doi:10.1371/journal.pone.0032374

Vandeperre F, Aires-da-Silva A, Fontes J, Santos M, Serrao Santos R, Afonso P. 2014. Movements of blue shark (*Prionace glauca*) across their life history. PLoSOne 9(8): e103538. doi: 10.1371/journal.pone.0103538.

Vandeperre F, Aires-da-Silva A, Santos M, Ferreira R, Bolton AB, Serrao Santos R, Afonso P. 2014. Demography and ecology of blue shark (*Prionace glauca*) in the central North Atlantic. Fish Res 153:89-102.

9.2 Oceanic Whitetip Shark (*Carcharhinus longimanus*)

9.2.1 Summary of EFH Review

Recent Changes to Management Structure

Oceanic whitetip sharks continue to be part of the pelagic shark management complex and there have been no changes to management structure or stock status since the publication of Amendment 1 to the 2006 Consolidated HMS FMP. The stock status for this species is unknown as it has not been assessed. Fishermen participating in ICCAT-related fisheries are subject to regulations implementing ICCAT Recommendation 10-07. Oceanic whitetip sharks are also listed in Appendix II of CITES (effective September 14, 2014), which makes international trade of oceanic whitetip sharks subject to additional regulation (e.g., permitting for importing/exporting oceanic whitetip sharks).

Summary of New Literature

- Several oceanic whitetip sharks have been tagged off the Bahamas. These animals tended to range along the outer continental shelf north of the Antilles islands of the eastern Caribbean northward to Cape Hatteras, NC. See Guy Harvey Research Institute website for PSAT tag data - http://www.nova.edu/ocean/ghri/tracking/?project=owtsharks; Howey-Jordan et al. 2013.
- Howey-Jordan et al. (2013) found that tagged sharks tend to stay within the epipelagic zone (0-200m depth), with a mean recorded depth of just under 50m; that oceanic whitetip shark depth preferences are weakly associated with sea surface temperature (warmer waters resulting in slightly deeper depth profiles); and that oceanic whitetip sharks exhibit similar deep diving behavior as other pelagic sharks (rapid descent, slow ascent).
- An oceanic whitetip shark tagged by the NMFS Pelagic Observer Program in the Gulf of Mexico moved from central portions of the Gulf of Mexico southeast to the edge of the

continental shelf north of the Yucatan Peninsula. This shark primarily remained in the upper 150m of the water column, made one recorded deep-dive, and spent a considerable amount of time in water temperatures of 24º-26ºC (Carlson and Gulak 2012).

Recommendations for EFH based on new information

We will update oceanic whitetip shark EFH based on new PSAT tag data, including tracks in the U.S. Caribbean and the Gulf of Mexico that are not included in the current EFH designation. We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

9.2.2 Literature Cited

Carlson JK, Gulak SJB. 2012. Habitat use and movement patterns of oceanic whitetip, bigeye thresher, and dusky sharks based on archival satellite tags. Collect Vol Sci Pap. ICCAT 68(5):1922-1932. SCRS/2011/099

Howey-Jordan LA, Brooks EJ, Abercrombie DL, Jordan LKB, Brooks A, Williams S, Gospodarczyk E, Chapman DD. 2013. Complex Movements, Philopatry and Expanded Depth Range of a Severely Threatened Pelagic Shark, the Oceanic Whitetip (*Carcharhinus longimanus*) in the Western North Atlantic. PLoS ONE. 8(2): e56588. doi:10.1371/journal.pone.0056588

9.3 Porbeagle Shark (*Lamna nasus*)

9.3.1 Summary of EFH Review

Recent Changes to Management Structure

The most recent stock assessment conducted by ICCAT in 2009 determined that porbeagle sharks in the northwest Atlantic are overfished and biomass has been depleted; however, biomass is currently increasing, and overfishing is no longer occurring (ICES/ICCAT 2009). Campana et al. (2010) developed a life history model to evaluate porbeagle population dynamics using data through 2008 and found that Northwest Atlantic populations were estimated to be at roughly one-quarter of historical (1961) biomass; the number of mature females was estimated to range between 11,000 and 14,000; that recovery of the species was dependent on keeping fishing mortality extremely low; and that recovery was projected to take over 100 years under minimal (4 percent) exploitation rates. Campana et al. (2013) provided a new stock assessment at Fisheries and Oceans Canada's 2012 pre-COSEWIC (Committee on the Status of Endangered Wildlife in Canada) review and found that the total population size is currently estimated to be about 22 to 27 percent of its size in 1961 and about 95 to 103 percent its size in 2001. The estimated number of mature females in 2009 is in the range of 11,000 to 14,000 individuals, or 12 to 16 percent of its 1961 level and 83 to 103 percent of its 2001 value. Porbeagle sharks are also listed in Appendix II of CITES (effective September 14, 2014), which makes international trade of porbeagle sharks subject to additional regulation (e.g., permitting for importing/exporting porbeagle sharks).

Summary of New Literature

- Campana et al. (2010a) found that porbeagle are known to overwinter in U.S. portions of the Gulf of Maine, Georges Bank, and the southern portion of the Scotian Shelf before moving northeast into Canadian waters for the rest of the year.

- Pade et al. (2009) conducted satellite tracking of porbeagle in the northeast Atlantic and describe seasonal, regional to localized site fidelity (Pade et al. 2009).
- Campana et al. (2013) identified two mating grounds: 1) on the Grand Banks, off southern Newfoundland, and at the entrance to the Gulf of St. Lawrence, and 2) Georges Bank.
- The definitive location of pupping grounds remains unknown (Simpson and Miri 2014), however Campana et al. (2013) identified two mating grounds for porbeagle sharks on the Grand Banks off Newfoundland and on Georges Bank off Nova Scotia. However, female PAT-tagged porbeagle sharks (n = 7) were noted to exit Canadian and northern U.S. coastal regions and make extensive migrations to deep, cold-water thermal refugia of the Sargasso Sea (Campana et al. 2010b). Given that the majority of mature females are gravid after November (Jensen et al. 2002), Campana et al. (2010b) hypothesize that pupping may occur in the Sargasso Sea and that pups and mature females follow the Gulf Stream back to northern feeding habitats.
- Semba et al. (2013) noted that CPUE of young porbeagle (neonates) is higher in areas north of 40º S latitude, as opposed to juvenile and adult porbeagle that were distributed in colder water regions.

Recommendations for EFH based on new information

We will update porbeagle shark EFH based on new tagging data.. We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

9.3.2 **Literature Cited**

Campana SE, Gibson AJF, Fowler M, Dorey A, Joyce W. 2010a. Population dynamics of porbeagle in the northwest Atlantic, with an assessment of status to 2009 and projections for recovery. Collect Vol Sci Papers ICCAT 65(6):2109-2182. SCRS/2009/095.

Campana SE, Joyce W, Fowler M. 2010b. Subtropical pupping ground for a cold-water shark. Can J Fish Aquat Sci. 67:769-773.

Campana SE, Gibson AJF, Fowler M, Dorey A, Joyce W. 2013. Population dynamics of northwest Atlantic porbeagle (*Lamna nasus*), with an assessment of status and projections for recovery. Fisheries and Oceans Canada, Research Document 2012/096. http://www.iob.gc.ca/sharks/documents/RES2012_096-eng.doc

ICES/ICCAT. 2009. Report of the 2009 Porbeagle Stock Assessment Meeting. SCRS/2009/014-Sharks Stock Assessment. SCI-032/2009. Copenhagen, Denmark, June 22-27, 2009.

Pade NG, Queiroz N, Humphries NE, Witt MJ, Jones CS, Noble LR, Sims DW. 2009. First results from satellite-linked archival tagging of porbeagle shark, *Lamna nasus*: area fidelity, wider-scale movements, and plasticity in diel depth changes. J Exp Mar Biol Ecol. 370:64-74.

Semba Y, Yokawa K, Matsunaga H, Shono H. 2013. Distribution and trends in abundance of the porbeagle (*Lamna nasus*) in the southern hemisphere. Mar Freshw Res. 64(6): 518-529. http://dx.doi.org/10.1071/MF12272

Simpson MR, Miri CM. 2014. A pre-COSEWIC assessment of porbeagle shark (*Lamna nasus*) in Newfoundland and Labrador waters. DFO Can Sci Advis Sec Res Doc. 2013/088. iv + 19 p.

9.4 Shortfin Mako (*Isurus oxyrinchus*)

9.4.1 Summary of EFH Review

Recent Changes to Management Structure

The North Atlantic shortfin mako stock is assessed by ICCAT's Standing Committee on Research and Statistics (SCRS). The most recent SCRS assessment of the North Atlantic shortfin mako stock took place in 2012. According to the stock assessment, current levels of catch may be considered sustainable, as indications of potential overfishing shown in the previous stock assessment have diminished. These results indicate that the stock is healthy because it is not overfished and the probability that overfishing is occurring is low.

Summary of New Literature

- Mucientes et al. (2009) describe spatial segregation of sexes.
- The Guy Harvey Research Institute has collected data from 15 PSAT tagged shortfin makos in the western Atlantic, and data from 15 PSAT tagged shortfin mako in the Caribbean and Gulf of Mexico. Most of the Caribbean/Gulf of Mexico sharks were tagged off Cozumel, and only a few were tracked into the northern Gulf of Mexico. Guy Harvey Research Institute (NOVA Southeastern University) tracking website: http://www.nova.edu/ocean/ghri/tracking/

Recommendations for EFH based on new information

We will update shortfin mako EFH based on new PSAT tag data. We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

9.4.2 Literature Cited

Mucientes GR, Queiroz N, Sousa LL, Tarroso P, Sims DW. 2009. Sexual segregation of pelagic sharks and the potential threat from fisheries. Biol Letters. doi:10.1098/rsbl.2008.0761

9.5 Thresher Shark (*Alopias vulpinus*)

9.5.1 Summary of EFH Review

Recent Changes to Management Structure

Thresher sharks continue to be part of the pelagic shark management complex and there have been no changes to management structure or stock status since the publication of Amendment 1 to the 2006 Consolidated HMS FMP. The stock status for this species is unknown as it has not been assessed.

Summary of New Literature

- Castro (2011) describes seasonal abundance and north-south migrations along the U.S. East Coast.
- Gervelis and Natanson (2013) found that males reach at least 22 years of age and females are known to reach 24 years of age; growth of both sexes is similar until age 8, when male growth slows down; and that females grow quickly until age 12, after which growth is slowed.

- Natanson and Gervelis (2013) found mature pregnant females in the northwest Atlantic Ocean between 221 and 251 cm FL in size. Mating is suspected to occur in the late fall (Natanson and Gervelis 2013).
- Evidence suggests a biennial, synchronous reproductive cycle, with potential for a triennial cycle (Castro 2009; Natanson and Gervelis 2013).

Recommendations for EFH based on new information

Recent studies support updating the life history descriptions of the species. However, we will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

9.5.2 Literature Cited

Castro JI. 2009. Observations on the reproductive cycles of some viviparous North American sharks. Aqua, International Journal of Ichthyology, 15: 205–222. Castro, J.I. 2011. The sharks of North America. Oxford University Press. ISBN 978-0-19-539294-4.

Gervelis BJ, Natanson LJ. 2013. Age and growth of the common thresher in the western North Atlantic Ocean. Trans Am Fish Soc. 142:1535-1545. doi:10.1080/00028487.2013.815658

Natanson LJ, Gervelis BJ. 2013. The Reproductive Biology of the Common Thresher Shark in the Western North Atlantic Ocean. Trans Am Fish Soc. 142 (6): 1546-1562 doi: 10.1080/00028487.2013.811099

10 PROHIBITED SHARKS

The following sections review and itemize all new literature (post-2009) on life history, behavior, distribution and habitat for prohibited sharks managed by the Atlantic HMS Management Division of NMFS that could be used to update EFH boundaries and text descriptions. Unless otherwise noted, this information is intended to 1) supplement the text descriptions of life history, behavior, and essential fish habitat presented in Amendment 1; and 2) itemize possible new sources of data that could be incorporated into EFH updates for these species.

Original text descriptions of life history, behavior and essential fish habitat may be found in Chapter 5 of Amendment 1: http://www.nmfs.noaa.gov/sfa/hms/documents/fmp/am1/index.html.

10.1 Atlantic Angel Shark (*Squantina dumeril*)

10.1.1 Summary of EFH Review

Recent Changes to Management Structure

Angel sharks continue to be a prohibited species and there have been no changes to management structure or stock status since the publication of Amendment 1 to the 2006 Consolidated HMS FMP. The stock status for this species is unknown as it has not been assessed.

Summary of New Literature

- New life history information, including size at maturity, female reproductive condition, litter size, gestation, and diet are available in Baremore 2010 and Baremore et al. 2008.
- Three species of angel sharks were described by Castro-Aguirre et al. (2006); however only one species is considered part of the HMS management unit (*Squantina dumeril*). Therefore, EFH is only described for one species of angel shark in the U.S. EEZ.

Recommendations for EFH based on new information

Recent studies support updating angel shark life history descriptions. We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

10.1.2 Literature Cited

Baremore IE. 2010. Reproductive aspects of the Atlantic angel shark *Squatina dumeril*. J Fish Biol. 76:1682-1695.

Baremore IE, Murie DJ, Carlson JK. 2008. Prey selection by the Atlantic angel shark *Squatina dumeril* in the northeastern Gulf of Mexico. Bull Mar Sci. 82(3):297-313.

Castro-Aguirre JL, Espinosa Perez H, Huidobro Campos L. 2006. Dos nuevas especies del genero *Squatina* (Chondrichthyes: Squatinidae) del Golfo de Mexico. Rev Biol Trop. 54(3):1031-1040.

10.2 Basking Shark (*Cetorhinus maximus*)

10.2.1 Summary of EFH Review

Recent Changes to Management Structure

Basking sharks continue to be a prohibited species and there have been no changes to management structure or stock status since the publication of Amendment 1 to the 2006 Consolidated HMS FMP. The stock status for this species is unknown as it has not been assessed.

Summary of New Literature

- Recent studies with PSATs have extended the known range of basking sharks. Skomal et al. (2009) and Skomal et al. (2012) indicated that basking sharks may travel into subtropical to tropical waters in the deep waters of the mesopelagic zone in wintertime, possibly as far as the northeastern coast of South America.
- Gore et al. (2012) documented extensive migrations across the Atlantic Ocean basin by tagged basking sharks (Gore et al. 2012).
- Basking sharks may be responsive to large scale environmental phenomena (e.g., North Atlantic Oscillation (Witt et al. 2012).
- Hoffmayer et al. (2011) suggested that basking sharks may exhibit seasonal migrations through the Gulf of Mexico.

Recommendations for EFH based on new information

We will update EFH boundaries based on results of new tagging studies, specifically from PSAT data. We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

10.2.2 Literature Cited

Gore MA, Rowat D, Hall J, Gell FR, Ormond, RF. 2008. Transatlantic migration and deep mid-ocean diving by basking shark. Biol Lett. 4:395-398. doi:10.1098/rsbl.2008.0147

Hoffmayer ER, Driggers III WB, Franks JS, Hanisko DS, Roffer MA, Cavitt LE. 2011. Recent occurrences of basking sharks, *Cetorhinus maximus* (Chondrichthyes: Cetorhinidae), in the Gulf of Mexico. Mar Biodivers Rec. 4:e87. doi:10.1017/S1755267211000844

Sims DW, Witt MJ, Richardson AJ, Southall EJ, Metcalfe JD. 2006. Encounter success of free-ranging marine predator movements across a dynamic prey landscape. Proc R Soc B. 273, 1195–1201.

Skomal GB, Zeeman SI, Chisholm JH, Summers EL, Walsh HJ, McMahon KW, Thorrold SR. 2009. Transequatorial migrations by basking sharks in the western Atlantic Ocean. Curr Biol. 19(12):1019-1022.

Witt MJ, Hardy T, Johnson L, McClellan CM, Pikesley SK, Ranger S, Richardson PB, Solandt J, Speedie C, Williams R, Godley BJ. 2012. Basking sharks in the northeast Atlantic: spatio-temporal trends from sightings in UK waters. Mar Ecol Prog Ser. 459:121-134. doi: 10.3354/meps09737

10.3 Bigeye Sand tiger (*Odontaspis noronhai*)

10.3.1 Summary of EFH Review

Recent Changes to Management Structure

Bigeye sand tiger sharks continue to be a prohibited species and there have been no changes to management structure or stock status since the publication of Amendment 1 to the 2006 Consolidated HMS FMP. The stock status for this species is unknown as it has not been assessed.

Summary of New Literature

There was no new literature found pertaining to EFH for bigeye sand tiger sharks.

Recommendations for EFH based on new information

Recent studies do not support updating EFH boundaries. However, we will update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

10.4 Bigeye Sixgill (*Hexanchus nakamurai*)

10.4.1 Summary of EFH Review

Recent Changes to Management Structure

Bigeye sixgill sharks continue to be a prohibited species and there have been no changes to management structure or stock status since the publication of Amendment 1 to the 2006 Consolidated HMS FMP. The stock status for this species is unknown as it has not been assessed.

Summary of New Literature

- Barnett et al. (2012) conducted a study on cow and frill sharks that contains some basic life history information on bigeye sixgill sharks.

Recommendations for EFH based on new information

Recent studies support updating the life history descriptions of the species. We will update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

10.4.2 Literature Cited

Barnett A, Braccini JM, Awruch CA, Ebert DA. 2012. An overview on the role of Hexanchiformes in marine ecosystems: biology, ecology and conservation status of a primitive order of modern sharks. J Fish Biol. 80: 966–990. doi: 10.1111/j.1095-8649.2012.03242.x

10.5 Bigeye Thresher (*Alopias superciliosus*)

10.5.1 Summary of EFH Review

Recent Changes to Management Structure

Bigeye thresher sharks continue to be a prohibited species and there have been no changes to management structure or stock status since the publication of Amendment 1 to the

2006 Consolidated HMS FMP. The stock status for this species is unknown as it has not been assessed.

Summary of New Literature

- Carlson and Gulak (2012) describe a bigeye thresher shark that was tagged by the NMFS Pelagic Observer Program in the Gulf of Mexico which remained around the Mississippi delta offshore during the 120 day tag event. It was found most frequently between 25.5-50 m and 20.05-22°C. The bigeye thresher dove up to 528 m with deeper dives occurring during the day.

Recommendations for EFH based on new information

Recent studies support updating the life history descriptions of the species. We will update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

10.5.2 **Literature Cited**

Carlson JK, Gulak SJB. 2012. Habitat use and movement patterns of oceanic whitetip, bigeye thresher, and dusky sharks based on archival satellite tags. Collect Vol Sci Pap. ICCAT. 68(5):1922-1932. SCRS/2011/099

10.6 Bignose Shark (*Carcharhinus altimus*)

10.6.1 **Summary of EFH Review**

Recent Changes to Management Structure

Bignose sharks continue to be a prohibited species and there have been no changes to management structure or stock status since the publication of Amendment 1 to the 2006 Consolidated HMS FMP. The stock status for this species is unknown as it has not been assessed.

Summary of New Literature

There was no new literature found pertaining to EFH for bignose sharks in the U.S. Atlantic EEZ.

Recommendations for EFH based on new information

Recent studies do not support updating EFH boundaries. However, we will update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

10.7 Caribbean Reef Shark (*Carcharhinus perezi*)

10.7.1 **Summary of EFH Review**

Recent Changes to Management Structure

Caribbean reef sharks continue to be a prohibited species and there have been no changes to management structure or stock status since the publication of Amendment 1 to the 2006 Consolidated HMS FMP. The stock status for this species is unknown as it has not been assessed.

Summary of New Literature

- Driggers et al. (2011) reports photographic evidence of a Caribbean reef shark in Flower Garden Banks National Marine Sanctuary, a discrete coral reef system in the northwestern Gulf of Mexico off the coast of Texas. Authors discuss the potential for this area to support a population of Caribbean reef sharks.

Recommendations for EFH based on new information

We will update Caribbean reef shark EFH boundaries in the western Gulf of Mexico, due to evidence presented in Driggers et al. (2011). We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

10.7.2 **Literature Cited**

Driggers WB, Hoffmayer ER, Hickkerson EL, Martin TL, Gledhill CT. 2011. Validating the occurrence of Caribbean reef sharks, *Carcharhinus perezi* (Poey), (*Chondrichthyes: Carcharhiniformes*) in the northern Gulf of Mexico, with a key for sharks of the family Carcharhinidae inhabiting the region. Zootaxa 2933:65–68.

10.8 Caribbean Sharpnose Shark (*Rhizoprionodon porosus*)

10.8.1 **Summary of EFH Review**

Recent Changes to Management Structure

Caribbean sharpnose sharks continue to be a prohibited species and there have been no changes to management structure or stock status since the publication of Amendment 1 to the 2006 Consolidated HMS FMP. The stock status for this species is unknown as it has not been assessed.

Summary of New Literature

There was no new literature found pertaining to EFH for Caribbean sharpnose sharks in the U.S. Atlantic EEZ.

Recommendations for EFH based on new information

Recent studies do not support updating EFH boundaries. However, we will update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

10.9 Dusky Shark (*Carcharhinus obscurus*)

10.9.1 **Summary of EFH Review**

Recent Changes to Management Structure

The latest stock assessment for dusky sharks was completed through the SEDAR 21 process in 2011. The stock assessment provides an update from the 2005/2006 assessment. The SEDAR 21 assessment found that the stock is still overfished and that overfishing is still occurring. Summarized stock assessment results can be found in the Amendment 5 DEIS. SEDAR 29 stock assessment documents can be found on the SEDAR website at: http://www.sefsc.noaa.gov/sedar/Sedar_Workshops.jsp?WorkshopNum=21

Dusky sharks continue to be prohibited from recreational and commercial retention.

Summary of New Literature

- New literature was presented at the SEDAR 21 stock assessment for dusky sharks (see assessment archives at http://www.sefsc.noaa.gov/sedar/Sedar_Workshops.jsp?WorkshopNum=21)
- Benavides et al. (2013) assessed global genetic stock structure in Benavides et al. (2011), whereby clearly distinct genetic stocks were identified for three major management units in the U.S. Atlantic, South Africa, and off Australia. This analysis included samples from both U.S. Atlantic (n= 76) and U.S. Gulf of Mexico (n = 26) dusky sharks, and results indicated that sharks from these two regions are genetically similar (i.e., are part of the same genetic stock). Under the most recent SEDAR assessment, dusky sharks are considered a single unit stock and assessed as such (SEDAR 2011).
- In cooperation with recreational anglers and NMFS scientists, approximately 7,832 dusky sharks were tagged between 1963 and 2009; of these, 161 dusky sharks were recaptured between 1967 and 2009 (2.1 percent recapture rate) (Kohler and Turner 2010).
- Thirty-six percent of the sharks tagged in U.S. Gulf of Mexico waters, and 14 percent of the sharks tagged in the U.S. Atlantic waters, were recaptured in Mexican territorial waters (SEDAR 2010; Bethea and Carlson 2010).
- Eight dusky sharks have been tagged by NMFS between 2007 and 2010 (Carlson and Gulak 2012); three PSATs provided usable data for dusky shark movements. These sharks spent over half their time in water temperatures between 20.05° and 24°C and in depths of 0-40 m the majority of the time, although dives up to 400 m were recorded. Movement patterns varied between the three sharks.
- Hoffmayer et al. (2014) tagged eight adult (all female) and two juvenile (one female and one male) dusky sharks with PSATs in July of 2008 and 2009. The authors note that despite being rare, dusky sharks form predictable, seasonal aggregations off the coast of Louisiana. Dusky sharks were primarily found along the northern Gulf of Mexico continental shelf-break between DeSoto Canyon and northeastern Mexico. In particular, many sharks were tracked between the Mississippi Delta and southeastern Texas.
- Natanson et al. (2013) noted that females mature at 17-18 years of age and that maximum confirmed age is 42 years.
- For stock assessment purposes, dusky sharks are assumed to have a 3-year reproductive cycle (2 year gestation and 1 year resting) (SEDAR 2011).
- McCandless et al. (2014) reviewed the status of the northwest Atlantic dusky shark and reported that there is no indication that the dusky shark’s range has contracted from the species’ historical range.

Recommendations for EFH based on new information

We will update EFH boundaries based on new literature regarding dusky shark ranges along the northern Gulf of Mexico shelf break (Hoffmayer et al. 2014), and whether EFH of dusky sharks should be combined with that of Galapagos sharks (per Naylor et al. 2012). We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

10.9.2 Literature Cited

Carlson JK, Gulak SJB. 2012. Habitat use and movement patterns of oceanic whitetip, bigeye thresher, and dusky sharks based on archival satellite tags. Collect Vol Sci Pap. ICCAT 68(5):1922-1932. SCRS/2011/099

Hoffmayer ER, Franks JS, Driggers III WB, McKinney JA, Hendon JM, Quattro JM. 2014. Habitat, movements and environmental preferences of dusky sharks, *Carcharhinus obscurus*, in the northern Gulf of Mexico. Mar Biol. 161: 911-924. doi: 10.1007/s00227-014-2391-0

Kohler NE, Turner PA. 2010. Preliminary mark/recapture data for the sandbar shark (*Carcharhinus plumbeus*), dusky shark (*C. obscurus*), and blacknose shark (*C. acronotus*) in the western North Atlantic. 2010 SEDAR Data Workshop Document, SEDAR21-DW-38.

McCandless CT, Conn P, Cooper P, Cortés E, Laporte SW, Nammack M. 2014. Status review report: northwest Atlantic dusky shark (*Carcharhinus obscurus*). Report to National Marine Fisheries Service, Office of Protected Resources. October 2014, 72pp.

Natanson LJ, Gervelis BJ, Winton MV, Hamady LL, Gulak SJ, Carlson JK. 2013. Validated age and growth estimates for *Carcharhinus obscurus* in the northwestern Atlantic Ocean, with pre-and post-management growth comparisons. Environ Biol Fish. 1-16.

SEDAR. 2011. SEDAR 21 Stock Assessment Report: HMS Dusky Shark. Southeast Data, Assessment and Review (SEDAR), Charleston, SC. 414p.

10.10 Galapagos Shark (*Carcharhinus galapagensis*)

10.10.1 Summary of EFH Review

Recent Changes to Management Structure

Galapagos sharks continue to be a prohibited species and there have been no changes to management structure or stock status since the publication of Amendment 1 to the 2006 Consolidated HMS FMP. The stock status for this species is unknown as it has not been assessed.

Summary of New Literature

- Benavides et al. (2011) found that Galapagos sharks are morphologically and genetically very similar to dusky sharks.
- Naylor et al. (2012) completed genetic research suggesting that dusky sharks (*C. obscurus*) and Galapagos sharks (*C. galapagensis*) are likely the same species.
- G. Naylor (personal communication, College of Charleston, as cited in McCandless et al. (2014)) and Corrigan et al. (2014) noted that an ongoing genetic study using mitochondrial DNA sequencing has found that specimens identified as Galapagos sharks from oceanic islands in the northwest Atlantic are indistinguishable from specimens identified as dusky sharks collected off the US east coast from New Jersey to Florida.

Recommendations for EFH based on new information

Recent studies do not support updating EFH boundaries; however, we will monitor results of future genetics studies to determine if Galapagos sharks are a genetically distinct species or if they are the same as dusky sharks. We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

10.10.2 Literature Cited

Benavides MT, Horn RL, Feldhelm KA, Shivji MS, Clarke SC, Winter S, Natanson L, Braccini M, Boomer JJ, Gulak SJB, Chapman DD. 2011. Global phylogeography of the dusky shark *Carcharhinus obscurus*: implications for fisheries management and monitoring the shark fin trade. Endang Species Res. 14:13-22

Corrigan S, Eddy C, Duffy C, and Naylor G. 2014. Are dusky and Galapagos sharks conspecific? A thousand genes indicate genetic homogeneity in spite of morphological disparity. Abstract. *In: Programm and Abstracts of Shark International, Durban 2014: 40.*

McCandless CT, Conn P, Cooper P, Cortés E, Laporte SW, Nammack M. 2014. Status review report: northwest Atlantic dusky shark (*Carcharhinus obscurus*). Report to National Marine Fisheries Service, Office of Protected Resources. October 2014, 72pp.

Naylor, GJP, Caira JN, Jensen K, Rosana KAM, White WT, Last PR. 2012. A DNA sequence-based approach to the identification of shark and ray species and its implications for global elasmobranch diversity and parasitology. Bull Am Mus Nat His. No. 367. http://digitallibrary.amnh.org/dspace/handle/2246/6183

10.11 Longfin Mako Shark (*Isurus paucus*)

10.11.1 Summary of EFH Review

Recent Changes to Management Structure

Longfin makos continue to be a prohibited species and there have been no changes to management structure or stock status since the publication of Amendment 1 to the 2006 Consolidated HMS FMP. The stock status for this species is unknown as it has not been assessed.

Summary of New Literature

- Records in Atlantic waters are generally restricted to regions along the continental shelf (Garrick 1967; Dodrill and Gilmore 1979; Killam and Parsons 1986; Wakida-Kusunoki and Anda-Fuente 2012). Queiroz et al (2008) and Mucientes et al. (2013) provide updated, limited data on the species in the high seas of the Mid-Atlantic Ocean (6º-44ºN; 19º - 54ºW).

Recommendations for EFH based on new information

Recent studies support updating life history descriptions for this species. We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

10.11.2 Literature Cited

Dodrill J, Gilmore R. 1979. First North American continental record of the longfin mako (*Isurus paucus* Guitart-Manday). Fla Sci. 42:52-58.

Garrick J. 1967. Revision of sharks of genus Isurus with description of a new species (Galeoidea, Lamnidae). Proc USA Natl Mus. 118: 663-690.

Killam K, Parsons G. 1986. First record of the longfin mako, *Isurus paucus*, in the Gulf of Mexico. Fish Bull. 84:748-749.

Mucientes G, Banon R, Queiroz N. 2013. Updated distribution range of longfin mako *Isurus paucus* (Lamniformes: Lamnidae) in the North Atlantic. J Appl Icthyol. 29: 1163-1165.

Queiroz N, Araujo S, Ribeiro PA, Tarroso P, Xavier R, Santos AM. 2008. A first record of longfin mako, *Isurus paucus*, in the mid-North Atlantic. Mar Biodivers Rec. doi: http://dx.doi.org/10.1017/S1755267206003484

10.12 Narrowtooth Shark (*Carcharhinus brachyurus*)

10.12.1 Summary of EFH Review

Recent Changes to Management Structure

Narrowtooth sharks continue to be a prohibited species and there have been no changes to management structure or stock status since the publication of Amendment 1 to the 2006 Consolidated HMS FMP. The stock status for this species is unknown as it has not been assessed.

Summary of New Literature

There was no new literature found pertaining to EFH for narrowtooth sharks in the U.S. Atlantic EEZ.

Recommendations for EFH based on new information

Recent studies do not support updating EFH boundaries. However, we will update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

10.13 Night Shark (*Carcharhinus signatus*)

10.13.1 Summary of EFH Review

Recent Changes to Management Structure

Night sharks continue to be a prohibited species and there have been no changes to management structure or stock status since the publication of Amendment 1 to the 2006 Consolidated HMS FMP. The stock status for this species is unknown as it has not been assessed.

Summary of New Literature

- Kerstetter and Bayse (2011) reported that relatively higher numbers of pelagic longline interactions with night sharks occur or have been reported in the Charleston Bump region of the South Atlantic Bight.

Recommendations for EFH based on new information

Recent studies do not support updating EFH boundaries. However, we will update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

10.13.2 Literature Cited

Kerstetter D, Bayse S. 2009. Characterization of the catch by swordfish buoy gear in southeastern Florida. Final Reported Submitted to the Highly Migratory Species Management Division, NMFS. NOAA Cooperative Research Program Grant Number NA07NMFS4540075.

10.14 Sand Tiger (*Carcharias taurus*)

10.14.1 Summary of EFH Review

Recent Changes to Management Structure

Sand tiger sharks continue to be a prohibited species and there have been no changes to management structure or stock status since the publication of Amendment 1 to the 2006 Consolidated HMS FMP. The stock status for this species is unknown as it has not been assessed.

Summary of New Literature

- Kneebone et al. (2012) tagged 73 young of year/neonate (78-108 cm FL) sand tiger sharks in Plymouth, Kingston, Duxbury Bay ("PKD Bay"), Massachusetts. This study found repeated seasonal use of habitats north of Cape Cod, and suggested the need for extending EFH north beyond its current extent. Young of year/neonates utilized this embayment between June and October, and exhibited strong levels of site fidelity while in nursery habitats.
- Kneebone et al. (2013) evaluated physical and physiological effects of capture on juvenile sand tiger by conventional rod and reel and found that, while post-release survivorship was high, there were significant physiological disruptions in blood biochemistry. Sharks hooked internally had lower survival rates 50-100 days following release.
- Kneebone et al. (2014) used multiple tagging approaches (passive acoustic telemetry, PSATs, conventional mark-recapture) to monitor seasonal movements of juvenile sand tiger sharks between Maine and Florida. Tag data indicated seasonal coastal migration between summer (Maine to Delaware Bay) and winter (North Carolina to Florida) habitats.
- Haulsee et al. (2014), Kilfoil et al. (2014), and Teter et al. (*in press*) tagged over 300 sand tiger sharks between 2007 and 2014. Two of these citations refer to presentations that were given at the 2014 Annual Meeting of the American Fisheries Society. One study has used Communicating History Acoustic Transponder (CHAT) tags to evaluate species associations and movement patterns; one study evaluated horizontal and vertical movements of sand tiger sharks with PSATs and via acoustic telemetry; and one study evaluated EFH and Habitat Areas of Particular Concern in Delaware Bay and nearby coastal regions. Sand tigers tend to migrate between Delaware Bay and coastal North Carolina.
- Passerotti et al. (2014) used bomb radiocarbon analysis of vertebral growth bands validate lifespan for sand tiger sharks and found that previous age estimates for large adult sharks may have been underestimated by 11 to 12 years. Validated lifespan for individuals in the study reached at least 40 years for females and 34 years for males.

- The Cooperative Atlantic States Shark Pupping and Nursery (COASTSPAN) survey conducted in Delaware and New Jersey state waters reports consistent, extensive seasonal use of Delaware Bay by all life stages of sand tigers from 2009 to 2014 (NOAA 2009, 2010, 2011, 2012, 2013, 2014).

Recommendations for EFH based on new information

We will update EFH boundaries based on new literature, specifically new data regarding adult and juvenile lifestages identified in the literature and from the public. Furthermore, new age and growth information will be included in the sand tiger life history profile. We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

We may evaluate whether an HAPC should be considered for all life stages of sand tiger sharks in Delaware Bay based on COASTSPAN data and for juveniles in adjacent coastal regions based on work presented by Kilfoil et al. (2014), and for juveniles in the Cape Cod region based on the work presented by Kneebone et al. (2012 and 2014).

10.14.2 Literature Cited

Haulsee D, Fox D, Breece M, Brown L, Wetherbee B, Oliver M. 2014. Social Sharks: Long-term internal acoustic transceivers reveal species associations and large-scale movements of a coastal apex predator. Oral Presentation, 144th Annual Meeting of the American Fisheries Society, August 17-21, 2014. Quebec City, Quebec, Canada.

Kilfoil J, Fox D, Wetherbee B, Carlson JK. 2014. Digging deeper than essential fish habitats: identifying habitat areas of particular concern for sand tigers. Oral Presentation, 144th Annual Meeting of the American Fisheries Society, August 17-21, 2014. Quebec City, Quebec, Canada.

Kneebone J, Chisholm J, Skomal GB. 2012. Seasonal residency, habitat use, and site fidelity of juvenile sand tiger sharks *Carcharias taurus* in a Massachusetts estuary. Mar Ecol Prog Ser. 471: 165-181.

Kneebone J, Chisholm J., Bernal D, Skomal G. 2013. The physiological effects of capture stress, recovery, and post-release survivorship of juvenile sand tigers (*Carcharias taurus)* caught on rod and reel. Fish Res. 147: 103-114

Kneebone J, Chisholm J, Skomal G. 2014. Movement patterns of juvenile sand tigers (*Carcharias taurus*) along the east coast of the USA. Mar Biol. 161: 1149-1163. doi:10.1007/s00227-014-2407-9

NMFS. 2009. Stock assessment and fishery evaluation (SAFE) report for Atlantic highly migratory species. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Sustainable Fisheries, Highly Migratory Species Management Division, Silver Spring, MD. Public Document.

NMFS. 2010. Stock assessment and fishery evaluation (SAFE) report for Atlantic highly migratory species. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Sustainable Fisheries, Highly Migratory Species Management Division, Silver Spring, MD. Public Document.

NMFS. 2011. Stock assessment and fishery evaluation (SAFE) report for Atlantic highly migratory species. National Oceanic and Atmospheric Administration, National Marine

Fisheries Service, Office of Sustainable Fisheries, Highly Migratory Species Management Division, Silver Spring, MD. Public Document.

NMFS. 2012. Stock assessment and fishery evaluation (SAFE) report for Atlantic highly migratory species. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Sustainable Fisheries, Highly Migratory Species Management Division, Silver Spring, MD. Public Document.

NMFS. 2013. Stock assessment and fishery evaluation (SAFE) report for Atlantic highly migratory species. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Sustainable Fisheries, Highly Migratory Species Management Division, Silver Spring, MD. Public Document.

NMFS. 2014. Stock assessment and fishery evaluation (SAFE) report for Atlantic highly migratory species. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Sustainable Fisheries, Highly Migratory Species Management Division, Silver Spring, MD. Public Document.

Passerotti MS, Andrews AH, Carlson JK, Wintner SP, Goldman KJ, Natanson LJ. 2014. Maximum age and missing time in the vertebrae of sand tiger shark (*Carcharias taurus*): validated lifespan from bomb radiocarbon dating in the western North Atlantic and southwestern Indian Oceans. Mar Freshw Res. 65, 674-687.

Teter S, Wetherbee B, Fox D, Lam C, Kiefer D, Shivji M. *In Press.* Migratory patterns and habitat use of the sand tiger shark (*Carcharias taurus*) in the western North Atlantic. Mar Freshw Res. Accepted June 26, 2014.

10.15 Sevengill Shark (*Heptranchias perlo*)

10.15.1 Summary of EFH Review

Recent Changes to Management Structure

Sevengill sharks continue to be a prohibited species and there have been no changes to management structure or stock status since the publication of Amendment 1 to the 2006 Consolidated HMS FMP. The stock status for this species is unknown as it has not been assessed.

Summary of New Literature

- Barnett et al. (2012) conducted a study on cow and frill sharks that contains some basic life history information on sevengill sharks.

Recommendations for EFH based on new information

Recent studies do not support updating EFH boundaries. However, we will update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

10.15.2 Literature Cited

Barnett A, Braccini JM, Awruch CA, Ebert DA. 2012. An overview on the role of Hexanchiformes in marine ecosystems: biology, ecology and conservation status of a primitive order of modern sharks. J Fish Biol. 80: 966–990. doi: 10.1111/j.1095-8649.2012.03242.x

10.16 Sixgill Shark (*Hexanchus griseus*)

10.16.1 Summary of EFH Review

Recent Changes to Management Structure

Sixgill sharks continue to be a prohibited species and there have been no changes to management structure or stock status since the publication of Amendment 1 to the 2006 Consolidated HMS FMP. The stock status for this species is unknown as it has not been assessed.

Summary of New Literature

- Andrews et al. (2009) studied 27 sixgill sharks in Puget Sound, WA with acoustic telemetry noted consistent diel activity patterns. Sixgill sharks were typically shallower and more active at night than during the day, made direct vertical movements at sunrise and sunset, seasonally occupied deeper habitats it autumn and winter versus spring, and were most active during autumn.
- Tsikliras and Stergiou (2014) noted that Mediterranean sixgill shark length-at-maturity for females and males were 350 cm FL and 300 cm FL, respectively.
- White and Dharmadi (2010) presented limited data from a study in Indonesia suggested that males attain maturity between 262 and 285 cm TL.

Recommendations for EFH based on new information

Recent studies support updating the life history profile for this species. We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

10.16.2 Literature Cited

Andrews KS, Williams GD, Farrer D, Tolimieri N, Harvey CJ, Bargmann G, Levin PS. 2009. Diel activity patterns of sixgill sharks, *Hexanchus griseus*: the ups and downs of an apex predator. Anim Behav. 78:525-536.

Tsikliras AC, Stergiou KU. 2014. Size at maturity of Mediterranean marine fishes. Rev Fish Biol Fisher. 24:219-268.

White WT, Dharmadi. 2010. Aspects of maturation and reproduction in hexanchiform and squaliform sharks. J Fish Biol. 76:1362-1378.

10.17 Smalltail Shark (*Carcharhinus porosus*)

10.17.1 Summary of EFH Review

Recent Changes to Management Structure

Smalltail sharks continue to be a prohibited species and there have been no changes to management structure or stock status since the publication of Amendment 1 to the 2006 Consolidated HMS FMP. The stock status for this species is unknown as it has not been assessed.

Summary of New Literature

There was no new literature found pertaining to EFH for smalltail sharks in the U.S. Atlantic EEZ.

Recommendations for EFH *based on new information*

Recent studies do not support updating EFH boundaries. However, we will update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

10.18 Whale Shark (*Rhincodon typus*)

10.18.1 Summary of EFH Review

Recent Changes to Management Structure

Whale sharks continue to be a prohibited species and there have been no changes to management structure or stock status since the publication of Amendment 1 to the 2006 Consolidated HMS FMP. The stock status for this species is unknown as it has not been assessed.

Summary of New Literature

- McKinney et al. (2012) described the regional distribution of whale shark feeding aggregations in the northern Gulf of Mexico. Suitable habitat was predicted along the continental shelf edge, with the most suitable habitat predicted south of the Mississippi River Delta.
- Hoffmayer et al. (2013) summarized the spatial and temporal distribution of whale shark aggregations in the northern Gulf of Mexico. Large aggregations (10+ sharks) were reported to exclusively occur during summer along the continental shelf edge, with 41 percent occurring at Ewing Bank.
- McKinney et al. (2013) investigated whale sharks seasonal habitat use in the northern Gulf of Mexico and found that their largest home range within the region occurred during summer. Significant use patterns occurred along the continental shelf-edge, encompassing shelf-edge banks south of Louisiana, and near the mouth of the Mississippi River.
- Hoffmayer and McKinney (2014) have been tracking the movements of whale sharks in the northern Gulf of Mexico using satellite tags from 2009-2014. To date, more than 25 sharks have been tracked.
- Hueter et al (2013) used conventional visual tags, photo-identification, and satellite tags to characterize movement, migration, and hypothesize population structure of whale sharks that aggregate in summer feeding areas off the Yucatan Peninsula, Mexico. Whale sharks were tracked through U.S. EEZ waters, and the authors developed predictions of habitat utilization and distribution that included waters off Louisiana.
- Habitat suitability modeling efforts by Sequeira et al. (2014) suggest that the northern Gulf of Mexico has a high suitability for whale sharks under current and future environmental modeling scenarios.

Recommendations for EFH based on new information

We will update EFH boundaries based on results of new studies describing spatial and temporal distribution and PSAT studies. We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

10.18.2 Literature Cited

Hoffmayer E, McKinney JA, Franks JS, Hendon J, Driggers III WB. 2013. Whale Shark aggregations in the northern Gulf of Mexico. PeerJ PrePrints 1:e85v1 http://dx.doi.org/10.7287/peerj.preprints.85v1

Hoffmayer E, McKinney J. Unpublished data. Whale shark movements in the northern Gulf of Mexico from 2009-2014.

Hueter RE, Tyminski JP, de la Parra R. 2013. Horizontal movements, migration patterns, and population structure of whale sharks in the Gulf of Mexico and northwestern Caribbean Sea. PLoS ONE 8(8): e71883. doi:10.1371/journal.pone.0071883.

McKinney JA, Hoffmayer ER, Wu W, Fulford R, Hendon JM. 2012. Species distribution modeling of whale sharks (*Rhincodon typus*) in the northern Gulf of Mexico. Mar Ecol Prog Ser. 458: 199-211.

McKinney JA, Hoffmayer ER, Franks JS, Hendon JM, Driggers III WB. 2013. Seasonal habitat use of whale sharks in the northern Gulf of Mexico, USA 2003 - 2013. PeerJ PrePrints 1:e93v1 http://dx.doi.org/10.7287/peerj.preprints.93v1.

Sequeira AMM, Mellin C, Fordham SA, Meekan MG, Bradshaw CJA. 2014. Predicting current and future global distributions of whale sharks. Glob Change Biol. 20:778-789.

10.19 White Shark (*Carcharodon carcharias*)

10.19.1 Summary of EFH Review

Recent Changes to Management Structure

White sharks continue to be a prohibited species and there have been no changes to management structure or stock status since the publication of Amendment 1 to the 2006 Consolidated HMS FMP. The stock status for this species is unknown as it has not been assessed.

Summary of New Literature

- In a comprehensive analysis of white shark landings, survey, and interaction records, Curtis et al. (2014) noted that 90 percent of compiled white shark interactions occurred between 22º00’ and 45º30’N latitude; the authors also noticed a center of distribution in southern New England and the Mid-Atlantic Bight. Seasonally, white shark interactions tended to occur off the southeastern U.S. and in the Gulf of Mexico in winter (predominantly juvenile white sharks); broad distribution through springtime between the Gulf of Mexico and the New York Bight; a concentration of white shark interactions between the New York Bight and Cape Cod (ranging from the Mid Atlantic to Canadian waters); and a broad distribution in the fall that indicates the start of a southward shift in distribution by November and December (New England to Florida). Most observations occurred in waters shallower than 100 meters. Curtis et al. (2014) also found an apparent abundance increase in the northwest Atlantic white shark population, which may be associated with a number of conservation measures implemented in the 1990s.

- Water temperatures associated with Atlantic white shark records compiled by Curtis et al. (2014) ranged from 9-28ºC. A majority (80 percent) of the records associated white sharks with temperatures between 14º and 23ºC.
- Skomal et al. (2012) observed white sharks aggregating in increasing numbers around pinniped colonies that have re-established along the coast of Massachusetts. New research by Massachusetts Division of Marine Fisheries biologists suggests that tagged white sharks exhibit seasonal site-fidelity over multiple years (G. Skomal, unpublished data, AFS 2014).
- Hamady et al. (2014) found that vertebral bomb radiocarbon dating suggests northwest Atlantic white sharks may live up to, or beyond, 70 years of age.
- Taylor et al. (2013) used aerial surveys to documented four separate white shark predation events occurring on a juvenile north Atlantic right whale and calves in calving areas off the northeast coast of Florida.
- Natanson and Skomal (2015) validated age estimates of white sharks from 77 specimens up to 44 years of age and further develop a growth curve for the species using these results and the results from Hamady et al. (2014).
- O'Leary et al. (2015) assessed white shark genetic diversity in the northwest Atlantic and off South Africa, noting that population dynamics are likely more driven by intrinsic reproduction than immigration. Genetic evidence of a population decline was noted for the northwest Atlantic.
- Huveneers et al. (2015) noted that white sharks exploit the angle of the sun during predatory approaches and hypothesize this behavior is intended to improve prey detection, avoid retinal overstimulation, and improve concealment upon approach.

Recommendations for EFH based on new information

We will update EFH boundaries based on results of new tagging studies. We will consider identifying white shark HAPCs that cover possible nursery grounds (based on distribution of pups and small juveniles) in the northern Mid-Atlantic, and aggregation sites off the coast of Massachusetts (due to rising pinniped populations). We will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

10.19.2 Literature Cited

Curtis TH, McCandless CT, Carlson JK, Skomal GB, Kohler NE, Natanson LJ, Burgess GH, Hoey JJ, Pratt Jr HL. 2014. Seasonal Distribution and Historic Trends in Abundance of White Sharks, Carcharodon carcharias, in the Western North Atlantic Ocean. PLoS ONE 9(6): e99240. doi:10.1371/journal.pone.0099240

Hamady, LL, Thorrold S, Natanson LJ. 2014. Bomb carbon age validation of the white shark, Carcharodon carcharias, in the western North Atlantic Ocean. PLoS ONE 9(1), e84006. doi:10.1371/JOURNAL.PONE.0084006

Huveneers C, Holman D, Robbins R, Fox A, Endler JA, Taylor AH. 2015. White sharks exploit the sun during predatory approaches. The American Naturalist 185(4):562-570.

Jorgensen SJ, Arnoldi NS, Estess EE, Chapple TK, Ruckert M, Anderson SD, Block BA. 2012. Eating or Meeting? Cluster Analysis Reveals Intricacies of White Shark (*Carcharodon carcharias*) Migration and Offshore Behavior. PLoS ONE 7(10): e47819. doi:10.1371/journal.pone.0047819

Natanson LJ, Skomal GB. 2015. Age and growth of white shark, *Carcharodon carcharias,* in the western North Atlantic Ocean. Mar Freshw Res 66:387-398. http://dx.doi.org/10.1071/MF14127

O'Leary SJ, Feldheim KA, Fields AT, Natanson LJ, Wintner S, Hussey N, Shivji MS, and Chapman DD. 2015. Genetic diversity of white sharks, *Carcharodon carcharias,* in the northwest Atlantic and Southern Africa. Hered 106 (3): 258-265. doi: 10.1093/jhered/esv001

Skomal GB, Chisholm J., Correia SJ. 2012. Implications of increasing pinniped populations on the diet and abundance of white sharks off the coast of Massachusetts. *Pages 405-418 in* Global Perspectives on the Biology and Life History of the White Shark. ML Domeier (ed.) Taylor & Francis Group, LLC. Boca Raton, FL.

Skomal G, Chisholm J. 2014. Broad and fine-scale movements of white sharks in the western north Atlantic derived from multiple technologies. 144th Annual Meeting of the American Fisheries Society, August 17-21, 2014. Quebec City, Quebec, Canada.

Taylor JKD, Mandelman JW, McLellan WA, Moore MJ, Skomal GB, Rotstein DS, Kraus SD. 2013. Shark predation on North Atlantic right whales (*Eubalaena glacialis*) in the southeastern United States calving ground. Mar Mammal Sci. 29: 204–212.

11 SMOOTHHOUND SHARKS

11.1 Smooth Dogfish Shark (*Mustelus canis*); Florida Smoothhound Shark (*Mustelus norrisi*); Gulf of Mexico Smoothhound Shark (*Mustelus sinusmexicanus*)

11.1.1 Summary of EFH Review

Recent Changes to Management Structure

In 2010, NMFS determined that smoothhound sharks (smooth dogfish and Florida smoothhound) were in need of conservation and management under Secretarial authority in Amendment 3 to the 2006 Consolidated HMS FMP. Smoothhound sharks were, therefore, added to federal management, although implementation of other smoothhound shark management measures from Amendment 3 have been delayed and are currently being addressed in Amendment 9 to the 2006 Consolidated HMS FMP.

Gulf of Mexico smoothhound sharks were not included in Amendment 3 to the 2006 Consolidated HMS FMP, which determined that smoothhound sharks were in need of conservation and management under Secretarial authority. Draft Amendment 9 to the 2006 Consolidated HMS FMP recognizes that Gulf of Mexico smoothhound sharks were in need of conservation and management under Secretarial authority, just like smooth dogfish and Florida smoothhound sharks. Because of the overlap in range between the different species and the extreme difficulty in distinguishing among the three species, NMFS will continue to group all the smoothhound species (all *Mustelus* species that are currently known and those that may be discovered within the U.S. EEZ of the Atlantic, Gulf of Mexico, and Caribbean) together within the term “smoothhound sharks” for management purposes and will manage them as a complex.

Summary of New Literature

- A sizeable amount of new literature was presented at the SEDAR 39 stock assessment for smoothhound (see assessment archives at http://www.sefsc.noaa.gov/sedar/Sedar_Workshops.jsp?WorkshopNum=39)
- Drymon et al. (2010) analyzed bottom longline survey data off of Alabama and Mississippi found that *Mustelus* spp. were only found offshore and not in shallow waters. However these data have already been included in EFH maps.
- Woodland et al. (2011) conducted a diet study in the Mid-Atlantic investigating smooth dogfish diet to determine their trophic resource overlap with teleost fish.
- Able et al. (2014) conducted an acoustic tagging study that investigated smooth dogfish movements in the Great Bay-Mullica River and Little Egg Harbor estuary areas within central-southern New Jersey.
- McElroy (2009) conducted a diet and feeding ecology study for smooth dogfish in the Delaware Bay estuary.
- Kohler et al. (2014) review a tagging program conducted by the NEFSC in which 1,134 smooth dogfish were released and 37 were recaptured. Smooth dogfish were tagged from the Gulf of Maine to the Gulf of Mexico and all were caught within 200 m depth or less throughout their range. Capture locations for mature females and young of the year overlap off Long Island, NY, in Delaware and Chesapeake Bays, and along coastal North

Carolina. Seasonal movements between Cape Cod, MA and North Carolina were documented by mark/recapture. No movement was reported between the Atlantic and Gulf of Mexico.

Recommendations for EFH based on new information

Recent studies do not support updating EFH boundaries. However, we will update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

11.1.2 **Literature Cited**

Able KW, Grothues TM, Turnure JT, Malone MA, Henkes GA. 2014. Dynamics of residency and egress in selected estuarine fishes: evidence from acoustic telemetry. Environ Biol Fish. 97(1): 91-102.

Drymon JM, Powers SP, Dindo J, Dzwonkowski B, Henwood TA. 2010. Distributions of sharks across a continental shelf in the northern Gulf of Mexico. Mar Coast Fish Dynam Manag Ecosys Sci. 2(1): 440-450.

Kohler NE, Turner PA, Pezzullo M, McCandless CT. 2014. Mark/Recapture Data for the Smooth Dogfish, *Mustelus canis*, in the Western North Atlantic from the NMFS Cooperative Shark Tagging Program. 2014 SEDAR Data Workshop Document, SEDAR39-DW-20.

McElroy WD. 2009. Diet feeding ecology, trophic relationships, morphometric condition , and ontogeny for the sandbar shark, *Carcharhinus plumbeus*, and smooth dogfish, *Mustelus canis*, within the Delaware Bay estuary [dissertation]. [Kingston (RI)]: University of Rhode Island.

Woodland RJ, Secor DH, Wedge ME. 2011. Trophic resource overlap between small elasmobranchs and sympatric teleosts in Mid-Atlantic Bight nearshore habitats. Estuar Coasts. 34(2): 391-404.

12 FISHING IMPACTS ON ESSENTIAL FISH HABITAT

12.1 Background

HMS Gear Impacts

Most HMS reside in the upper part of the water column and habitat preferences are likely influenced by oceanic factors such as current confluences, temperature edges, and surface structure. Most HMS gears are fished in these areas and do not pose any adverse impact to HMS EFH. NMFS completed reviews of fishing gear impacts in the 1999 HMS FMP, 2006 Consolidated HMS FMP, and Amendment 1 to the 2006 Consolidated HMS FMP. These analyses determined that the majority of HMS gears are fished within the water column and do not make contact with the sea floor. Shark bottom longline gear is an HMS gear that does make contact with the bottom, and NMFS conducted an additional review of bottom longline gear impacts to EFH in Amendment 1. Some shark species prefer benthic habitats, but shark bottom longline gear does not pose a threat to the EFH of sharks using benthic habitats because it occurs in mainly sandy/mud areas.

The shark bottom longline fishery is prohibited from operating in the MPAs, HAPCs, and time/area closures that were established by the South Atlantic Fishery Management Council to protect vulnerable deep water coral habitats. The protected areas established for deep water coral can be found in Figure 12.1.

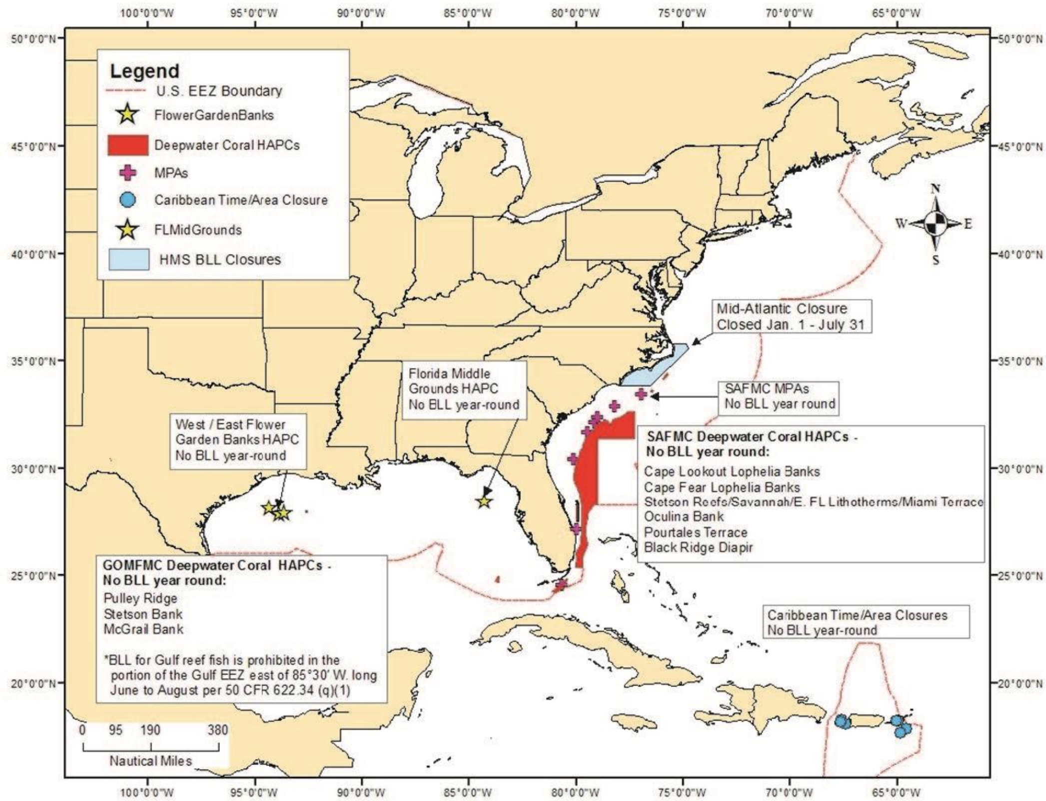

Figure 12.1 Marine protected areas (MPAs), Habitat Areas of Particular Concern (HAPCs), and Time/area Closures that Restrict use of Bottom Longline Gear in the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea

The impacts of shark bottom longline gear on hermatypic (reef building) and shallow water corals recently listed under the Endangered Species Act (ESA) were assessed by NMFS in a Biological Evaluation prepared in October 2014. The analysis conducted in the October 2014 Biological Evaluation stated that, although observer reports indicated interactions between shark bottom longline gear and coral, sea fans, and other coral reef life occurs, these instances are very rare. The Biological Evaluation found that fishermen setting shark bottom longline gear prefer sandy bottom away from coral habitats and generally set gear on sandy bottoms. Using observer data from the shark bottom longline fishery, NMFS mapped current Gulf of Mexico coral EFH and sets of shark bottom longline gear that interacted with coral. Although there are coral interactions with shark bottom longline gear, NMFS only noted 16 interactions out of 614 observed sets between 2008 and 2013 (Figure 12.2). None of the 16 interactions occurred in coral EFH identified by the Gulf of Mexico Fishery Management Council or involved the newly listed corals. If gear conflict were to occur, it would be due to unintentional gear drift. Although interactions between listed corals and shark bottom longline gear could cause long term impacts to the reef habitat, minimal interactions occur on coral habitats spatially and temporally. NMFS has determined that the continued operation of the shark bottom longline fishery may affect, but not adversely affect, ESA and non-ESA listed deep water coral species (NMFS 2014).

Both shallow and deep water coral interactions with bottom longlines could cause long-term impacts to the reef habitat but, due to minimal interactions with coral habitats spatially and temporally, NMFS does not anticipate any adverse effects on shallow or deep water coral with bottom longline gear.

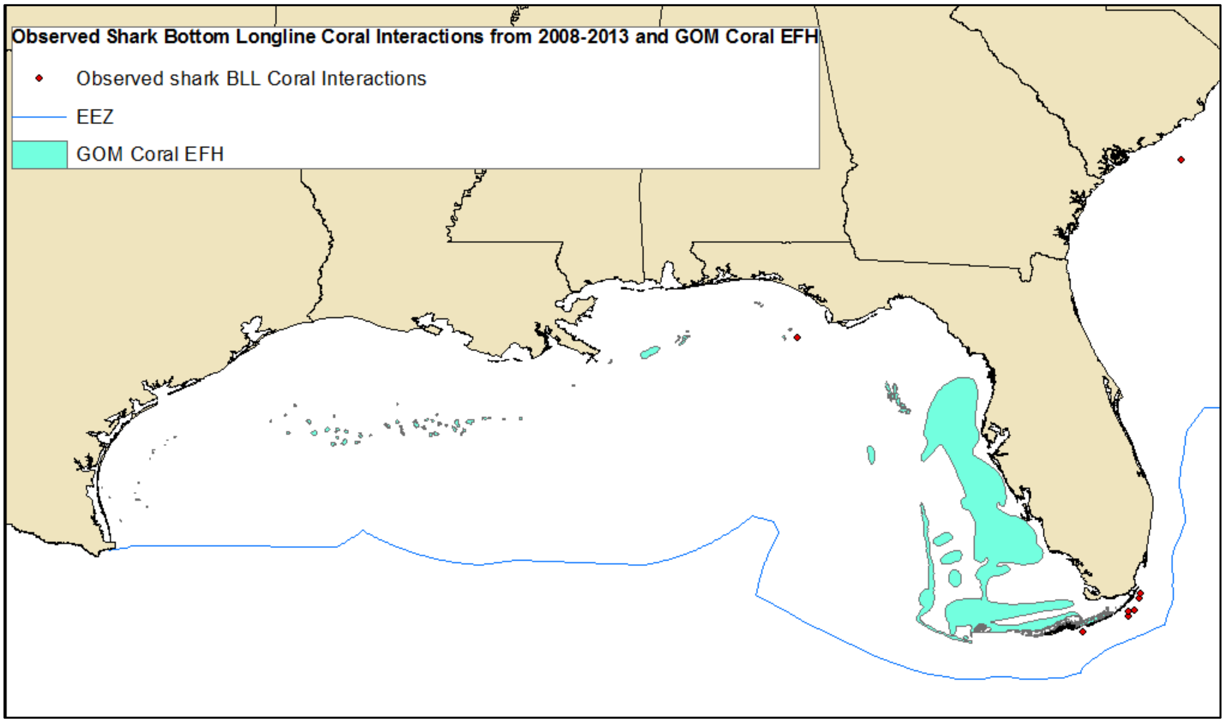

Figure 12.2 Shark Bottom Longline Gear Interactions with Coral and Gulf of Mexico Coral EFH

EFH of Council-managed fish species that spans from the Mid-Atlantic to the Gulf of Mexico likely overlaps in areas that the shark bottom longline fishery operates. NMFS has backstopped management measures implemented by the Caribbean Fishery Management Council, which closed six areas to protect EFH of mutton snapper, red hind, and other reef-dwelling species. NMFS has closed these six areas in the U.S. Virgin Islands and Puerto Rico to HMS bottom longline gear (February 7, 2007, 72 FR 5633). Although bottom longline fishing for sharks occurs in other areas of EFH, it is anticipated to not have detrimental impacts to EFH because it occurs in mainly sandy/mud areas. Reef habitat EFH for many Council-managed species is not expected to be adversely impacted by shark bottom longline fisheries based on the analysis above because NMFS assumes fishermen actively avoid setting shark bottom longline in coral reef areas. Non-reef species may also reside in sensitive habitats identified by the Councils as EFH where shark bottom longline fishing occurs. In 2004, the Northeast Fisheries Science Center (NEFSC) published a technical memorandum that evaluated different gear types and their impacts on EFH (NMFS-NE-181). Each gear was scored by the NEFSC from 0-14 with 14 having the highest impact on EFH. The NEFSC gave bottom longline gear a score of 0 due to limited information on benthic habitat effects and the temporary nature of the gear (Stevenson et al. 2004). NMFS therefore anticipates minimal negative impacts to EFH of Council-managed species by the Atlantic shark bottom longline fishery, and determines that the shark bottom longline fishery would not have significant impacts to EFH based on the data that are available at this time.

12.2 Summary of Review Findings

NMFS has conducted a literature review to investigate additional impacts of HMS fishing gears on Atlantic HMS EFH since Amendment 1 in this EFH five-year review document. During this review, NMFS did not find any significant changes in impacts to HMS EFH from HMS and non-HMS fishing gears since the gear analysis was conducted for Amendment 1. This EFH five-year review also contains an analysis of ESA listed and non-ESA listed coral habitat and shark bottom longline interactions that was conducted by NMFS. While long-term negative effects could occur on coral habitats from shark bottom longline gear, the impacts are expected to be minimal due to infrequent interactions. EFH for Council-managed fish species was also considered in this analysis and shark bottom longline gear was determined to not have negative effects on those species EFH.

Conservation Measures

Because no substantial changes in fishing impacts were found for this review, the conservation measures outlined in Amendment 1, Amendment 3, and the interpretive rule for white marlin and roundscale spearfish are still valid.

Future Recommendations

NMFS recommends more research to be conducted on the impacts of fishing gear and Atlantic HMS EFH within U.S. waters. NMFS will continue to work with Regional Fishery Management Councils and Interstate Marine Fisheries Commissions to minimize gear impacts in areas where HMS EFH is delineated.

12.3 Literature Cited

NMFS. 2014. Central and Southwest Atlantic DPS of Scalloped Hammerhead Shark (*Sphyrna lewini*) and Seven Threatened Coral Species: Biological Assessment on Effects of Commercial and Recreational Fisheries under the 2006 Consolidated Atlantic HMS Fishery Management Plan and Supplemental Information on Effects of Atlantic Pelagic Longline Fishery, Biological Evaluation.

Stevenson D, Chiarella L, Stephan D, Reid R, Wilhelm K, McCarthy J, Pentony M. 2004. Characterization of the fishing practices and marine benthic ecosystems of the northeast U.S. shelf, and an evaluation of the potential effects of fishing on essential fish habitat. NOAA Tech Mem. NMFS-NE-181.

13 NON-FISHING EFFECTS ON ESSENTIAL FISH HABITAT

13.1 Background

The EFH regulations (50 CFR 600.815(a)(3)) require FMPs to identify non-fishing related activities that may adversely affect EFH. Broad categories of such activities include, but are not limited to: dredging, filling, excavation, mining, impoundment, discharge, water diversions, thermal additions, actions that contribute to non-point source pollution and sedimentation, introduction of potentially hazardous materials, introduction of exotic species, and the conversion of aquatic habitat that may eliminate, diminish, or disrupt the functions of EFH.

NMFS conducted thorough reviews of non-fishing impacts in the 2006 Consolidated HMS FMP and Amendment 1 to the 2006 Consolidated HMS FMP; neither of which is repeated in detail here. The intent of the current non-fishing impacts analysis is to consider those impacts that are most likely to have an adverse effect on HMS EFH and for which new information may be available. At this time, climate change is the only newly-identified non-fishing impact to HMS EFH.

13.2 Review Approach and Summary of Findings

The review of habitat use for HMS identified both benthic and water column habitats in coastal, estuarine, and offshore areas as HMS EFH; although in many cases the particular habitat characteristics that influence species habitat use are not clearly understood or identified. Many of these habitat characteristics appear to be related to water quality (e.g., temperature, salinity, dissolved oxygen); therefore, water quality degradation is a primary focus in this section. When analyzing the impacts that water quality changes can have on HMS EFH, it is important to examine all habitats, including offshore areas which can be affected by actions that originate in coastal habitats (both terrestrial and aquatic) and adjacent estuaries. Many HMS aggregate over submarine canyons or along river plumes; these physiographic features can serve as conduits for currents moving from inshore out across the continental shelf and slope, while carrying and redistributing contaminants from the nearshore realm to offshore habitats.

13.2.1 Land-Based Activities That May Impact HMS EFH

NMFS conducted thorough reviews of land-based activities that may impact HMS EFH in the 2006 Consolidated Atlantic HMS FMP and Amendment 1. These two documents found coastal development and agriculture to be the main sources of land-based impacts through water run-off.

Coastal development activities include urban, suburban, commercial, and industrial construction, along with development of corresponding infrastructure. These activities may result in: erosion and sedimentation; dredging and filling; point and non-point source discharges of nutrients, chemicals, and cooling water into streams, rivers, estuaries and ocean waters; and, destruction of coastal wetlands that filter sediments, nutrients, and contaminants. In addition, hydrological modifications associated with coastal development alter freshwater inflow to coastal waters, resulting in changes in salinity, temperature, and nutrient regimes, and thereby contributing to further degradation of estuarine and nearshore marine habitats.

Agricultural and silvicultural practices can affect estuarine, coastal, and marine water quality through nutrient enrichment and chemical contamination from animal wastes, fertilizers, pesticides and other chemicals via non-point source runoff or via drainage systems that serve as conduits for contaminant discharge into natural waterways. Major impacts also include nutrient over-enrichment with subsequent deoxygenation of surface waters. Agricultural activities also increase soil erosion and associated sediment transport in adjacent water bodies, resulting in high turbidity. Many of these same concerns may apply to silviculture as well.

13.2.2 Coastal and Offshore Activities That May Impact HMS EFH

NMFS conducted thorough reviews of coastal and offshore activities that may impact HMS EFH in the 2006 Consolidated Atlantic HMS FMP and Amendment 1. These two documents found eight broad activity categories that impact HMS EFH: dredging and disposal of dredging material, navigation, marinas and recreational boating, marine sand and mineral mining, ocean dumping, petroleum exploration and development, liquefied natural gas (LNG), and renewable energy projects.

Dredging and disposal of dredging material can result in the temporary degradation of water quality due to the resuspension of bottom materials, resulting in water column turbidity, potential contamination due to the release of toxic substances (metals and organics), and reduced oxygen levels due to the release of oxygen-consuming substances (e.g., nutrients, sulfides).

Navigation-related threats to HMS EFH include navigation support activities such as excavation and maintenance of channels (including disposal of excavated sediments), which result in the elevation of turbidity and resuspension of contaminants; construction and operation of ports, mooring, and cargo facilities; construction of ship repair facilities; and construction of channel stabilization structures such as jetties and revetments. Threats to both nearshore and offshore waters are posed by vessel operation activities such as the discharge and spillage of oil, other hazardous materials, trash and cargo, all of which may result in localized water quality degradation and direct effects on HMS. Wakes from vessel operation may also exacerbate shoreline erosion, affecting habitat modification and potential degradation.

Marinas and recreational boating are increasingly popular uses of coastal areas. Impacts caused by pollutants associated with marinas include lowered dissolved oxygen, increased temperatures, bioaccumulation of pollutants by organisms, toxic contamination of water and sediments, resuspension of sediments and toxics during construction, eutrophication, change in circulation patterns, shoaling, and shoreline erosion. Pollutants that result from marina activities include nutrients, metals including copper released from antifouling paints, petroleum hydrocarbons, pathogens, and polychlorinated biphenyls. Also, chemicals commonly used to treat timber used for piers and bulkheads (e.g., creosote, copper, chromium, and arsenic salts) are introduced into the water. Other potential impacts associated with recreational boating are the result of improper sewage disposal, fuel and oil spillage, cleaning operations, and disposal of fish waste. Propellers from boats can also cause direct damage to multiple life stages of organisms, including eggs, larvae/neonates, juveniles and adults; destratification; elevated temperatures, and increased turbidity and contaminants by resuspending bottom materials.

Mining for sand (e.g., for beach nourishment projects), gravel, and shell stock in estuarine and coastal waters can result in water column effects by changing circulation patterns, increasing turbidity, and decreasing oxygen concentrations at deeply excavated sites where flushing is minimal. Deep borrow pits created by mining may become seasonally or permanently anaerobic.

Ocean dumping of hazardous and/or toxic materials (e.g., industrial wastes) containing concentrations of heavy metals, pesticides, petroleum products, radioactive wastes, and pathogens, in the ocean degrades water quality and benthic habitats.

Petroleum exploration and development can impact HMS EFH through disturbance created by the activity of drilling, associated pollution from drilling activities, discharge of wastes associated with offshore exploration and development, operational wastes from drilling muds and cuttings, potential for oil spills, and potential for catastrophic spills caused by accidents or hurricanes, and alteration of food webs created by the submerged portions of the oil platform, which attract various invertebrate and fish communities. On April 20, 2010, an explosion and subsequent fire damaged the Deepwater Horizon MC252 oil rig, which capsized and sank approximately 50 miles southeast of Venice, Louisiana. Oil flowed for 86 days into the Gulf of Mexico from a damaged well head on the seafloor. More information about HMS impacts from this event can be found in Chapter 3 of this document.

For LNG facilities, a major concern is the saltwater intake system used to heat LNG and regasify it before piping to shore; which could subject early life stages of marine species to entrainment, impingement, thermal shock, and water chemistry changes.

Alternative energy includes, but is not limited to wind, wave, solar, underwater current and generation of hydrogen. Construction, maintenance, and operation for these installations can disturb water quality in HMS EFH.

13.2.3 Climate Change

In its most recent assessment, the Intergovernmental Panel on Climate Change (IPCC) of the United Nations Environment Program reiterated findings from previous assessments - that the earth is warming as evidenced by widespread observations of increases in global air and ocean temperatures, melting of snow and ice, and rising global average sea level (IPCC 2014). The International Symposium on the Effects of Climate Change on the World's Oceans (May 19-23, 2009, Gijon, Spain) also concluded that the global warming trend and increasing emissions of carbon dioxide and other greenhouse gases are already affecting environmental conditions and biota in the oceans on a global scale (Valdes et al. 2009). Ocean warming has affected global fisheries in the past four decades, as evidenced by Cheung et al. (2013)'s analysis of indices of inferred temperature preferences for exploited species. Similar conditions are occurring in U.S. waters. The third national climate assessment "Climate Change Impacts in the United States," (Melillo et al. 2014) concluded that marine ecosystem processes have been affected by climate change, and that large-scale shifts in marine species ranges, seasonal timing, and migrations have occurred and are very likely to continue.

The amount of information available on climate impacts to marine systems has increased substantially in recent years. However, still relatively little is known about impacts to Atlantic HMS, many of which have very broad thermal tolerances. It is difficult to predict climate-induced responses of marine fish populations, particularly those on a higher trophic level, due to exposure to a complex mix of changing abiotic (e.g., temperature, salinity, pH) and biotic (e.g., abundance and distribution of predators and prey) conditions (Hollowed et al. 2013) and inconsistent and incomplete data (Murawski 2013).

The CLIOTOP (climate impacts on top ocean predators) program was initiated in 2004, with the general objective to organize a worldwide effort that would further understanding of impacts of both climate variability and fishing on pelagic ecosystems (Hobday et al. 2013). Results of this effort and other research have provided some HMS-specific climate research, mostly in Pacific regions, and widely applicable modelling strategies (e.g., Earth System Model). In the recent FAO review of physical and ecological impacts of climate change on marine fisheries, Barange and Perry (2009) assert that current knowledge about a species' life history stages in past and current climates, along with observations on climate change and research on climate change effects, can be used as a basis to discuss potential current or future effects of climate change on the species, short of projection. The Atlantic Bluefin Tuna Status Review Team (SRT 2011)[1] used this approach and reviewed available literature on bluefin tuna life stages and trophic dynamics to identify potential areas of vulnerability for this species relative to climate changes. Sources of assessment information and modelling or framework approaches are briefly described in the next few paragraphs. Application of modelling or framework assessments described in the following paragraphs to Atlantic HMS could provide useful information to support refinement of EFH designations.

The potential impacts of climate change, from the organism to ecosystem level, are detailed in the "Ocean Systems" chapter of the IPPC's 2014 review of climate induced impacts, adaptions and vulnerabilities to ocean systems (Portner et al. 2014). It describes expected changes in physical and chemical variables including temperature, salinity, carbon dioxide-induced acidification, hypoxia, light, and nutrients, and highlighted recent studies with examples of observed changes. The chapter also described types of expected concurrent responses of organisms to multiple climate-induced drivers, and the effect of organismal responses on food web dynamics to identify ecosystem considerations.

In their review of projected impacts of climate change on marine fish and fisheries, Hollowed et al. (2013) noted that the marine science community is now regularly using projections released by the IPCC to make qualitative and quantitative assertions about marine ecosystem responses to climate change and ocean acidification. Murawski (2013) stated that coupled models, with nested atmosphere, land, ocean and biological components, are currently being used. Climate-driven changes in the environment may affect the physiology, phenology, and behavior of marine fish at any life-history stage, and any of these affects may result in population-level changes in distribution and/or abundance that can be identified by modelling exercises.

Frameworks that can be used broadly for assessing impacts or vulnerability to impacts have also been developed. Pettigas et al. (2013) developed a framework that integrates requirements in all life stages to assess impacts across the entire life cycle and then applied it to case studies of species important in regional fisheries. The framework includes a review of

---

[1] On May 24, 2010, the Center for Biological Diversity petitioned NMFS to list Atlantic bluefin tuna as endangered or threatened under the Endangered Species Act (ESA). NMFS evaluated the petition as required by the ESA, determined that the petitioned action may be warranted, and published a positive 90 day finding (75 FR 57431). A status review was conducted under the requirements of the ESA and published on March 22, 2011.

habitats required by each life stage, habitat availability, and connectivity between habitats, and then explores how each could be altered by climate change. The key results of this study were that climate-driven changes in larval dispersion seemed to be the major unknown, and that species with specific habitat requirements for spawning or nursery grounds display “bottlenecks” in their life cycle.

With the goal of developing a nationally applicable framework for assessing the vulnerability of economically important species, NOAA developed “Methodology for assessing the vulnerability of fish species to changing climate” (Morrison et al. in review). The objectives for this study included developing a relative vulnerability rank for studied species, determining factors driving that rank, and identifying data gaps. The assessment was first applied to species in the northeast region (i.e., Cape Hatteras north to the Scotian Shelf), and included a regional perspective on the vulnerability of several highly migratory shark species (dusky, porbeagle, and sand tiger; further discussed below).

The IPCC assessment (Portner et al. 2014) reported some general projections of impacts to global fisheries. Climate change is projected to cause a large-scale redistribution of global catch potential, with an average 30 to 70 percent increase in yield at high latitudes. Redistribution between areas, with average catch potential remaining unchanged, is projected for mid-latitudes. Acidification and hypoxia is expected to reduce maximum catch potential through 2050 in the North Atlantic and northeast Pacific. Responses of exploited marine species may interact with other stressors such as overfishing to exacerbate the impacts of climate change. Considerable social economic disruption for small island nations and large industrial fleets may occur because of climate change (Hobday et al. 2013).

Several studies have specifically considered the potential impacts of climate change on HMS (Table 13.1). These studies use a variety of methods, and as a result, the conclusions for the same species can vary. Simpler models make fewer assumptions, but can miss important ecological processes. Most of these studies took place in areas other than the western North Atlantic, and application of the findings are not particularly relevant to Atlantic HMS, depending upon the circumstances of the study, such as the physical and biological characteristics of the regional ecosystem, and the effect of climate-related factors driving the response. Modelling exercises that show specific responses of non-Atlantic ecosystems are less useful for determining relevant impacts to Atlantic HMS, but do illuminate the types of impacts and/or responses that could occur in the northwest Atlantic ecosystem. The studies that are most relevant to Atlantic HMS management are summarized below.

Table 13.1 Studies Investigating Climate Change Impacts on HMS (BAYS – bigeye, albacore, yellowfin, skipjack tunas; YFT – yellowfin tuna; BFT – bluefin tuna; SHK- shark)

Study	Region	HMS
Chang et al. 2013	Tropical Atlantic	Swordfish
Dueri et al. 2013	Worldwide	Skipjack
Ganachaud et al. 2013	Pacific	BAYS
Hobday et al. 2011	Pacific	Swordfish, YFT, Albacore
Lehody et al. 2013	Pacific	Skipjack
Liu et al. 2012	Gulf of Mexico	BFT
Muhling et al. 2015	Gulf of Mexico, Caribbean	BFT, Skipjack
Muhling et al. 2014	Gulf of Mexico, Caribbean	BFT, Skipjack, Swordfish
Muhling et al. 2011	Gulf of Mexico	BFT
Morrison et al. In review	Northwest Atlantic	SHK (dusky, sand tiger, porbeagle)
Prince et al. 2010	Tropical Northeast Atlantic	Billfishes, Tunas
Sequeira et al. 2014	Worldwide	SHK (whale)
SRT 2011[2]	Gulf of Mexico, Atlantic	BFT
Stramma et al. 2012	Tropical Northeast Atlantic	Billfishes, Tunas
Trenkel et al. 2014	North Atlantic	Albacore, BFT, Swordfish, Blue marlin

Trenkel et al. (2014) reviewed the current state of knowledge regarding the ecology of widely distributed pelagic fish stocks in the North Atlantic basin, including albacore and bluefin tuna, swordfish, and blue marlin, with an emphasis on their role in the food web. This information was used as a starting point for a EURO-BASIN[3] evaluation of environmental factors (including climate change) and fishing factors that could influence population dynamics and distribution of these species, and the North Atlantic ecosystem as a whole.

Prince et al. (2010) and Stramma et al. (2012) found that climate-related changes to ocean chemistry and the mixed layer depth exacerbated vertical habitat compression for some billfish and tuna in the tropical Northeast Atlantic. Off the west coast of Africa, high-oxygen demand HMS were closer to the surface and more vulnerable to fishing gear because of the current-related dissolved oxygen profile of this region.

Muhling et al. (2014) summarized recent collaborative climate change research activities on HMS in the Gulf of Mexico and Caribbean Sea by NOAA and partners. In addition to a summary of the findings on bluefin and skipjack tunas by Muhling et al. (2015, below), Muhling et al. (2014) reported on a study investigating the potential for building size-dependent models of temperature habitat for HMS. Preliminary results of the analysis of swordfish geographic distribution by size found that larger swordfish (particularly females) are associated with relatively cooler waters. Other ongoing collaborative research includes modelling broad-scale patterns of environmental variability, studies in larval ecology, and modelling of larval distribution and abundance.

---

[2] Studies cited by the SRT review are not included in Table 1.

[3] EURO-BASIN is the European branch of the international BASIN (Basin-scale Analysis, Synthesis, and Integration) program which focuses on climate and human forcing, ecosystem impact, and consequences for living resources management in the North Atlantic

Sequeira et al. (2014) used 30 years of whale shark observations by tuna purse seine fishermen from the Atlantic, Indian, and Pacific Oceans to build a model of environmental variables that would predict future distribution of the species. According to the results of their model, which used unchecked carbon emission scenarios of changes to sea surface temperature, suitable habitat for whale sharks in the Atlantic and Indian Oceans would shift towards the poles by 2070, accompanied by an overall range contraction.

In an initial review of potential climate-related impacts to bluefin tuna, the SRT identified projected temperature increases in the Gulf of Mexico as a potential physiological stressor for bluefin tuna during spawning (SRT 2011). In the initial review, the SRT noted that average ambient temperatures measured during bluefin spawning activity ranged from 23.5° – 27.3°C (Teo et al. 2007), and that bluefin tuna have been found to withstand temperatures ranging from 3° to 30°C (Block et al. 2001). Although bluefin are believed to use deep diving to thermoregulate, spawning behavior may preclude thermoregulation behavior (Teo et al. 2007). Block et al. (2005) indicated that thermal stress appeared to be contributing to mortality of pelagic longline-caught bluefin tuna on the Gulf of Mexico spawning grounds. The SRT considered that increases in ocean temperature could mirror those forecasted for air temperature by the IPCC (2007; i.e., + 0.20°C per decade), and added ten decade's worth of temperature increase (i.e., a total of 2.0°C) to the temperatures reported by Teo et al. (2007), estimating that Gulf of Mexico temperatures during bluefin tuna spawning season could reach 25.5° – 29.3°C by the turn of the century. Further, Muhling et al. (2011) modeled a variety of climate change simulations in the Gulf of Mexico specifically to quantify potential effects of warming on the suitability of the Gulf of Mexico as a spawning ground for bluefin tuna. Model results showed that bluefin tuna were indeed likely to be vulnerable to climate change impacts with increasing water temperature, affecting both spawning times and locations, as well as larval growth, feeding, and survival (Muhling et al. 2011). In a follow-up modelling exercise, Liu et al. (2012) used a downscaled high-resolution ocean model to look at potential changes to the Loop Current induced by climate change. The current effect of the Loop Current is to warm the Gulf of Mexico; however, in this study, volume transport by the Loop Current was projected to be considerably reduced (20-25 percent) as a result of climate induced reductions to the Atlantic Meridional Overturning Circulation. The reduction in the Loop Current would have less of a warming impact in the Gulf of Mexico, particularly in the northern basin. Liu et al. (2012) indicated that this reduction in warming was underestimated by the low resolution model used by Muhling et al. (2011). Muhling et al. 2015 updated their previous study to account for the importance of regional scales as indicated in Liu et al. (2012), and again showed marked temperature induced habitat loss for both adult and larval BFT in the spawning grounds in the northern Gulf of Mexico, supporting their previous conclusions. However, as indicated in Liu et al. (2012), habitat loss in this study was somewhat mitigated by the slowing of the Caribbean Current-Loop Current system. This study also showed an increase in skipjack spawning and larval habitat, suggesting that influences of climate change on highly migratory Atlantic tuna species are likely to be substantial, and strongly species-specific.

In its review of the potential impacts of climate change on bluefin tuna, the SRT also investigated the potential direct and indirect impacts of ocean acidification. Fabry et al. (2008) reviewed the potential impacts of ocean acidification on marine fauna and ecosystem processes, and found that marine fish were physiologically highly tolerant of carbon dioxide. Ishimatsu et al. (2004) found that hatchling stages of some species appeared fairly sensitive to pH decreases on the order of 0.5 or more, but high carbon dioxide tolerance developed within a few days of hatching.

The SRT found that effects of ocean acidification might be more likely to impact bluefin tuna via trophic dynamics. Orr et al. (2005) reported that acidification would likely lead to dissolution of shallow-water carbonate sediments and could affect marine calcifying organisms, including pteropods which are an important component of the plankton in many marine ecosystems. Yamada and Ikeda (1999) found increased mortality for certain arthropod plankton (krill and certain copepods) with increasing exposure time and decreasing pH. Larval *Thunnus* spp. have been found to feed primarily on copepods (Catalan et al. 2007; Llopiz and Cowen 2009) and appear to exhibit selective feeding behavior (Llopiz and Cowen 2009). Chase (2002) identified squid as one of several important food sources for bluefin tuna caught off New England. Epipelagic squid (e.g., *Illex* and *Loligo* spp.) have been found to be highly sensitive to carbon dioxide because of their unique physiology (Portner et al. 2004; Seibel 2007). The SRT noted that as pelagic predators, bluefin tuna are considered opportunistic and loss of one food source may not have negative consequences.

13.2.4 **Oil/Gas Exploration Activities (Seismic Surveys)**

Seismic surveys, such as those utilized in oil and gas exploration activities, are the subject of controversy due to projected impacts on protected resources (specifically cetaceans and sea turtles), EFH, and on fish and fisheries. The effects of seismic surveys have not been researched specifically on Atlantic HMS, but have been for some other fish species (e.g., Deffenbaugh 2002; Engas and Lokkenborg 2002; McCauley et al. 2002; Gordon et al. 2004; Popper et al. 2005; Weilgart 2013; BOEM 2014).

BOEM issued a Final Programmatic Environmental Impact Statement (PEIS) in February 2014 that assessed potential environmental impacts associated with the authorization of geological and geophysical survey activity in the Mid- and South-Atlantic outer continental shelf regions and adjacent state waters. The final PEIS, and supporting documentation, can be found at the following website: http://www.boem.gov/Atlantic-G-G-PEIS/. The analysis contained within the PEIS included Atlantic HMS in these regions (sharks and tunas but not billfish or swordfish) as part of an overall analysis of the effects on marine fisheries resources. The analysis includes a thorough review of the literature concerning seismic survey impacts on fish and other marine life.

BOEM found that airguns associated with seismic surveys have the greatest potential to affect fishes physiologically because of the nature of their sound output. At close range, airgun noise can damage auditory and non-auditory anatomy in fishes of all life stages, including eggs and larvae. Fishes with swim bladders are primarily affected, but airguns can cause physiological damage any time in which gas bubbles are embedded in soft tissues or where the change in pressure is sufficient to cause a change in state from dissolved to free for blood gases. Sensory cells lining the auditory system of fishes may also be damaged by sounds produced from seismic survey equipment (BOEM 2014).

Longer duration surveys over broad areas would likely cross schools or aggregations of fishes. Depending on water depth, these would include coastal pelagic, epipelagic, and demersal hard bottom species. Interactions with these fisheries resources would be temporary because the survey vessel is constantly moving, but because of the broad survey areas, the likelihood of encountering fisheries resources increases. Surveys focused in a smaller area using airguns would present a greater potential threat to fishes because of higher levels of sound exposure. Long duration but widespread vs. short duration over small areas presents different sound exposure situations, both of which could lead to adverse impacts. Spawning aggregation sites, feeding areas, hard bottom habitats, artificial reefs, and any other habitats where fishes aggregate would be susceptible to impacts from airgun noise (BOEM 2014).

BOEM (2014) has defined impacts to fisheries resources and EFH as follows:

- **Negligible impacts** have little to no observed or expected measurable impacts on federally managed fish species or EFH.
- **Minor impacts** are detectable but are not severe or extensive and may include temporary displacement, disruption of important behavioral patterns, or spatially limited impact to EFH of key species or prey.
- **Moderate impacts** would be detectable and extensive but not severe, and may include some degree of population-level physiological/anatomical damage to, population-level mortality to, or extended displacement of, large numbers of (i.e., population-level) a federally managed fish species. Moderate impacts would also include extensive damage (quantifiable loss depending on the habitat type) to EFH, or extensive disruption of behavioral patterns (including spawning, feeding, or ontogenetic migrations) that may adversely affect a species.
- **Major impacts** would be detectable, extensive, and severe and would include a high level of physiological/anatomical damage to, mortality to, or extended, long-term displacement of, a federally managed fish species. Major impacts would also include extensive, long-term damage (quantifiable loss depending on the habitat type) to EFH, or extensive, chronic disruption of behavioral patterns (including spawning, feeding, or ontogenetic migrations) that would adversely affect a species.

BOEM (2014) noted that the potential to disrupt spawning aggregations or schools of fishes important as prey for other fishes and marine mammals, when coupled with the mobile nature of the surveys, the temporary (short-term) nature of the surveys, the small area of the seafloor affected during the surveys relative to the overall area of interest (AOI), and the possibility of fishes to temporarily move away from noise that is affecting them, suggests that the impacts from airguns to fisheries resources and EFH would be **minor** to **moderate**. Overall background noise would increase during surveys of particular pre-plotted areas of seafloor such as individual OCS lease blocks, renewable energy sites, and sand borrow areas. Noise levels would return to ambient once a survey ends and the noise source is shut down. When exposure to sound ends, stress-related behavioral response by fishes would also be expected to end.

High-frequency sounds emitted by active electromechanical acoustic operations in the AOI would likely affect the behavior of herrings and other fish resources in a detectable way. Changes in behavior, particularly in pre-spawning fish assembling to move into spawning rivers, could affect reproductive potential or feeding activity. In addition, temporary displacement of prey species like herring could affect feeding routines of predatory fishes (including HMS) and marine mammals. Because the use of electromechanical sources would be mostly from moving vessels and individual surveys would be temporary and spatially limited, the impacts on these fishes and populations are expected to be **minor**.

NMFS provided recommendations on the Programmatic EIS that are non-specific to Atlantic HMS, but which could be broadly applicable to Atlantic HMS fish, EFH, and fisheries (other recommendations are heavily focused on marine mammals and on National Marine Sanctuaries programs):

- In the draft seismic airgun survey protocol, there are a number of instances where BOEM proposes specific time periods (e.g., time period for ramp-up, time period not requiring new ramp-up, requirements relating to borehole surveys) without explaining the rationale for the specific measures. NMFS recommended that BOEM justify the specifics of the draft protocol.

- BOEM indicates mitigative measures similar to the Gulf of Mexico Region Notice to Leaseholders (GOM NTL) are expected to provide protective buffers to the benthic resources of the South Atlantic; however, specific measures have not been developed. Because oceanic features, such as the Gulf Stream, and the extent of important and valuable benthic habitats (e.g., corals, live bottoms, hard bottoms) in the South Atlantic differ from those in the Gulf of Mexico the mitigative measures contained in GOMR NTLs may not be directly transferable for application in the South Atlantic. BOEM should indicate that specific avoidance measures (e.g., buffer zones) will be established through required consultations such as the EFH Consultation with NMFS.

- Minimum standards for benthic mapping and surveys should be described and defined. BOEM should also consider adoption of a classification scheme to standardize habitat definitions and descriptions for benthic survey reporting requirements.

- Many fish and invertebrates are sensitive to particle motion (both otoliths in fish and statocysts in invertebrates act as accelerometers) and to gain a full understanding of the effects of sound on these animals it may be necessary to measure or estimate particle motion. Based on outcomes from a recent BOEM-hosted hydroacoustic workshop for fish and invertebrates, and other efforts (e.g., CEF 2011, Worchester 2006), particle motion may be a more appropriate measure of potential impact for many species. BOEM should consider including discussion of particle motion changes due to seismic surveys.

13.3 EFH Conservation Recommendations

Conservation recommendations to prevent or mitigate non-fishing effects of EFH of previously analyzed activities are included in the 2006 Consolidated Atlantic HMS FMP and Amendment 1 and are not repeated here.

At this time, climate change and seismic surveys are the only newly-identified activities with potential to generate detrimental non-fishing impact to HMS EFH. Climate change impacts are global and ongoing with a wide range of causes and impacts both inside and outside of fisheries. Specific conservation recommendations to limit or mitigate climate change often have national and global implications that are outside the scope of this document. At this time, a vigilant review of emerging climate change impacts to HMS distribution and migration is important to ensure HMS EFH is appropriately designated and that management measures are effective at maintaining sustainable HMS fisheries and habitat. While seismic testing, and airguns, are known to have detrimental effects on many species of fish (e.g., sciaenids, clupeids) and mammals, and may render pelagic habitats in the immediate area of surveys or testing temporarily unsuitable for many species, NMFS has not identified conclusive empirical evidence in the literature that Atlantic HMS species or Atlantic HMS EFH are detrimentally affected by seismic testing or, assuming there are impacts, the extent of any impacts. NMFS recommends that additional research in this subject area be conducted to evaluate potential effects on Atlantic HMS and on HMS EFH.

13.4 Conclusions

At this time, climate change and seismic testing are the only non-fishing impacts to HMS EFH that has not been previously analyzed, and have the potential to affect Atlantic HMS EFH.

Although climate change will likely affect HMS EFH, there is not sufficient information at this time to assess HMS EFH impacts. Impacts from climate change would likely manifest through alterations in distribution as ocean conditions change. Analyzing changes in distribution will occur over time. As noted under Future Recommendations, regular review of HMS EFH should continue to monitor HMS distribution for changes to EFH.

The next step for incorporating climate change considerations into EFH designations for Atlantic HMS, and potentially other HMS management applications, could include conducting framework analyses such as Morrison et al. (in review) or the SRT’s 2011 bluefin tuna review for each species, to identify vulnerabilities to climate change in life history or trophic dynamics. Similar to the bottleneck of vulnerability for bluefin tuna spawning in the Gulf of Mexico (Liu et al. 2012, Muhling et al. 2011, SRT 2011), other HMS may have particular climate related vulnerabilities. The release of the vulnerability analyses on porbeagle, sand tiger, and dusky sharks in 2015 (J. Hare, personal communication) will likely illustrate the applicability of this approach to Atlantic HMS on a regional scale (i.e., Cape Hatteras to Scotian Shelf). Broadening the approach to take into account the full geographic range of Atlantic HMS may be warranted.

The HMS Advisory Panel and some constituents expressed significant concern about the potential effects of seismic testing on Atlantic HMS and Atlantic HMS EFH. NMFS has not identified conclusive empirical evidence in the literature that Atlantic HMS or Atlantic HMS EFH are detrimentally affected by seismic testing. However, given that detrimental impacts have been observed in other species, there is a possibility that these activities may also generate detrimental impacts on Atlantic HMS or Atlantic HMS EFH. NMFS recommends that additional research in this subject area be conducted to evaluate potential effects on Atlantic HMS and on HMS EFH. NMFS will monitor scientific literature for papers dealing with seismic surveys, and will incorporate these findings into future evaluations of Atlantic HMS EFH as sufficient information regarding seismic survey impacts on HMS EFH becomes available.

13.5 Future Recommendations

Near-term climate change impacts to HMS EFH will likely include range and distribution shifts as water temperature changes and seismic testing may impact Atlantic HMS or Atlantic HMS EFH. We recommend continuing to monitor emerging research on climate change and seismic testing impacts and continuing to regularly reassess the distribution of HMS and adjust HMS EFH boundaries accordingly.

13.6 Literature Cited

Barange M, Perry RI. 2009. Physical and ecological impacts of climate change relevant to marine and inland capture fisheries and aquaculture. In: Cochrane K, De Young C, Soto D, Bahri T, editors. Climate change implications for fisheries and aquaculture: overview of current scientific knowledge. FAO Fisheries and Aquaculture Technical Paper. No. 530. Rome, FAO. p. 7-106.

Block BA, Dewar H, Blackwell SB, Williams TD, Prince ED, Farwell CJ, Boustany A, Teo SLH, Seitz A, Walli A, Fudge D. 2001. Migratory movements, depth preferences and thermal biology of Atlantic bluefin tuna. Science. 293(5533): 1310-1314.

Block BA, Teo SLH, Walli A, Boustany A, Stokesbury MJW, Farwell CJ, Weng KC, Dewar H, Williams TD. 2005. Electronic tagging and population structure of Atlantic bluefin tuna. Nature. 434: 1121-1127.

[BOEM]. Bureau of Ocean Energy Management. 2014. Atlantic OCS Proposed Geological and Geophysical Activities Mid-Atlantic and South Atlantic Planning Areas Final Programmatic Environmental Impact Statement. Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, U.S. Department of the Interior. New Orleans, LA. http://www.boem.gov/BOEM-2014-001-v1/

Catalan IA, Alemany F, Morillas A, Morales-Nin B. 2007. Diet of larval albacore *Thunnus alalunga* off Mallorca Island (NW Mediterranean). Sci Mar. 71(2): 347-354.

CEF Consultants Ltd. 2011. Report on a Workshop on Fish Behaviour in Response to Seismic Sound held in Halifax, Nova Scotia, Canada, March 28-31, 2011, Environmental Studies Research Funds Report No. 190. Halifax, 109 p.

Chase B. 2002. Differences in diet of Atlantic bluefin tuna (*Thunnus thynnus*) at five seasonal feeding grounds on the New England continental shelf. Fish Bull. 100:168-180.

Chang Y, Sun C, Chen Y, Yeh S, DiNardo G, Su N .2013. Modelling the impacts of environmental variation on the habitat suitability of swordfish, *Xiphias gladius*, in the equatorial Atlantic Ocean. ICES J Mar Sci. 70(5): 1000-1012. doi:http://dx.doi.org/10.1093/icesjms/fss190

Cheung WWL, Watson R, Pauly D. 2013. Signature of ocean warming in global fisheries catch. Nature (Res Lett). 497: 365-369. doi:10.1038/nature12156.

Deffenbaugh M. 2002. Mitigating seismic impact on marine life: current practice and future technology. Bioacoustics 12(2-3):316-318.

Dueri S, Bopp L, Maury O. 2014. Projecting the impacts of climate change on skipjack tuna abundance and spatial distribution. Glob Change Biol. 20(3): 742-753. doi:http://dx.doi.org/10.1111/gcb.12460

Engas A, Lokkenborg S. 2002. Effects of seismic shooting and vessel-generated noise on fish behavior and catch rates. Bioacoustics 12(2-3): 313-316

Fabry VJ, Seibel BA, Feely RA, Orr JC. 2008. Impacts of ocean acidification on marine fauna and ecosystem processes. ICES J Mar Sci. 65:414-432.

Ganachaud A, Sen Gupta A, Brown JN, Evans K, Maes C, Muir LC, Graham FS. 2013. Projected changes in the tropical pacific ocean of importance to tuna fisheries. Climatic Change, 119(1), 163-179. doi:http://dx.doi.org/10.1007/s10584-012-0631-1

Gordon J, Gillespie D, Potter J, Frantzis A, Simmonds MP, Swift R, Thompson D. 2004. A review of the effects of seismic surveys on marine mammals. Mar Tech Soc J 37(4):16-34.

Hobday AJ, Young JW, Abe O, Costa DP, Cowen RK, Evans K, Gasalla MA, Kloser R, Maury O, Weng KC. 2013. Climate impacts and oceanic top predators: moving from impacts to adaptation in oceanic systems. Rev Fish Biol Fisher. doi 10.1007/s11160-013-9311-0.

Hobday AJ, Young JW, Moeseneder C, Dambacher JM. 2011. Defining dynamic pelagic habitats in oceanic waters off eastern Australia. Deep-Sea Res II. 58.5: 734-745. doi:http://dx.doi.org/10.1016/j.dsr2.2010.10.006

Hollowed AB, Barange M, Beamish R, Brander K, Cochrane K, Drinkwater K, Foreman M, Hare J, Holt J, Ito S-I, Kim S, King J, Loeng H, MacKenzie B, Mueter F, Okey T, Peck MA, Radchenko V, Rice J, Schirripa M, Yatsu A, Yamanaka Y. 2013. Projected impacts of climate change on marine fish and fisheries. ICES J Mar Sci. 70: 1023-1037.

IPCC. 2014. Climate Change 2014 Synthesis Report Approved Summary for Policymakers, IPCC Fifth Assessment Synthesis Report, IPCC, Geneva, Switzerland. 40 p. http://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_SPM.pdf

Ishimatsu A, Kikkawa T, Hayashi M, Lee K, Kita J. 2004. Effects of carbon dioxide on marine fish: larvae and adults. J Ocean 60:731-741.

Lehodey P, Senina I, Calmettes B, Hampton J, Nicol S. 2013. Modelling the impact of climate change on pacific skipjack tuna population and fisheries. Climatic Change. 119(1): 95-109. doi:http://dx.doi.org/10.1007/s10584-012-0595-1

Llopiz JK, Cowan RK. 2009. The successful and selective feeding of larval fishes in the low-latitude open ocean: is starvation an insignificant source of mortality? ICES CM 2009/T:14.

Liu Y, Lee S-K, Muhling BA, Lamkin JT, Enfield DB. 2012. Significant reduction of the loop current in the 21st century and its impact on the Gulf of Mexico. J Geophys Res 117: C05039. doi:10.1029/2011JC007555.

McCauley RD, Fewtrell J, Duncan AJ, Adhitya A. 2002. Behavioural, physiological and pathological response of fishes to air gun noise. Bioacoustics 12(2-3):318-321

Melillo JM, Richmond TC, Yohe GW, Editors. 2014: Climate change impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, 841 pp. doi:10.7930/J0Z31WJ2.

Morrison WE, Nelson MW, Howard JF, Teeters EJ, Hare JA, Griffis RB, Scott JD, Alexander MA. In review. Methodology for assessing the vulnerability of fish species to a changing climate. NOAA, National Marine Fisheries Service. Office of Sustainable Fisheries. 1315 East West Highway, Silver Spring, MD. 42 p.

Muhling BA, Lee S-K, Lamkin JT. 2011. Predicting the effects of climate change on bluefin tuna (*Thunnus thynnus*) spawning habitat in the Gulf of Mexico. ICES J Mar Sci. 68(6): 1051-1062. doi:10.1093/icesjms/fsr008.

Muhling, BA, Liu Y, Lee S-K, Lamkin JT, Malca E, Llopiz J, Ingram Jr. GW, Quattro JM, Walter JF, Doering K, Roffer MA . Muller-Karger F. 2014. Past, ongoing and future research on climate change impacts on tuna and billfishes in the western Atlantic. SCRS/2014/174. International Commission for the Conservation of Atlantic Tunas. 15 p.

Muhling, BA, Liu Y, Lee S-K, Lamkin JT, Roffer MA, Muller-Karger F, Walter III JF. 2015. Potential impact of climate change on the Intra-Americas Sea: Part 2. Implications for Atlantic bluefin tuna and skipjack tuna adult and larval habitats. J Mar Sys 148(2015): 1-13.

Murawski S. 2013. Summing up Sendai: progress integrating climate change science and fisheries. ICES J Mar Sci. 68: 1368-1372. doi:10.1093/icesjms/fsr086.

Orr JC, Fabry VJ, Aumont O, Bopp L, Doney SC, Feely RA, Gnanadesikan A, Gruber N, Ishida A, Joos F, Key RM, Lindsay K, Maier-Reimerh, Matear R, Monfray P, Mouchet A, Najjar RG, Plattner GK, Rodgers KB, Sabine CL, Sarmiento JL, Schlitzer R, Slater RD, Totterdell IJ, Weirig MF, Ymanaka Y, Yool A. 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. Nature 437: 681-686.

Pettigas P, Rijnsdorp AD, Dicky-Collas M, Engelhard GH, Peck MA, Pinnegar JK, Drinkwater K, Huret M, Nash RDM. 2013. Impacts of climate change on the complex life cycles of fish. Fish Oceanogr. 22(2): 121-139.

Popper AN, Smith ME, Cott PE, Hanna BW, MacGillivray AO, Austin ME, Mann DA. 2005. Effects of exposure to seismic airgun use on hearing of three fish species. J Acoust Soc Am 117(6):3958-3971.

Portner HO, Karl DM, Boyd PW, Cheung WWL, Lluch-Cota SE, Nojiri Y, Schmidt DN, Zavialov PO. 2014. Ocean systems in climate change 2014: impacts, adaptations and vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the IPPC. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 411-484.

Portner HO, Langebuch M, Reipschlager A. 2004. Biological impact of elevated ocean carbon dioxide concentration: lessons from animal physiology and Earth history. J Ocean. 60: 705-718.

Prince ED, Luo J, Goodyear CP, Hoolihan JP, Snodgrass D, Orbesen ES, Serafy JE, Ortiz M, Schirripa MJ. 2010. Ocean scale hypoxia-based habitat compression of istiophorid billfishes. Fish Oceanogr. 19(6): 448-462.

Seibel BA. 2007. On the depth and scale of metabolic rate variation: scaling of oxygen consumption and enzymatic activity in the Class Cephalopoda (Mollusca). J Exp Biol. 210: 1-11.

Sequeira AM, Mellin C, Fordham DA, Meekan MG, Bradshaw CJA. 2014. Predicting current and future global distributions of whale sharks. Glob Change Biol. (2014) 20: 778-789. doi: 10.1111/gcb.12343

[SRT] Atlantic Bluefin Tuna Status Review Team. 2011. Status review report of Atlantic bluefin tuna. Report to the National Marine Fisheries Service, Northeast Regional Office. March 22, 2011. 104 pp.

Stramma L, Prince ED, Schmidtko S, Luo J, Hoolihan JP, Visbeck M, Wallace DWR, Brandt P, Kortzinger A. 2011. Expansion of oxygen minimum zones may reduce available habitat for tropical pelagic fishes. Nat Clim Change. (2)1: 33-37.Teo SLH, Boustany A, Dewar H, Stokesbury MJW, Weng KC, Beemer S, Seitz AC, Farwell CJ, Prince ED, Block BA. 2007. Annual migrations, diving behavior, and thermal biology of Atlantic bluefin tuna, *Thunnus thynnus* on their Gulf of Mexico breeding grounds. Mar Biol. 151: 1-18.

Trenkel, VM, Huse G, MacKenzie BR, Alvarez P, Arrizabalaga H., Castonguay M, Goni N, Gregoire F, Hatun H, Jansen T, Jacobsen JA, Lehodey P, Lutcavage M, Mariani P,, Melvin GD, Neilson JD, Nottestad L, Oskarsson GJ, Payne MR, Richardson DE, Senina I, Speirs DC. 2014. Comparative ecology of widely distributed pelagic fish species in the North Atlantic: Implications for modelling climate and fisheries impacts. Prog Oceanogr 129 (2014) 219-243.

Valdes L, Peterson W, Church K, Marcos M. 2009. Our changing oceans: conclusions of the first international symposium on the effects of climate change on the world's oceans. ICES J Mar Sci. 66: 1435-1438.

Weilgart L. 2013. A review of the impacts of seismic airgun surveys on marine life. CBD Expert Workshop on Underwater Noise and its Impacts on Marine and Coastal Biodiversity, 25-27 February 2014, London, UK. http://www.cbd.int/doc/?meeting=MCBEM-2014-01

Worcester T. 2006. Effects of Seismic Energy on Fish: A Literature Review. DFO Can Sci Advis Sec Res Doc 2006/092: 66p.

Yamada Y, Ikeda T. 1999. Acute toxicity of lowered pH to some oceanic zooplankton. Plankton Biol Ecol. 46: 62-67.

14 HABITAT AREAS OF PARTICULAR CONCERN

14.1 Regulations and Processes

To further the conservation and enhancement of EFH, the EFH guidelines (§600.815(a)(8)) encourage FMPs to identify Habitat Areas of Particular Concern (HAPCs). HAPCs are areas within EFH that should be identified based on one or more of the following considerations:

- the importance of the ecological function provided by the habitat;
- the extent to which the habitat is sensitive to human-induced environmental degradation;
- whether, and to what extent, development activities are, or will be, stressing the habitat type; and
- the rarity of the habitat type.

A HAPC designation does not automatically result in time/area closures or other management measures designed to reduce or eliminate fishing effort. Rather, a HAPC designation identifies an area as particularly important ecologically and may take into account the degree to which the habitat is sensitive to human-induced environmental degradation. If NMFS determines that human activities are having an effect on HAPCs, then NMFS could propose measures to minimize impacts from fishing activities or develop conservation recommendations for non-fishing activities. NMFS has identified the impacts of fishing and non-fishing impacts on Atlantic HMS EFH in Chapter 12 and 13, respectively.

Designation of an HAPC does not change the fishery regulations of any species that inhabit that area. NMFS will provide the public and Regional Fishery Management Councils a chance to comment on any new HMS HAPCs designations resulting from this 5-year review of Atlantic HMS EFH. HAPCs can also be used to target areas for additional scientific research. Measures intended to reduce impacts on habitat would need to be proposed and analyzed in an additional rulemaking and could include gear restrictions, time/area closures, or other measures that minimize impacts to the habitat as necessary to protect the habitat.

14.2 Current HMS HAPCs

Currently, HAPCs have been designated for two Atlantic HMS: sandbar sharks and bluefin tuna. Areas off of North Carolina, Virginia (Chesapeake Bay), Delaware (Delaware Bay), and New Jersey (Great Bay) have been identified as HAPCs for sandbar sharks (NMFS 1999) (Figure 14.1). An HAPC for bluefin tuna was designated in Amendment 1 to the 2006 Consolidated HMS FMP (Figure 14.2) and is located across the western, northern, and central Gulf of Mexico.

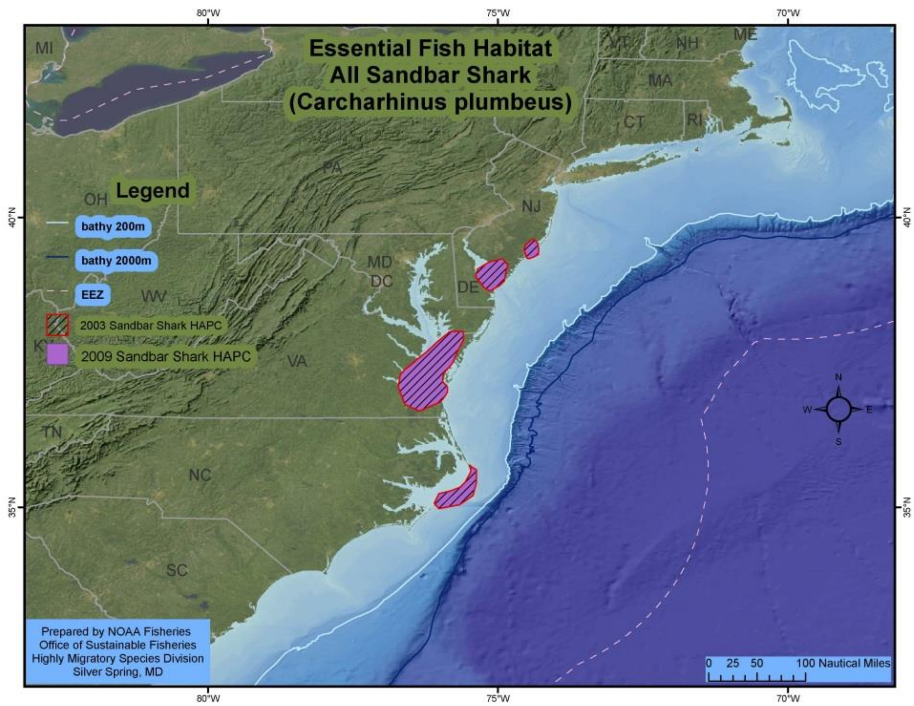

Figure 14.1 Sandbar shark HAPC designated off New Jersey, Delaware, Virginia (Chesapeake Bay), and off the Outer Banks of North Carolina

Source: Amendment 1 to the 2006 Consolidated HMS FMP.

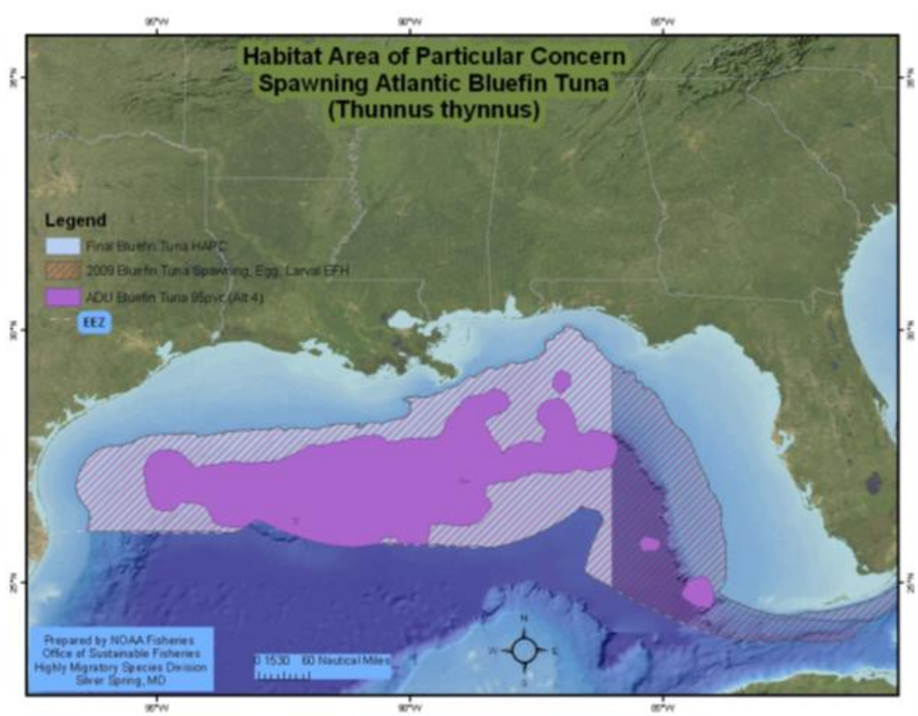

Figure 14.2 Bluefin tuna HAPC in the Gulf of Mexico (shown in light blue shading with diagonal bars).

Source: Amendment 1 to the 2006 Consolidated HMS FMP.

14.3 Recommendations

Throughout the process of developing this 5-year EFH review for Atlantic HMS, NMFS has collected comments from the public, new scientific literature, and conducted internal consolations with NMFS biologists and fishery managers to collect new information regarding Atlantic HMS EFH. Below is a list of species, based on that information, which NMFS may evaluate for adjusting their EFH range or development or adjustment of an HAPC:

Bluefin Tuna

NMFS received public comment indicating that the agency should retain the current HAPC due to the unique ecological function of the Gulf of Mexico in western Atlantic bluefin tuna life history. NMFS also found new literature on bluefin tuna life history, migration, and pelagic habitat utilization. During the upcoming amendment to update HMS EFH, NMFS will evaluate if changes to the current bluefin HAPC boundaries are warranted.

Lemon Sharks

NMFS received public comment regarding a high density lemon shark nursery within the Cape Canaveral - Jupiter Inlet region of southeastern Florida, and off Chandeluer Sound, Mississippi. New scientific literature also suggests that this nursery is spatially discrete and may be a unique and important habitat for this species. During the upcoming amendment to update HMS EFH, NMFS will evaluate whether new data warrants a HAPC for lemon sharks.

Sand Tiger Sharks

NMFS has identified new literature and tagging data for sand tiger sharks, which may indicate important nursery grounds for this species in Delaware Bay and in the Cape Cod region. During the upcoming amendment to update HMS EFH, NMFS will evaluate whether these new data warrant a HAPC for sand tiger sharks.

Sandbar Sharks

There is currently a HAPC for sandbar sharks that includes coastal regions of Delaware, New Jersey, Virginia, and North Carolina. During the upcoming amendment to update HMS EFH, NMFS will re-evaluate if changes to the current sandbar shark HAPC boundaries are warranted.

Billfishes

Larval distribution of billfishes (blue and white marlin, sailfish, roundscale spearfish, and longbill spearfish) is the subject of ongoing research within the Florida Straits, Gulf of Mexico, and the U.S. Caribbean, suggesting that these areas could be considered primary spawning grounds for billfishes. During the upcoming amendment to update HMS EFH, NMFS will evaluate whether these studies have provided findings to warrant HAPC designation for billfishes.

15 RESEARCH AND INFORMATION NEEDS

Amendment 1 to the HMS FMP outlined a number of research and information needs to improve HMS EFH designation. Amendment 1 noted that, in many cases, movements of HMS are still not well understood or have only been defined in broad terms. Furthermore, although the habitats through which HMS transit may be well studied, and the physical and biological processes fairly well understood in broad terms, there is little understanding of the particular characteristics that influence the distribution of tuna, swordfish, sharks, and billfish within those systems. Unlike many estuarine or coral reef species that can be easily observed, collected or cultured, the extensive mobility and elusiveness of HMS, combined with the rarity of some species, has delayed the generation of much of the basic biological and ecological information needed to analyze their habitat affinities.

Although a large amount of research in these areas has occurred since publication of Amendment 1, all of the research and information needs listed in Chapter 7 of Amendment 1 are incorporated by reference here.

15.1 EFH Research Priorities

Since publication of Amendment 1 to the HMS FMP, NMFS published the Atlantic HMS Management-Based Research Needs and Priorities document. The document contains a list of near- and long-term research needs and priorities that can be used by individuals and groups interested in Atlantic HMS to identify key research needs, improve management, reduce duplication, prioritize limited funding, and form a potential basis for future funding.

The priorities range from biological/ecological needs to socioeconomic needs, and the document can be found at:
http://www.nmfs.noaa.gov/sfa/hms/documents/hms_research_priorities_2014.pdf

The Research Needs and Priorities document, along with feedback gathered on this draft EFH review from NMFS scientists specifically on EFH research needs, were used to develop the following list of research priorities that would support HMS EFH designation and protection:

15.1.1 Priorities for All Atlantic HMS EFH

High Priorities

- Assess long-term socioeconomic and ecological impacts of the Deepwater Horizon oil spill.

Medium Priorities

- Assess the possibility of ecosystem-based assessments and explore the feasibility of ecosystem-based management for all HMS.
- Collect data that would allow for all HMS essential fish habitat designations to be based on more than presence/absence data.
- Examine the influence of climate change on range, migration, nursery/pupping grounds, and prey species for HMS in general.

15.1.2 Bluefin Tuna EFH

High Priorities

- Enhance information on larval distribution to support stock assessments.
- Determine seasonal migration and localized abundance information including size, distribution, and stock structure.

Low Priorities

- Examine the feasibility of dynamic area management based on oceanic conditions.

15.1.3 BAYS (Bigeye, Albacore, Yellowfin, and Skipjack) Tunas EFH

High Priorities

- Determine seasonal migration and localized abundance, distribution, and stock structure.

Medium Priorities

- Determine larval distribution.

15.1.4 Billfish EFH

High Priorities

- Determine spawning areas and spawning seasonality, seasonal migration and localized abundance, distribution, and stock structure.

Medium Priorities

- Determine larval distribution.

15.1.5 Swordfish EFH

Medium Priorities

- Determine seasonal migration and localized abundance, distribution, and stock structure.

Low Priorities

- Determine larval distribution.

15.1.6 Shark EFH

High Priorities

- Determine migration and stock structure of all sharks. Consider implications for assessments and management of stocks that straddle multiple national jurisdictional boundaries (e.g., Mexico, Caribbean nations, and the United States).
- Improve life history information of all sharks, particularly commercially and recreationally important species or species that are caught as bycatch frequently (e.g., fecundity, sex-specific age/length of maturity, pupping grounds, mating grounds, gestation period, reproductive frequency, number of pups); determine if these characteristics have changed over time.
- Monitor stock over spatially broad areas to gain a better understanding of biological and abiotic factors driving distributions in those areas.
- Identify key nursery, feeding, and mating habitats.

Low Priorities

- Develop year-round abundance/distribution estimates of sharks in current closed areas or key habitats (e.g., mid-Atlantic shark closure, Charleston Bump); consider how and when sharks use certain key habitat areas.

16 EFH DELINEATION

The purpose of this chapter is to evaluate whether the current method of delineating essential fish habitat is still the most appropriate. In order to evaluate the most appropriate methodology, this chapter: 1) reviews all previous methodologies considered in delineating EFH; 2) discusses the most recent approach to delineate HMS EFH as a "status quo" method; 3) provides a review of other approaches that have been used to evaluate EFH in the scientific literature and by other entities (i.e., Regional Fishery Management Councils); 4) reviews recent public comment that NMFS has received concerning EFH delineation methodology; and 5) provides an analysis of options and a recommendation by the Highly Migratory Species Management Division on appropriate methodologies for use in future HMS EFH reviews.

16.1 Review of Approaches Previously Considered

1999 FMP for Atlantic Tunas, Swordfish, and Sharks

Section 303(a)(7) of the Magnuson-Stevens Act, 16 U.S.C. §§ 1801 et seq., as amended by the Sustainable Fisheries Act in 1996, requires that FMPs describe and identify EFH for the fishery based on the guidelines established by the Secretary under section 305(b)(1)(A), minimize to the extent practicable adverse effects on such habitat caused by fishing, and identify other actions to encourage the conservation and enhancement of such habitat. The 1999 HMS Fishery Management Plan for Atlantic Tunas, Swordfish, and Sharks included two chapters that reviewed HMS Habitat Provisions (Chapter 5, http://www.nmfs.noaa.gov/sfa/hms/documents/fmp/tss_fmp/hmsch5.pdf) and HMS Essential Fish Habitat Provisions (Chapter 6, http://www.nmfs.noaa.gov/sfa/hms/documents/fmp/tss_fmp/hmsch6.pdf) in order to fulfill the requirements of newly established EFH updates to the Magnuson-Stevens Act.

Per EFH regulations established under the Sustainable Fisheries Act, an initial inventory of available environmental and fisheries data sources was undertaken to compile information necessary to describe and identify EFH and to identify major species-specific habitat data gaps. Available information was evaluated through a hierarchical analysis based on: 1) presence/absence of the species in specific habitats; 2) habitat-related densities or relative abundances; 3) growth, reproduction, or survival rate comparisons between habitats; and 4) habitat-dependent production rates (quantified by habitat quantities, qualities and specific locations). NMFS scientists at the Southeast Fisheries Science Center (SEFSC) and the Northeast Fisheries Science Center (NEFSC) conducted a complete review and qualitative analysis of the literature and data available to date following these guidelines.

Their review covered the life histories of all HMS fishery species in the management unit, with an emphasis on the factors that influence distribution of the species. Much of the descriptive information for tunas and swordfish species was from the 1970s and 1980s. For all HMS, additional information was available in the form of fishery-independent sources (directed research investigations) and fishery-dependent sources (capture and bycatch reporting). Although the location information is suitable for Geographic Information System (GIS) based spatial analysis of distributions, there was a general lack of accompanying environmental or habitat data with which to define habitat tolerances or preferences.

Written accounts detailing HMS life history, distribution, and habitat use were peer-reviewed, and comments were considered and assessed by the scientific authors and included as appropriate. In general, the initial designations of EFH for tuna and swordfish established under this rulemaking were a combination of life history information, expert opinion regarding the importance of certain areas, and presence/absence and relative abundance information from fishery-independent and fishery-dependent sources.

To visually represent species presence/absence, data were analyzed using GIS. Once an overall range was established using multiple data sets, they were refined through consideration of data based on individual movements and aggregations. Noticeable areas of aggregations, as bounded by some easily identifiable geographic feature or description (e.g., bathymetry, distance from shore), were delineated as EFH for each relevant species life stages. EFH boundaries were digitized and represented by shaded polygons in supplemental maps.

1999 Amendment 1 to the Atlantic Billfish FMP

NMFS undertook the same approach to delineate EFH for Atlantic billfish that was utilized in the 1999 FMP for Atlantic Tunas, Swordfish, and Sharks.

2003 Amendment 1 to the FMP for Atlantic Tunas, Swordfish, and Sharks

Amendment 1 to the FMP for Atlantic Tunas, Swordfish and Sharks addressed species for which there had been a change in management status (blacktip, sandbar, and finetooth sharks), or for which new information had become available (dusky and nurse sharks).

NMFS undertook a different analytical process to refine EFH for these species. To visually represent species' distributions, data points from a number of datasets were combined and analyzed by species and life stage using GIS. To identify areas with the highest concentration of observations, individual observations were spatially joined to a 10 minute grid (i.e., each grid cell equivalent to roughly 100 nm^2), which was then color-coded according to the number of observations per square. Depending on the number of observations in the data set, and the status of the species, a higher or lower number of observations per 10 minute grid was used as a guide for identifying potential EFH areas.

This Amendment established criteria for delineating EFH based on the status of a stock (i.e., "Stock Status Method"):

- Rebuilt species - greater than 10 observations per 100 nm^2 was used to help identify and map areas as EFH.
- Overfished species - a more precautionary criteria of > 1 observation per 100 nm^2 was used to help identify and map EFH areas.

The average percentage of observed distribution points included in the EFH designation were calculated after the EFH boundaries were established and were provided for illustrative purposes only.

2006 Consolidated HMS FMP

After reviewing published scientific reports and consulting with experts in the field, NMFS determined that several of the size ranges for various life stages of sharks published in the 1999 Fishery Management Plan for Atlantic Tunas, Swordfish and Sharks and the 1999 Amendment to the Billfish Fishery Management Plan needed to be updated. In particular, a "neonate" life stage (where available) was identified that differed from the "early juvenile" life stage previously identified in the 1999 FMPs. The 1999 definition was modified to include primarily neonates and young-of-the-year sharks in the neonate category in order to better define and identify the life stage that occupies nursery habitat. The change in classification of "late juveniles/subadults," to "juveniles" was done to ensure that all immature sharks from young juveniles to older or late juveniles were included in the juvenile category. Finally, the "adult" size class was maintained and consisted of mature sharks based on the size at first maturity for females of the species.

NMFS utilized methodologies similar to those previously adopted to update EFH maps with new size information. After careful screening to ensure standardization and quality of the data, all of the data points for each species were compiled in a GIS program for mapping. NMFS first identified areas with the highest concentration of observations by spatially joining available data on a regional grid (10' × 10' squares, approximately 100 nm^2) covering coastal waters in the U.S. Exclusive Economic Zone (EEZ). Each square was given a summary of the numeric attributes and a count field of the points that fell inside it. The squares containing observations were color-coded depending upon the number of observations per square, and scaled to reflect the frequency of occurrence. The criteria previously established in the 2003 Amendment 1 to the Atlantic Tunas, Swordfish, and Sharks FMP to delineate EFH based on the status of the stock was again used to identify and map EFH in the 2006 Consolidated HMS FMP.

2009 Amendment 1 to the Consolidated HMS FMP

The Predraft requested public comment on several newly considered methodological approaches to delineating EFH:

- **High cell count selection** (4 classes) - This approach consisted of joining point data with a grid such that grid cell values reflected the sum of points that fell within the grid, and display the grid using Jenks Natural Breaks. EFH boundaries were created around buffer areas that contained two or more high count cells within buffers that are twenty nautical miles or less from one another. As a precautionary measure, and due to uncertainty about the exact location of points within a cell, NMFS included a ten nautical mile buffer around high count cells.
- **High cell count selection** (16 classes) - This alternative used the same approach as the other high cell count selection method, with the exception of creating sixteen classes with Jenks natural breaks instead of 4 classes. The greater number of classes resulted in inclusion of a greater number of points, thus resulting in larger EFH areas.
- **Kernal density estimator** - Data would be input into a Percent Volume Contour/Kernel Density Estimator (PVC KDE) tool in the Hawth's Analysis Tools (www.spatialecology.com) extension for ArcGIS. The PVC KDE used all the data points and the distance between points to calculate an area of probability across the entire U.S. EEZ. The 95 percent area of probability would therefore on average contain 95 percent of the points that were used to generate the kernel density estimate.
- **Kernal density estimator for separate management regions** - Data would be input into a Percent Volume Contour/Kernel Density Estimator (PVC KDE) in the Hawth's Tools extension for ArcGIS. The PVC KDE used all the data points and the distance between points to calculate an area of probability within different parts of the U.S. EEZ (i.e., separate analyses would be completed for the Gulf of Mexico and the Atlantic). The 95

percent area of probability would therefore on average contain 95 percent of the points that were used to generate the kernel density estimate.

- **EFH encompasses all locations where known interactions occur** - This option was most precautionary, but contrary to the advice provided by the NMFS Office of Habitat Conservation. Making the range extent equivalent to EFH does not allow NMFS to identify and make special management provisions for habitats that are critical for the continued recruitment of fishery resources.

Under Amendment 1, NMFS identified and specified geographic areas, rather than specific habitat types, that were considered EFH in written text descriptions. Where possible, NMFS included specific habitat requirements for individual species in the text descriptions; however the spatial boundaries described in maps defined the EFH boundaries.

NMFS considered a number of different analytical approaches to mapping and analyzing the data in an effort to develop a methodology that would be reproducible, transparent, and result in specific areas that could be mapped and identified with spatial boundaries. Several of these options were first evaluated in the Predraft to this Amendment, and NMFS consulted internally and externally to identify the best options for consideration. NMFS included the following as alternatives in the final amendment:

1 No Action Alternative - Keep the Current EFH Designations
2 High Cell Count Selection Method (4 classes, Alternative 2)

Alternative 2 is similar to the High Cell Counts option presented in the Predraft; however, EFH boundaries would be delineated around the three highest classes of cells.

NMFS identified several disadvantages to using this approach, including a lack of consistency in the classes that are created for different species and life stages, determining the appropriate threshold for high count cells to include in the new boundaries, and greater variability in the boundaries which must be manually created.

1. *95 Percent Probability Method (Alternative 3) - Preferred*

The preferred alternative established new EFH boundaries based on the 95 percent probability boundary estimated with a Percent Volume Contour/Kernal Density Estimator (PVC KDE) tool using ESRI ArcGIS and Hawth's Analysis Tools (www.spatialecology.com), as described above.

NMFS selected this approach as the preferred alternative because it was based on the actual data points as opposed to points that are merged with a grid as described in Alternative 2, provides a standardized and transparent method for delineating EFH, was reproducible, and the 95 percent probability boundaries were easily calculated in ArcGIS using Hawth's Spatial Analysis Tools (www.spatialecology.com).

2. Use All Points of Data (Alternative 4)

This alternative would use all data points for a particular species to delineate new EFH boundaries. This represents a more precautionary approach than either alternative 2 or 3 and would result in larger EFH areas due to the wide distribution of HMS. Analysis of distribution data indicated that, under this alternative, very large areas could potentially be identified as EFH. In some cases, this could result in EFH including nearly all Federal waters within the EEZ, which may run counter to the intent of identifying areas that are considered essential. The NMFS Office of Habitat Conservation advised against the use of this method to delineate EFH

In 2009, under Amendment 1, NMFS updated all HMS species' EFH using the procedures using the 95 percent probability method identified under preferred Alternative 3.

2010 Amendment 3 to the Consolidated HMS FMP

Smoothhound (*Mustelus* spp.) EFH was designated using the 95 percent probability method identified in Amendment 1 to the 2006 Consolidated HMS FMP.

75 FR 57698, Specification and Incorporation of Roundscale Spearfish under the Consolidated HMS FMP

Roundscale spearfish (*Tetrapturus georgii*) EFH was designated using the 95 percent probability method identified in Amendment 1 to the 2006 Consolidated HMS FMP.

16.2 Current Methodology to Delineate HMS EFH

The current method consists of using the PVC KDE tool in the Hawth's Analysis Tools extension toolkit (www.spatialecology.org) for ArcGIS, as previously described. The PVC KDE uses all the data points and the distance between points to calculate an area of probability across the entire U.S. EEZ. The 95 percent area of probability would therefore on average contain 95 percent of the points that were used to generate the kernel density estimate. This methodology is commonly used in the scientific literature to delineate essential fish habitat, habitat utilization, and home range.

Hawth's Analysis Tools was updated through ArcGIS version 9.3 (roughly, through early 2010). However, the Hawth's Analysis Tool programmers recently transitioned to a new software program called "Geospatial Modeling Environment", concurrent with the release of ArcGIS version 10.x. Geospatial Modeling Environment has since replaced Hawth's Analysis Tools, and the programmers are no longer producing updates or fixes for bugs associated with Hawth's Analysis Tools.

NMFS currently uses ArcGIS versions 10.2 and 10.3, which are incompatible with Hawth's Analysis Tools. In the event that NMFS determines EFH must be redrawn for any HMS, and NMFS determines that the status quo methodology is appropriate for continued use, then the Agency would need to either use Kernal Density Estimator tools embedded in ArcGIS, or a separate tool extension like Geospatial Modeling Environment to delineate the 95 percent probability contours for EFH. Other tool packs may also be used to draw the 95 percent probability contours and would be identified during the analysis at the draft stage.

16.3 Some Other Methodologies Used to Delineate EFH

The following table identifies other methodologies used to delineate EFH by Regional Fishery Management Councils and from EFH scientific literature publications. This table is intended to provide a list of alternative methodologies different from those previously considered for HMS EFH that have been utilized by other entities or scientific institutions since the finalization of Amendment 1 to the Consolidated HMS FMP. In the event that NMFS determines a new delineation methodology is appropriate, NMFS could consider the following approaches in a future rulemaking. If a different methodology is selected in a future rulemaking, NMFS would have to redraw EFH boundaries for all Atlantic HMS.

Table 16.1 Previous Methodologies Used to Delineate EFH

Citation	Method	Description/Notes
North Pacific Fishery Management Council (NPFMC). 2010. Essential Fish Habitat 5-Year Review. Final Summary Report Submitted to the North Pacific Fishery Management Council and the National Marine Fisheries Service. http://www.alaskafisheries.noaa.gov/habitat/efh/review/efh_5yr_review_sumrpt.pdf	Literature Meta-Analysis	Authors of NPFMC groundfish species stock assessments were asked to evaluate current FMP text relating to EFH based on new information that had become available in the preceding 5 years. Authors completed a worksheet with some general questions about new habitat information available since the 2005 EFH EIS, and recommendations on potential HAPC or EFH conservation recommendations. The recommendations were peer reviewed and passed on to the Council for consideration.
Allee, RJ, Kurtz J, Gould Jr. RW, Ko DS, Finkbeiner M, Goodin K. 2014. Application of the coastal and marine ecological classification standard using satellite-derived and modeled data products for pelagic habitats in the Northern Gulf of Mexico. Ocean Coast Manage. 88:13-20.	Coastal and Marine Ecological Water Column Classification Standards	This paper included an evaluation of remote sensing and hydrodynamic model products (variables identified as key to the classification of water column habitats) to evaluate their use as a proxy for characterizing pelagic habitats in the absence of robust *in situ* data. Validated models can generate basin-wide GIS layers that can be overlaid and analyzed to identify EFH.
Cerveny, K, Appeldoorn RS, and Recksiek CW. 2010. Managing habitat in coral reef ecosystems for fisheries: just what is essential? Proceedings of the 63rd Gulf and Caribbean Fisheries Institute. Nov 1-5, 2010. San Juan, PR.	Cross Shelf Habitat Framework (Lindeman et al. 1998)	A color coded grid was developed depicting relative abundance/density by location along the shelf (inner, intermediate, outer shelf with more specific identifiers) and habitat type (e.g., grass, algae, coral). This approach allowed for visual comparison and pattern analysis across the grid. Relative abundance was a proxy for habitat utilization and EFH. The example in this paper grouped all species together for analysis by life stage.
Pacific Fishery Management Council (PFMC). 2012. Pacific coast groundfish 5-year review of essential fish habitat. Report to Pacific Fishery Management Council. Phase 1: New information, September 2012. Portland, OR. 416 p.	Habitat Suitability Modeling (developed in 2004, used in 2008 West Coast Groundfish FMP, PFMC 2011) (see Appendix H)	NMFS and outside contractors developed a habitat suitability model incorporating benthic habitat, depth and location (latitude) to describe/identify EFH. The paper assigned a habitat suitability score (HSP) for different environmental variables. HSP for given locations were combined and analyzed. High HSP scores were assumed to be EFH.
Echave K, Eagleton M, Farley E, Orsi J. 2012. A refined description of essential fish habitat for Pacific salmon within the U.S. Exclusive Economic Zone in Alaska. U.S. Dep. Comer., NOAA Tech Memo.	Removal of Outliers Based on Relative Abundance; Kriging; Cumulative	NMFS estimated the data points that fell within 95 percent of the spatial distribution of each species. EFH was mapped and spatially interpolated from these data points with kriging. Kriging is a geostatistical interpolation method that fits a model to point data in order to estimate values in the

Citation	Method	Description/Notes
NMFS-AFSC-236, 104p.	Frequency Distribution Modeling (Habitat Associations)	surface between points. The model operates under the assumption that the distance or direction between sample points reflects a spatial correlation that can be used to explain variation in the surface. Cumulative frequency distribution models were developed to identify environmental associations that reflect the 95 percent "preferred" ranges.
Pacific Fishery Management Council (PFMC). 2012. Pacific coast groundfish 5-year review of essential fish habitat. Report to Pacific Fishery Management Council. Phase 1: New information, September 2012. Portland, OR. 416 p.	Fish-Habitat Association Modeling (see Appendix H)	This paper reviewed approaches to model and predict spatial patterns via habitat association analysis (i.e., using habitat maps and quantified habitat relationships). Approaches reviewed included GLM modeling, canonical correlation analyses, cluster analyses, and discriminant function analyses.
Pacific Fishery Management Council (PFMC). 2012. Pacific coast groundfish 5-year review of essential fish habitat. Report to Pacific Fishery Management Council. Phase 1: New information, September 2012. Portland, OR. 416 p.	Ecopath/ Ecosim Models trophodynamic models that can be used to evaluate predator/prey considerations in EFH (see Appendix H)	Ecopath is a static (typically steady–state) mass balance model of trophic structure that integrates information from diet composition studies, bioenergetics models, fisheries statistics, biomass surveys, and stock–assessments. It represents the initial or reference state of a food web. Ecosim is a dynamic model in which biomass pools and vital rates change through time in response to simulated perturbations.
Pacific Fishery Management Council (PFMC). 2012. Pacific coast groundfish 5-year review of essential fish habitat. Report to Pacific Fishery Management Council. Phase 1: New information, September 2012. Portland, OR. 416 p.	Atlantis Model - integrated ecosystem modeling (see Appendix H) to evaluate fishing and nonfishing impacts to EFH	This model evaluated biophysical, economic and social aspects of ecosystems. The model can evaluate impacts of disturbance, compare different management measures, and test the utility of ecosystem indicators for long-term ecosystem based management.
Arrizabalaga H, Dufour F, Kell L, Merino G, Ibaibarriaga L, Chust G, X Irigoien, Chifflet M, Goikoetxea N, Sagarminaga Y, et al. 2014. Global habitat preferences of commercially valuable tuna. Deep-Sea Res PT ***II***, http://dx.doi.org/10.1016/j.dsr2.2014.07.001	Quotient Analysis; Generalized Additive Models (international longline CPUE data)	Environmental variable tolerance range for each species was established using quotient analysis to develop broad descriptions of environmental preferences. Generalized additive models were built for each environmental variable and for all variables combined. A stepwise backward model selection procedure was adopted, and the model with the lowest AIC was selected to predict and map habitat preferences. Habitat models could be used to predict EFH.
Gasper JR, Kruse GH. 2013. Modeling of the spatial distribution of Pacific spiny dogfish (*Squalus suckleyi*) in the Gulf of Alaska	General Linear Models and Generalized Additive	This paper created polygons in ArcGIS with summarized environmental data over four time periods and modeled (GLM and GAM) total number of spiny dogfish by the number of hooks,

Citation	Method	Description/Notes
using generalized additive and generalized linear models. Can J Fish Aquat Sci. 70:1372-1385. dx.doi.org/10.1139/cjfas-2012-0535	Models (observer data and longline survey data)	bottom depth, latitude and longitude. Maps generated by models were analyzed to identify potential EFH.
Kitchens LA, Rooker JR. 2014. Habitat associations of dolphinfish larvae in the Gulf of Mexico. Fish Oceanogr. 23: 460–471. doi:10.1111/fog.12081	Generalized Additive Model Presence / Absence and Density Models (survey data)	Models were used to compare environmental parameters (*in situ*, model predictions, and satellite data) with presence/absence and density of larval fish. Final models were selected manually using a backwards stepwise procedure.

* Many recent papers attempting to evaluate habitat preferences using GAM or GLM modeling were found in the literature search. Only a few are listed in this table for illustrative purposes.

16.4 Pros and Cons of Methodologies Used to Delineate EFH

The following table was created to display an initial analysis of the pros and cons of the following potential EFH delineation methods: 1) methodologies previously considered by NMFS for EFH delineation; 2) the method adopted under Amendment 1 to the Consolidated HMS FMP (Kernal Density Estimation / 95 Percent Probability Method); 3) methods used by other Regional Fishery Management Councils to delineate EFH; and 4) methods presented in the scientific literature.

Method	Pros	Cons
Stock Status Method (see 2003 Amendment 1 to 1999 FMP for Tunas, Sharks and Swordfish)	Easy incorporation of all available point data; allows for further refinement of EFH based on stock status (gets away from labeling range extent as EFH)	Many HMS have an unknown stock status.
High Count Cell Selection (see Amendment 1 to the 2006 Consolidated HMS FMP)	Flexible for data poor situations - number of observations is used as a proxy for abundance; variety of options for mapping based on the number of thresholds used to create breaks in the data; builds on previous methodologies used; can use subjective evaluation to smooth data.	Lack of consistency in the classes that are created for different species and life stages, lack of consistency in determining the appropriate threshold for high count cells to include in the new boundaries, and greater variability in the boundaries which must be manually created.
Kernal Density Estimation / 95 Percent Probability Method (see Amendment 1 to the 2006 Consolidated HMS FMP) – Current	Based on the actual data points as opposed to points that are merged and summarized with a grid, provides a standardized and transparent method for delineating EFH and is reproducible.	Disadvantages are that data poor species result in smaller, discontinuous areas than do data rich species; boundaries based on extent of sampling/known data points instead of drawn from true species distributions.

Methodology Used to Delineate HMS EFH		
Literature Review / Meta Analysis	Allows incorporation of multiple different types of literature; easy to do with online search engines; reproducible with bibliography; allows incorporation of Level I and some study-specific Level II data*.	A thorough analysis takes a lot of staff time; literature does not cover all possible HMS habitats; subjective judgment in translating verbal descriptions to a map makes reproducibility difficult.
Coastal and Marine Ecological Water Column Classification Standards	EFH based on standardized, common habitat standards (increases reproducibility and reduces subjectivity) for species as described in literature; allows for refinement of EFH in pelagic habitat; allows extrapolation of EFH for data poor species.	Identifies/classifies pelagic habitats, but not species use of the habitat; could be used in conjunction with other geospatial methods to delineate EFH if combined with survey/observer/longline data; by itself the method does not meet EFH Level I (or other EFH Descriptive Information Levels).
Cross-Shelf Habitat Framework	Meets Level I and Level II requirements (considers distribution, relative abundance, and density by life stage). Provides a simplified means of visually comparing different habitats.	Example is based on a small scale coastal habitat complex with many different classifications, which would require having to development of an approach to classify pelagic habitats in a similar way; example grouped all species together and an HMS EFH - our analysis would not be as simple given need to analyze each species and life history stage; HMS does not have data depicting density by habitat type.
Removal of Outliers Based on Relative Abundance; Kriging; Cumulative Frequency Distribution Modeling (Habitat Associations)	Removes outliers from analysis and makes EFH smaller than range extent; Incorporates survey and fishery data; satisfies Level I and Level II EFH information data requirements; based on direct observations/point data.	Requires high resolution CPUE and environmental data to develop suitability curves; does not work well with data-poor species (developed for salmonids from targeted research survey data).
Habitat Suitability Modeling	Many examples (commonly used in the literature); approach satisfies Level I and Level II EFH information data requirements; based on direct observation/point data.	Requires high resolution CPUE and environmental data to develop suitability curves; does not work well with data-poor species.
Ecopath-Ecosim Models	Allows for analysis and incorporation of predator-prey relationships into EFH delineation; allows for the ability to predict how anthropogenic or natural changes will affect vital rates (i.e., Level III data);- models can be incorporated into map.	Many HMS species are data-poor, and vital rates/process flow inputs are not available (would have to be subjectively developed).
Atlantis model	Ecosystem model useful for evaluating fishing, non-fishing, and	More useful for other aspects of the 5-year review than to physically delineate

	anthropogenic effects on EFH.	EFH on a map (however, map-based models can be developed).
Generalized Additive Model; General Linear Model	Allows for extrapolation and prediction of habitat utilization; GLM handles non-normal data with lots of 0's; satisfies Level I EFH information requirements and can satisfy Level II EFH information requirements; very common modeling approach to evaluate habitat associations and to identify EFH.	May not work well for exceptionally data-poor species (i.e., several HMS).

*EFH regulations (§ 600.815(a)(1)) require that, at a minimum, distribution data (level 1 information) be used to identify EFH. Level 1 information is based on presence/absence data of the species or life stages in specific habitats used. Where possible, data sets and information on habitat-related densities of species (level 2), growth, reproduction and survival within habitats (level 3), and production rates by habitat (level 4), should be used to identify EFH. Distribution data (level 1) are the most common data available for HMS.

16.5 Public Comment on EFH Methodology

NMFS has solicited public comments on Atlantic HMS EFH, including comments regarding the approach NMFS should use to delineate EFH. NMFS published a notice announcing the intention to initiate a 5-year review of essential fish habitat (79 FR 15959; March 24, 2014) and that solicited comments and information from the public regarding Atlantic HMS EFH. NMFS did not receive any comments that specifically addressed EFH delineation techniques. One comment did address how EFH should be defined, but did not recommend a specific delineation approach. Public comments were also received on the draft 5-year review, which was made available in March 2015, but none of the comments focused on EFH delineation methodology.

Comments were collected during the development of Amendment 1 to the 2006 Consolidated HMS FMP that addressed EFH designations, and can be found in Appendix 1 of the Amendment 1 FEIS. Comments that addressed EFH delineation approaches focused on how, under the current approach, data-poor species may result in smaller, discontinuous areas of EFH when compared to data-rich species and if statistical analyses were done to determine whether there were sufficient points or adequate sample size to determine EFH based on presence/absence data. These comments were addressed by NMFS in the Amendment 1 FEIS, but should still be considered when determining if the current EFH delineation approach is still appropriate.

16.6 Recommendation on EFH Delineation Methods

One suite of options for delineating EFH is the development of sophisticated models that predict habitat associations and identify suitability of habitat for particular species. Although labor intensive, these approaches avoid the assumption that habitat preferences can be inferred from distribution and instead quantifies habitat preferences directly. However, robust models require robust datasets depicting metrics concerning the target species (e.g., presence/absence, catch-per-unit effort, density) and environmental variables. Numerous HMS species are data poor, and most surveys that compare CPUE to *in situ* environmental data are limited to certain spatial and temporal frameworks. HMS species-environmental associations would be heavily influenced and potentially biased by discrete studies conducted in parts of the total HMS species' ranges. Adequate species-assessment models would have to adopt a basin-wide approach sensitive to natural variability within these regions. The methodologies presented under "Coastal and Marine Ecological Water Column Classification Standards" result in simple classifications of pelagic habitat within the northern Gulf of Mexico that could be used as variables to evaluate EFH. NMFS could consider whether the tables presented under the "Cross Shelf Habitat Framework" methodology could be appropriate for visually depicting EFH; however, the major product of this approach is not a map (which is required under the current EFH regulations). Furthermore, NMFS would have to adapt this method to make the model more appropriate in scale to the habitats encountered by HMS.

In Amendment 1 to the 2006 Consolidated HMS FMP, NMFS determined that classifying EFH across the entire range of distribution of each species and life stage would result in an overly-broad EFH designation that runs counter to the intent of identifying habitats that are the most "essential" for a species. EFH should be a subset of all habitats that are necessary to fish for spawning, breeding, feeding, or growth to maturity, where "necessary" means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem (CFR 600 Part 10). Therefore, the inclusion of new data, and the removal of outliers from models, could be an important step in refining EFH (e.g., see Echave et al. 2012). Furthermore, most of the approaches considered under this review allow users some metric to identify only the most important areas (e.g., highest suitability, strongest model predictions, percent volume contour). Modeling approaches commonly encountered in the literature include the use of habitat suitability models, and Generalized Additive Models or General Linear Models which predict the occurrence of a species (i.e., presence/absence, CPUE, or density) by habitat associations. These models are then used to generate maps of predicted EFH.

The HMS Management Division conducted extensive consultation with the public and with NOAA scientists to evaluate EFH methodologies between the development of the 2006 Consolidated HMS FMP and Amendment 1 to the 2006 Consolidated HMS FMP. During these consultations, the Kernal Density Estimation / 95 Percent Volume Contour approach was identified as being the most appropriate for the available data, and provided a standardized method to calculate EFH that was transparent and easily reproducible. Instead of attempting to model habitat associations, this method infers habitat use (and EFH) from distribution data.

NMFS encouraged public comment on the following:

- Is the Kernal Density Estimation/95 percent Volume Contour Approach the best method to delineate HMS EFH?
- Should NMFS consider using one of the other methods highlighted in this section? If so, why?
- Are there other methods not mentioned in this chapter that NMFS should consider?

After review of the previously used methodologies, alternatives methodologies in the literature, methodologies employed by Councils to identify and delineate EFH, and public comments on EFH methodologies, we have concluded that changes to methodologies used to delineate EFH for HMS (i.e., NMFS could continue to use the Kernal Density Estimation / 95 Percent Volume Contour approach in delineating EFH in this 5-year review and the future) are not necessary at this time. However, we recommend further analysis of the information gathered through the EFH review process and subsequent revision or amendment of EFH delineation methodologies, if warranted in the future. Where appropriate, we will also update EFH boundaries based on new observer, survey, and tag/recapture data since 2009.

17 CONCLUSIONS

The Final 5-Year EFH Review for Atlantic HMS has been completed and is documented in this summary report. At this stage, NMFS' primary decision point is to determine, based on the new information available in the last five years and on public comment on the draft, whether changes to the HMS EFH designations are warranted. Any such changes would require initiation of an FMP amendment and associated analysis.

The recommendations contained within the review are summarized in Table 14.1. During the review process, NMFS considered the following questions:

- Do the EFH descriptions and geographical distributions for individual species warrant revision? Should the FMP be revised to reflect new information on their life history, biological/ habitat/ predator-prey associations, or fishery?
- Is a new evaluation of the adverse effects of fishing on EFH needed?
- Should any new conservation measures be considered to mitigate adverse effects of fishing?
- Should the conservation and enhancement recommendations for non-fishing threats to EFH be revised?
- Is there a need to identify new HAPCs?
- Does NMFS want to identify new directions for EFH research for the next 5 years?

Based on the review and public comment, NMFS has determined that new information warrants the initiation of an amendment to revise EFH components found in Amendment 1, Amendment 3, and the 2010 White Marlin/Roundscale Spearfish Interpretive Rule and Final Action. During the FMP amendment process, NMFS will apply any new and appropriate information including, but not limited to, observer data, survey data, logbook information, and tag/recapture data that are available for all HMS. NMFS will consider delineating new EFH if new data warrants any changes. During this process, NMFS will conduct supporting analyses, consistent with all statutes and other requirements, and provide for public comment on the draft amendment. If any changes to the regulations are also needed, NMFS will issue proposed and final rules with public comment.

Table 17.1 5-Year Review Summary of Change Recommendations for Atlantic HMS EFH

EFH Component	Species	Potential For Change Based On Literature Reviews
EFH description of individual species	**Tunas**	
	Atlantic Bigeye Tuna, *Thunnus obesus*	Not Likely
	Atlantic Skipjack Tuna, *Katsuwonus pelamis*	Not Likely
	Atlantic Albacore Tuna, *Thunnus alalunga*	Not Likely
	Atlantic Yellowfin Tuna, *Thunnus albacares*	**Likely**
	Atlantic Bluefin Tuna, *Thunnus thynnus*	**Likely**
	Swordfish	
	Atlantic Swordfish, *Xiphias gladius*	Not Likely
	Billfishes	
	Atlantic Blue Marlin, *Makaira nigricans*	**Likely**
	Atlantic White Marlin, *Kajikia albidus*	**Likely**
	Roundscale Spearfish, *Tetrapturus georgii*	**Likely**
	Longbill Spearfish, *Tetrapturus pfluegeri*	**Likely**
	Sailfish, *Istiophorus platypterus*	**Likely**
	Large Coastal Sharks	
	Atlantic and Gulf of Mexico blacktip, *Carcharhinus limbatus*	**Highly Likely**
	Bull, *Carcharhinus leucas*	**Likely**
	Great hammerhead, *Sphyrna mokarran*	**Likely**
	Lemon, *Negaprion brevirostris*	**Likely**
	Nurse, *Ginglymostoma cirratum*	**Likely**
	Sandbar, *Carcharhinus plumbeus*	**Likely**
	Scalloped hammerhead, *Sphyrna lewini*	**Likely**
	Silky, *Carcharhinus falciformis*	Not Likely
	Smooth hammerhead, *Sphyrna zygaena*	Not Likely
	Spinner, *Carcharhinus brevipinna*	Not Likely
	Tiger, *Galeocerdo cuvier*	**Likely**
	Small Coastal Sharks	
	Atlantic sharpnose, *Rhizoprionodon terraenovae*	**Highly Likely**
	Atlantic and Gulf of Mexico blacknose, *Carcharhinus acronotus*	**Highly Likely**
	Bonnethead, *Sphyrna tiburo*	**Highly Likely**
	Finetooth, *Carcharhinus isodon*	Not Likely
	Pelagic Sharks	
	Blue, *Prionace glauca*	Not Likely
	Oceanic whitetip, *Carcharhinus longimanus*	**Likely**
	Porbeagle, *Lamna nasus*	**Likely**
	Shortfin mako, *Isurus oxyrinchus*	**Likely**

EFH Component	Species	Potential For Change Based On Literature Reviews
	Thresher, *Alopias vulpinus*	Not Likely
	Prohibited Sharks	
	Atlantic angel, *Squatina dumeril*	Not Likely
	Basking, *Cetorhinus maximus*	**Likely**
	Bigeye sand tiger, *Odontaspis noronhai*	Not Likely
	Bigeye sixgill, *Hexanchus nakamurai*	Not Likely
	Bigeye thresher, *Alopias superciliosus*	Not Likely
	Bignose, *Carcharhinus altimus*	Not Likely
	Caribbean reef, *Carcharhinus perezi*	**Likely**
	Caribbean sharpnose, *Rhizoprionodon porosus*	Not Likely
	Dusky, *Carcharhinus obscurus*	**Likely**
	Galapagos, *Carcharhinus galapagensis*	Not Likely
	Longfin mako, *Isurus paucus*	Not Likely
	Narrowtooth, *Carcharhinus brachyurus*	Not Likely
	Night, *Carcharhinus signatus*	Not Likely
	Sand tiger, *Carcharias taurus*	**Likely**
	Sevengill, *Heptranchias perlo*	Not Likely
	Sixgill, *Hexanchus griseus*	Not Likely
	Smalltail, *Carcharhinus porosus*	Not Likely
	Whale, *Rhincodon typus*	**Likely**
	White, *Carcharodon carcharias*	**Likely**
	Smoothhound Sharks	
	Smooth dogfish, *Mustelus canis*	Not Likely
	Florida smoothhound, *Mustelus norrisi*	Not Likely
	Gulf of Mexico smoothhound, *Mustelus sinusmexicanus*	Not Likely

EFH Component	Species	Recommendation for Change
Fishing Activities that may adversely affect EFH	All HMS	NMFS did not find any significant changes in impacts to HMS EFH from HMS fishing gears since the gear analysis was conducted for Amendment 1. NMFS analyzed interactions between shark bottom longline gear and ESA listed and non-ESA listed coral habitats. While long term negative effects could occur to coral habitats from shark bottom longline gear, the impacts are expected to be minimal due to infrequent interactions. EFH for council-managed fish species was also considered. Shark bottom longline gear was determined to not have negative effects on EFH of those species. In addition, shark bottom longline is prohibited from operating in the MPAs, HAPCs, and time/area closures that have been established by the South Atlantic Fishery Management Council, the Caribbean Fishery Management Council, and the Gulf of Mexico Fishery Management Council.
Non-fishing activities that may adversely affect EFH	All HMS	At this time, climate change is the only non-fishing impact to HMS EFH that has not been previously analyzed (see Section 13.2.3); No new non-fishing activities have been identified that have the potential to adversely affect EFH besides climate change and seismic surveys. In the future, NMFS may need to consider conducting framework analyses such as Morrison et al. (in review) or the Status Review Team's 2011 bluefin tuna review for each species to identify vulnerabilities to climate change or seismic surveys in life history or trophic dynamics for HMS.
HAPC identification	Bluefin tuna, lemon shark, sand tiger shark, sandbar shark, and billfish species	NMFS will evaluate new data to see if additional HAPCs are warranted (see Section 14.3).
Research and information needs	All HMS	NMFS recently published the Atlantic HMS Management-Based Research Needs and Priorities document, which contains a list of near- and long-term research needs and priorities for all HMS, and include priorities that would support HMS EFH designation and protection (see Section 15.1).

18 LIST OF PREPARERS

The development of this document involved input from many NMFS employees and contractors, the public, constituent groups, and the HMS Advisory Panel. Staff and contractors from the HMS Management Division, in alphabetical order, who reviewed the literature and drafted this document include:

Craig Cockrell, BS, Fish Biologist

Peter Cooper, MEM, Fishery Management Specialist

Jennifer Cudney, MS, Fish Biologist

Katie Davis, BS, Fish Biologist

Steve Durkee, MEM, Fishery Management Specialist

Sarah McLaughlin, MPM, Fishery Management Specialist

Delisse Ortiz, PhD, Fishery Management Analyst

Dianne Stephan, MS, Fishery Management Specialist

Jenni Wallace, MEM, Fishery Management Specialist

Jackie Wilson, PhD, Fishery Management Specialist

NMFS staff and contractors, in alphabetical order, who contributed literature and reviewed the document include:

Dana Bethea, MS, Research Ecologist

John Carlson, PhD, Research Fish Biologist

Tobey Curtis, PhD, Fishery Policy Analyst

Guillermo A. Diaz, PhD, Research Fishery Biologist

William Driggers III, PhD, Research Fish Biologist

Mark A. Grace, BS, Research Fish Biologist

Eric Hoffmayer, PhD, Research Fish Biologist

Cami McCandless, PhD, Research Fisheries Biologist

Eric Prince, PhD, Research Fish Biologist

Derke Snodgrass, BS, Fishery Biologist