FHWA Programmatic Essential Fish Habitat Consultation and General Concurrence for Select Transportation Actions in the NMFS Greater Atlantic Region

Prepared by:
NOAA's National Marine Fisheries Service
Greater Atlantic Regional Fisheries Office
Habitat and Ecosystem Services Division Office
55 Great Republic Drive, Gloucester, MA 01930

With and for:

Federal Highway Administration, Office of Project Development and Environmental Review

1200 New Jersey Avenue SE, Washington, DC 20590

Assisted by:

Greater Atlantic State DOT Fisheries Workgroup

Volpe, The National Transportation Systems Center, US Department of Transportation 55 Broadway, Kendall Square, Cambridge, MA 02142

January 2024

Table of Contents

<u>**List of Appendices**</u>

1.0 Programmatic Consultation Overview

In 2018, NOAA's National Marine Fisheries Service's (NMFS), Greater Atlantic Regional Fisheries Office, Habitat and Ecosystem Services Division (HESD) and the Federal Highway Administration (FHWA) developed a programmatic consultation under the Magnuson-Stevens Fishery Conservation and Management Act (MSA) and the Fish and Wildlife Coordination Act (FWCA) for certain activities for which FHWA is the lead federal agency. This programmatic consultation was part of a broader effort that included the development of the NMFS GARFO/FHWA Best Management Practices (BMP) Manual and FHWA/NMFS Consultation Process Guide for Transportation Actions in the NMFS Greater Atlantic Region. This revised programmatic consultation (2023) is intended to improve and streamline the processes developed as part of the 2018 document.

Section 305(b)(2) of the MSA requires federal action agencies such as FHWA or their designated non-federal representative, such as state Departments of Transportation (state DOTs), to consult with NMFS on any action they authorize, fund, or carry out that may adversely affect essential fish habitat (EFH). EFH is defined as, "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" while adverse effect is defined as "any impact which reduces the quality and/or quantity of EFH." An adverse effect may include direct or indirect physical, chemical or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat and other ecosystems components, and may result from actions occurring within EFH or outside EFH. They may also include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions.

NMFS also provides comments under the FWCA (16 U.S.C. 661-666(e)) to reduce environmental impacts to migratory, estuarine, and marine fish and their habitats during EFH consultation. The FWCA requires that all federal agencies consult with NMFS whenever the waters of any stream or other body of water are proposed or authorized to be impounded, diverted, the channel deepened, or the stream or other body of water otherwise controlled or modified for any purpose by any federal agency. The FWCA also requires that those federal agencies consider the effects that these projects would have on fish and wildlife, prevent the loss of and damage to fish and wildlife resources, and provide for the development and improvement of those resources.

Based on the EFH regulations at 50 CFR Subpart K, 600.920(j), programmatic consultation is an efficient and effective method for FHWA and NMFS to consult on a potentially large number of projects that FHWA routinely funds, authorizes, or carries out in the Greater Atlantic Region (GAR) which includes coastal states from Maine through Virginia. Specifically, this includes the states of Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, and the District of Columbia. Due to the routine nature of the transportation actions as described herein, and with the descriptions of the stressors and effects of transportation actions on EFH found in the NMFS GARFO/FHWA Best Management Practices (BMP) Manual, sufficient information is available to develop programmatic EFH conservation recommendations and other recommendations under the FWCA that will address reasonably foreseeable adverse impacts to EFH and NOAA trust resources. This programmatic EFH consultation was developed upon a thorough review of past and projected transportation actions to create a more efficient consultation process for certain transportation projects that FHWA funds, authorizes, or carries out through their authorities.

This programmatic EFH consultation reduces the number of project specific consultations between FHWA or its non-federal designee and HESD by issuing EFH conservation recommendations for transportation actions that may adversely affect EFH or NOAA trust resources, without detailed information on a specific project or site. Transportation activities may avoid and minimize adverse impacts to EFH both individually and cumulatively by incorporating the practices identified in the NMFS GARFO/FHWA Best Management Practices (BMP) Manual and by modifying an activity according to the EFH conservation recommendations provided. Individual EFH consultation is required for excluded activities and those activities that exceed impact thresholds as listed in Appendix A. While a project specific EFH consultation may be required for excluded activities or activities exceeding the impact thresholds of this programmatic consultation, such consultations may still qualify for an abbreviated consultation. Eligible transportation activities that incorporate all of the FHWA Minimum Conservation Measures listed in Section 6.0 below and the relevant programmatic EFH conservation recommendations included in Appendix B do not require additional coordination with HESD.

1.1 Eligible Transportation Activities

FHWA supports state and local governments in the design, construction, and maintenance of the nation's highway system. This programmatic EFH consultation applies to a subset of transportation activities that are funded or authorized by FHWA that may adversely affect EFH and/or other NOAA trust resources. FHWA administers the Federal-Aid Highway Program, Federal Lands Highway Program, and Federal Lands Access Program to maintain the integrity and safety of roads and bridges.

In accordance with the EFH Final Rule (§ 600.920 (a)(3)(C), a federal agency, such as FHWA, may designate a non-federal representative to conduct an EFH consultation by giving written notice of such designation to NMFS. If a non-federal representative is used, the federal action agency remains ultimately responsible for compliance with sections 305(b)(2) and 305(b)(4)(B) of the MSA. As a result, although this programmatic EFH consultation is with FHWA, FHWA Divisions or State DOTs may use this consultation for applicable FHWA funded or authorized activities including the National Culvert Removal, Replacement, and Restoration Grant program (Culvert AOP Program). FHWA/State DOTs may also use this consultation for eligible projects or consult with HESD on a case-by-case basis through project specific EFH consultation as outlined in the FHWA/NMFS Consultation Process Guide For Transportation Actions in the NMFS Greater Atlantic Region and the FHWA/State DOT Standard Operating Procedures outlined in Appendix C. This consultation may also be used in instances where the State DOT further delegates consultation activities to local governmental entities such as county road or public works departments. Regardless of the transportation project contracting approach, complete information on the project design in relation to effects to EFH must be available, in accordance with the NMFS/FHWA Consultation Process Guide for each of the projects using this consultation.

Actions eligible under this consultation include the following activities with certain limitations and restrictions:

- bridge repair, demolition, and replacement
- culvert repair and replacement
- slope stabilization, and
- docks, piers, and waterway access projects.

This consultation is applicable in tidally influenced waters and wetlands of the U.S. and non-tidal waters that support diadromous fish within the GAR. Projects included under this programmatic EFH consultation, individually and cumulatively will not have a substantial adverse effect on EFH, because FHWA/state DOT will implement the projects in a manner that avoids and minimizes impacts to EFH and sensitive life stages of managed species and other trust resources. Project specific consultation is required for any activity that may have a substantial adverse effect on EFH, sensitive life stages of managed species, and other trust resources. Certain activities in sensitive or highly ecologically valuable habitats may require additional project specific coordination to determine if the programmatic consultation, or a project specific abbreviated or expanded consultation is applicable.

1.2 Organization of the Programmatic Consultation

The programmatic consultation procedures described in Section 2.0 apply to all of GAR. This includes early coordination, coordination on individual projects, annual reporting and meetings, and training. Section 3 of this programmatic consultation describes the geographic scope of the consultation, identifies federally managed species, EFH, and other NOAA trust resources and important aquatic habitats within the Greater Atlantic Region, as well as information on the effects of climate change on these resources. Section 4 includes an overview of many of the transportation activities undertaken by state DOTs and included in this programmatic consultation with additional details on selected activities in Appendix G. In Section 5, the stressors and effects of the potentially eligible transportation activities is discussed with much of the information being derived from the NMFS GARFO/FHWA Best Management Practices (BMP) Manual. FHWA and the state DOTs have identified a number of minimum conservation measures that are generally accepted as standard operating procedure (SOP) in highway-related transportation activities in Section 6.

Appendix A identifies activities and thresholds of impacts to certain habitat types that require project specific consultation (ineligible activities). Stressor specific conservation recommendations can be found in Appendix B while regional and species specific time of year restrictions for certain in-water activities are listed in Appendix C. Consultation procedures, definitions, and useful resources to aid FHWA and state DOTs in identifying resources and habitats in the project area are also included as appendices.

1.3 Overlap with Federal Permitting Authorities

Individual transportation projects eligible under this programmatic consultation generally also require permits issued by other federal agencies including the USACE or the U.S. Coast Guard (USCG). FHWA is the lead federal agency for the purposes of EFH consultation with HESD on FHWA funded or authorized projects. Because all of the actions that adversely affect EFH or require coordination with HESD under the FWCA will also require authorizations from the USACE, the USCG or both agencies, it is important to recognize these existing programmatic consultations described below. This helps to ensure consistent and equal treatment of included transportation activities in which FHWA is the lead agency and those where other entities, such as the USACE, Federal Aviation Administration, Federal Railway Administration, and others are the lead federal agency. Any FHWA/state DOT action eligible for this programmatic consultation, must still also comply with all the conditions of any authorizations granted under those USACE permitting programs.

1.3.1 New England USACE Programmatic Consultation

The HESD and the USACE, New England District Regulatory Division have developed a programmatic consultation for activities that have no more than minimal individual and cumulative adverse effects on the aquatic environment, as well as coordination procedures for projects that do not meet the terms and conditions of the programmatic consultation for activities in Maine, New Hampshire, Massachusetts, Rhode Island, and Connecticut. This programmatic consultation was developed to allow for a more efficient consultation process for projects that are authorized under the USACE's Regulatory program in New England.

1.3.2 Mid-Atlantic USACE Programmatic Consultations and Permitting Mechanisms - Nationwide Permits, Regional General Permits and Statewide General Programmatic Permits

In the Mid-Atlantic states (NY, NJ, PA, DE, MD, DC, and VA), activities that have no more than minimal individual and cumulative adverse effects on the aquatic environment, including transportation projects, may be authorized by the USACE under a NWP, RGP (VA), and/or SPGPs (PA and MD).Consultations between HESD and USACE occur every five years as RGPs and SPGPs are reissued and revalidated. During the reissuance of the NWPs, each USACE District (New York, Philadelphia, Baltimore, and Norfolk) completed programmatic consultations with HESD. These programmatic consultations resulted in the addition of a number of Regional General Conditions to the NWPs, as well as the issuance of General Concurrences for a number of NWPs, RGPs and SPGPs. A General Concurrence identifies specific types of federal actions that may adversely affect EFH, but for which no further consultation is generally required because NMFS has determined, through an analysis of that type of action, that it will likely result in no more than minimal adverse effects individually and cumulatively.

1.4 FHWA/State DOT Transportation Project Oversight/Compliance

FHWA and State DOTs work closely throughout project planning, design, permitting, and construction. State DOTs and local transportation agencies are the facility owners, operators and managers of transportation infrastructure. As a result, State DOTs provide significant oversight and continuity within their individual programs. As the federal project sponsor, FHWA is directly responsible for ensuring projects adhere to environmental commitments under the National Environmental Policy Act (*see* 23 CFR § 771.133) and remains ultimately responsible for compliance with sections 305(b)(2) and 305(b)(4)(B) of the MSA. Methods to ensure environmental compliance vary, but key components are: enforceable contract language, specifications, construction oversight (inspections), monitoring, and reporting. States may use different contractual mechanisms for enforcement of environmental commitments (e.g., withholding of contractor pay, claim adjustments or formal arbitration). Stop-work orders can also be issued in real-time to correct compliance issues during construction.

DOTs should review and discuss all environmental commitments with contractors prior to construction and request clarification from NMFS if needed. During construction, consistent application of environmental commitments is ensured by DOT field operations staff who visit projects, answer contractor questions, alert resource agencies to any non-compliance issues, and negotiate corrective actions. At the program level, FHWA manages region-wide reporting, compliance, and adaptive management for this programmatic. In some cases, FHWA Divisions may provide additional construction inspections. FHWA provides resources such as training and data management, which ensures program consistency and transparency.

The ownership and long-term management of public transportation infrastructure results in the refinement and enhancement of environmentally-friendly design considerations. DOTs continually strive to improve conservation strategies and employ avoidance and minimization best practices. Eventually "tried and tested" conservation measures are incorporated into standard contract language. In this way DOT projects apply lessons learned, afford a significant amount of project oversight, and are uniquely situated to successfully and consistently implement, track and improve conservation measures to better meet habitat protection goals.

2.0 Programmatic Consultation Procedures

For a given transportation activity, FHWA/state DOTs must first determine whether EFH and/or NOAA trust resources may be present in the project area and then whether the activity may be eligible under this programmatic EFH consultation. The NOAA Fisheries EFH Mapper is a useful tool for viewing the spatial distribution of designated EFH and Habitat Areas of Particular Concern (HAPC). The full designations for each species may be viewed as PDF links provided for each species within the Mapper, or via HESD's website which includes links to Mapper, the New England Fishery Management Councils Omnibus Habitat Amendment 2 (Omnibus EFH Amendment), the Mid-Atlantic Fishery Management Councils FMPs (MAFMC - Fish Habitat), or the Highly Migratory Species Division's Atlantic HMS Fishery Management Plans and Amendments website. In addition, because summer flounder HAPC (defined as: "all native species of macroalgae, seagrasses, and freshwater and tidal macrophytes in any size bed, as well as loose aggregations, within adult and juvenile summer flounder EFH") does not have region-wide mapping, local sources and on-site surveys may be needed to identify submerged aquatic vegetation beds within the project area.

The links provided in Appendix H may also help FHWA/state DOTs to obtain general fishery resource and habitat information at a project site, as well as information on other NOAA trust resources that may be present including diadromous fishes, shellfish and other assorted fish and invertebrates. NOAA jointly manages a number of these species through Interstate Fisheries Management Plans with the Atlantic States Marine Fisheries Commission. A list of Commission species and plans can be found on their website at http://www.asmfc.org.

2.1 Early Coordination

Early coordination is strongly encouraged especially for activities where eligibility for the programmatic consultation is uncertain or if minor project modifications or alternatives to the programmatic EFH conservation recommendation may result in improved habitat protection. FHWA/state DOTs should contact the appropriate regional biologist by email or telephone to initiate early coordination or assistance with understanding whether your project is included for programmatic coverage. (see list of HESD staff points of contact available on our EFH consultation website).

2.2 Coordination under the Programmatic Consultation

Coordination procedures for the programmatic consultation are outlined in Appendix D - FHWA/State DOT Standard Operating Procedures. For those projects that are eligible for this programmatic consultation (i.e., impacts are below the thresholds in Appendix A, incorporate all FHWA's minimum conservation measures outlined in Section 6), additional project specific coordination is not required and verification forms are not needed. This includes projects that do not incorporate all of the relevant programmatic EFH conservation recommendations listed in Appendix B. For these projects, verification forms are not needed and will not be reviewed or signed by HESD staff. For those that do not incorporate all of the programmatic EFH conservation recommendations, information on the project and the rationale for not including the conservation recommendations should be provided in the annual report. All projects must be tracked by FHWA/state DOTs and included in the Annual Report as described in Section 2.5.

2.3 Project specific EFH Consultation for ineligible activities

Project specific EFH consultation may be required for those activities that:

- Exceed impact thresholds listed in Appendix A
- Do not include all the applicable FHWA Minimum Conservation Measures (Section 6.0)
- Are specifically excluded from the programmatic consultation due to project type/activity.

FHWA/state DOT will email the EFH consultation request to HESD's New England or Mid-Atlantic Branch Chief and the regional biologist listed on the Contact Regional Office Staff section on the HESD EFH consultation website and as described in the project specific consultation process in the SOPs (Appendix D). Additional details on the EFH consultation process, frequently asked questions and an EFH worksheet are available on our website. Project specific EFH consultations may be abbreviated consultations using the EFH worksheet, or may require an expanded EFH consultation requiring a more detailed EFH assessment. The EFH worksheet is designed for abbreviated EFH consultations only where impacts to EFH are not expected to be substantial. It should not be used for large, complex actions that may have substantial adverse impacts to EFH.

2.4 Compensatory Mitigation

Compensatory mitigation may be necessary to offset the adverse impacts of transportation activities eligible for this programmatic consultation, as well as those that require project specific coordination through either an abbreviated or expanded EFH consultation. Compensatory mitigation is a method of offsetting adverse impacts by replacing or providing equivalent substitute resources or environments through the restoration, establishment, enhancement, or preservation of resources with commensurate services and functions. The purpose of compensatory mitigation is to offset unavoidable adverse impacts that remain after all appropriate and practicable avoidance, and minimization has been achieved. It is the final element of the mitigation sequence outlined in the Council on Environmental Quality (CEQ) National Environmental Policy Act (NEPA) regulations (40 CFR 1508.1(s)), the Clean Water Act 404 (b)(1) Guidelines, and NOAA's Mitigation Policy for Trust Resources. Because FHWA/state DOT will implement the projects under this programmatic EFH consultation in a manner that avoids and minimizes impacts to EFH and sensitive life stages of managed species and other trust resources, included projects will not individually or cumulatively have a substantial adverse effect on EFH. However, they may still result in some unavoidable adverse effects that may warrant compensatory mitigation to offset the loss of aquatic habitat functions.

Because compensatory mitigation is intended to offset adverse effects of an action, it cannot be viewed separately from an action causing the effect. For project specific consultations, FHWA/State DOTs should provide HESD with information on both the transportation activity causing the adverse effect and the proposed compensatory mitigation at the same time. Compensatory mitigation plans should be developed in accordance with the 2008 Final Rule for Compensatory Mitigation for Losses of Aquatic Resources and NOAA's Mitigation Policy.

2.5 Annual Reporting

FHWA will provide an annual region-wide report of the activities funded, authorized, and/or carried out under this programmatic EFH consultation for the purpose of determining the effectiveness of the programmatic EFH consultation and calculating cumulative effects. This also enables tracking of transportation activities and adaptive management techniques. As an appendix to the annual report, FHWA will include a project information sheet for each project covered by this programmatic consultation that **did not** incorporate all of the applicable programmatic EFH conservation recommendations. Information required includes the applicable programmatic EFH conservation recommendations, which of these recommendations were not followed, and the reason why they were not followed. This requirement is consistent with Section 305(b)(4)(B) of the MSA, which requires federal agencies to explain their reasons for not following the EFH conservation recommendations issued.

FHWA will provide the compiled information to HESD no later than October 1 following each calendar year that the programmatic EFH consultation is in effect. If the annual report indicates that adaptive measures are necessary, they will be explored during the annual meeting described below.

FHWA will send an electronic copy of the Annual Report and description of results to:

NOAA's National Marine Fisheries Service
Greater Atlantic Regional Fisheries Office
Habitat and Ecosystem Services Division
55 Great Republic Drive
Gloucester, MA 01930

Attn: Lou Chiarella, Assistant Regional Administrator
lou.chiarella@noaa.gov

2.6 Annual Meeting

Following the submission of the annual report, FHWA and HESD will meet either in-person or via conference call or virtual meeting. FHWA and HESD may subsequently agree to meet less often if both agencies agree that the programmatic consultation is functioning as intended and if less frequent meetings will not undermine the goals of the programmatic EFH consultation. FHWA may invite Divisions and state DOTs to participate in the annual meeting. At the meeting, FHWA and NMFS will:

- discuss the annual tracking of covered projects;
- evaluate and discuss the continued effectiveness of the programmatic EFH consultation;
- account for any new information or technology;
- ensure that activities authorized by the programmatic consultation continue to minimize adverse effects to EFH; and/or
- evaluate the procedures and conservation recommendations, and update as necessary.

2.7 Revision

FHWA and HESD will discuss the need for revisions at the annual meetings, as noted above. Revisions may be needed to account for new information or technology or to better streamline the coordination process. HESD may revise this document at any time by agreement of both agencies. Conflicts that cannot be resolved at the State program level should be elevated for discussion between FHWA HEPE and HESD via a dispute resolution process. If a resolution cannot be reached, HESD or FHWA may revoke this programmatic EFH consultation.

2.8 Supplemental Consultation

Pursuant to 50 CFR 600.920(l), FHWA must reinitiate EFH consultation with HESD if a proposed action is substantially revised in a manner that may adversely affect EFH, if new information becomes available that affects the basis for NMFS' EFH conservation recommendations, or if the activity is no longer covered by this programmatic EFH consultation. In addition, if HESD receives new or additional information that may affect the programmatic EFH conservation recommendations, HESD may request additional consultation and/or provide additional EFH conservation recommendations.

2.9 Statutory Response Requirement

Section 305(b)(4)(B) of the MSA requires FHWA to provide a written response to this programmatic EFH consultation within 30 calendar days of receipt. FHWA must respond to HESD in writing before this programmatic EFH consultation can take effect. The response must indicate FHWA's acceptance of the conservation recommendations to avoid, minimize, or offset the impacts from covered transportation projects on EFH. The continued use of the programmatic EFH consultation is contingent on acceptance of the subsequent required annual reports by HESD.

2.10 Training

As requested by FHWA, HESD will provide training to FHWA/state DOT staff on the application of these procedures and implementation of this programmatic EFH consultation. Training will be made available to staff through workshops, web-based training, or other appropriate forums. HESD welcomes FHWA training on project process, design, and construction.

3.0 Geographic Scope and EFH

The geographic scope of this programmatic consultation includes all tidal waters and non-tidal waters that support diadromous fish, within the jurisdiction of HESD. Specifically, this includes coastal and riverine areas within and offshore of the states of Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, and the District of Columbia. The New England and Mid-Atlantic Fishery Management Councils, and NOAA Fisheries (for highly migratory species) designate EFH for multiple federally managed fish and shellfish species in marine, estuarine, and riverine waters of the GAR. This programmatic EFH consultation applies to transportation activities occurring in areas identified as EFH for various life stages of fish species managed by the Councils and NOAA Fisheries.

3.1 EFH Habitat Descriptions

EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of EFH:

- "waters" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate;
- "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities;
- "necessary" means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and
- "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle.

EFH includes pelagic water column habitat as well as benthic bottom habitats such as sand, mud, gravel, cobble, hard bottom, submerged aquatic vegetation (SAV), and areas containing shellfish. Structurally complex habitats, rocky habitats, and areas containing shellfish are productive areas, which provide shelter and forage for many of the managed species. In addition, special aquatic sites (SAS) are areas that are afforded additional protection due to their significant contribution to the environment under the Section 404(b)(1) guidelines of the Clean Water Act. They are defined at 40 CFR 230.3 and listed in 40 CFR 230 Subpart E. SAS include fish and wildlife sanctuaries and refuges, wetlands, mudflats, vegetated shallows (which includes SAV beds), and riffles and pool complexes. A description of the affected habitats is provided in Appendix F.

The NOAA Fisheries EFH Mapper provides the spatial distribution of designated EFH and Habitat Areas of Particular Concern (HAPC). The full designations for each species may be viewed as PDF links provided for each species within the Mapper, or via HESD's website links to the New England Fishery Management Councils Omnibus Habitat Amendment 2 (Omnibus EFH Amendment), the Mid-Atlantic Fishery Management Councils FMPs (MAFMC - Fish Habitat), the South Atlantic Fishery Management Council's Final Essential Fish Habitat Plan, or the Highly Migratory Species Division's Atlantic HMS Fishery Management Plans and Amendments website. The descriptions of EFH in the fishery management plans takes precedence over any information on our website and the EFH mapper.

In the GAR, EFH is designated for the following species:

> Acadian redfish, American plaice, Atlantic cod, Atlantic halibut, Atlantic herring, Atlantic mackerel, Atlantic salmon, Atlantic sea scallop, Atlantic wolffish, black sea bass, bluefish, blueline tilefish, butterfish, chub mackerel, golden tilefish, haddock, king mackerel, longfin squid, monkfish, ocean pout, ocean quahog, offshore hake, pollock, red hake, scup, shortfin squid, skates (barndoor, clearnose, little, rosette, smooth, thorny, winter), Spanish mackerel, spiny dogfish, summer flounder, surf clam, white hake, whiting (silver hake), windowpane flounder, winter flounder, witch flounder, and yellowtail flounder.

EFH is also designated for the following highly migratory species and billfish in the GAR:

> Albacore tuna, Atlantic angel shark, Atlantic bigeye tuna, Atlantic bluefin tuna, Atlantic sharpnose, Atlantic skipjack tuna, Atlantic swordfish, Atlantic yellowfin tuna, basking shark, bigeye thresher shark, blue marlin, blue shark, common thresher shark, dusky shark, longbill spearfish, longfin mako shark, porbeagle shark, roundscale spearfish, sand tiger shark, sandbar shark, scalloped hammerhead shark, shortfin mako shark, silky shark, smoothhound shark, tiger shark, white marlin, and white shark.

3.2 Habitat Areas of Particular Concern (HAPC)

HAPCs are subsets of EFH identified based on one or more of the following considerations: 1) the importance of the ecological function; 2) extent to which the habitat is sensitive to human-induced degradation; 3) whether and to what extent, development activities are stressing the habitat type; and/or 4) rarity of habitat type (50 CFR 600.815(a)(8)). In GAR, the following HAPCs have been designated:

1. Juvenile Atlantic cod:

- an area on Georges Bank of approximately 300 square nautical miles along the northern edge of Georges Bank and the Hague Line containing grave cobble substrate
- inshore areas of the Gulf of Maine and Southern New England between 0-20 meters (relative to mean high water). Structurally-complex habitats, including eelgrass, mixed sand and gravel, and rocky habitats (gravel pavements, cobble, and boulder) with and without attached macroalgae and emergent epifauna, are essential habitats for juvenile cod;

2. Adult Atlantic salmon: 11 rivers in Maine (Dennys, Machias, East Machias, Pleasant, Narraguagus, Ducktrap, Kennebec, Penobscot, St. Croix, Tunk Stream, and Sheepscot);
3. Summer flounder: all native species of macroalgae, seagrasses, and freshwater and tidal macrophytes in any size bed, as well as loose aggregations within adult and juvenile summer flounder EFH;
4. Sandbar shark: areas at the mouth of Great Bay, NJ, in Delaware Bay, and lower Chesapeake Bay;
5. Sand tiger shark: lower portions of Delaware Bay and the entire Plymouth-Duxbury-Kingston bay system in coastal Massachusetts;
6. Canyon and Seamount HAPCs in federal waters of the Atlantic Ocean; and
7. Southern New England Habitat HAPC

3.3 Other NOAA Trust Resources

Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (FWCA) requires that all federal agencies consult with NMFS when proposed actions might result in modifications to a natural stream or body of water. It also requires that they consider the effects that these projects would have on fish and wildlife and must also provide for improvement of these resources. Under this authority, NMFS works to protect, conserve and enhance species and habitats for a wide range of aquatic resources such as shellfish, diadromous species, and other commercially and recreationally valuable species that are not managed by the federal fishery management councils and do not have designated EFH.

Under the FWCA, NMFS' authority extends to numerous other aquatic resources in the GAR, including, but not limited to, the following species and their habitats:

> American lobster, striped bass, American shad, alewife and blueback herring (collectively known as river herring), Atlantic menhaden, Atlantic silversides, Eastern oyster, American eel, sea lamprey, rainbow smelt, quahog/hard clam, soft clam, blue mussel, horseshoe crab, tautog, weakfish, and other assorted fish and invertebrates.

Under the FWCA, HESD works to conserve and enhance a wide variety of species with at least one marine/estuarine life stage including diadromous fishes and a trust resources with at least one marine/estuarine life stage, as well as a wide range of estuarine species that managed by the Atlantic States Marine Fisheries Commission (Commission) through Interstate Fishery

Management Plans. NOAA also jointly manages a number of these species with the Commission. A list of Commission species and plans can be found on their website at http://www.asmfc.org.

3.4 Climate Change Effects

Climate change is impacting the function and distribution of species and habitats used by marine, coastal, and diadromous species worldwide and in the northeast region (Howard et al. 2013; IPCC 2014; Nelson et al. 2013; Pershing et al. 2018). A habitat climate vulnerability assessment in the northeast region found over half of the habitats examined are expected to be impacted negatively by climate change over the 21st century (Farr et al. 2021). These impacts often exacerbate other anthropogenic stressors that species and habitats face (USFWS and NOAA 2012; Staudt et al. 2013; Smith et al. 2017; Farr et al. 2021). Climate change is shifting thermal habitat poleward and into deeper water, resulting in concomitant changes in species distributions, and in some cases contraction of habitats and species populations (Hare et al. 2010; Hare et al. 2012; Kleisner et al. 2017; Morley et al. 2018; Allyn et al. 2020).

Global sea levels are rising due to warming oceans (thermal expansion) and land ice and snow melting (Church et al. 2013; Church et al. 2008). Kopp et al. (2016) reported a significant acceleration of global sea level rise (SLR) beginning in the 19th century and yielded a 20th century rate of SLR that is extremely likely to be greater than during any of the previous 2,800 years. The mean rate of SLR along the northeast coast has accelerated during the 20th century to approximately 3.1 mm per year (Kunkel et al. 2013), which exceeds the global average of approximately 1.7 mm per year (Church et al. 2013). By 2050, the projected SLR for the northeast coast ranges between 0.4 and 0.5 m, but increases to between 0.6 and 2.1 m by 2100 (Sweet et al. 2022). These end-of-century projections imply an annual rate of SLR for the northeast coast of between 6.3 mm per year and 22.1 mm per year.

Over the past century, coastal wetlands have been affected by SLR and erosion, contributing to a cumulative loss of habitat (Nicholls et al. 1999; Gedan et al. 2011; Kirwan and Mudd 2012; Watson et al. 2017). Because carbon sequestered in the soils of coastal wetlands can be stored for centuries to thousands of years, the loss of coastal wetlands will have significant implications for mitigating greenhouse gas emissions. Stored carbon often is released to the atmosphere when wetlands are destroyed or converted to a different habitat type (Chmura et al. 2003; Duarte and Cebrián 1996; Pendleton et al. 2012), or through increased decomposition due to higher temperature (Kirwan and Blum 2011; Kirwan and Mudd 2012).

Calcifying marine organisms, including mollusks, echinoderms, and corals, are particularly sensitive to changes in pH, carbonate ion concentration, and the saturation state of calcium carbonate minerals – collectively known as ocean acidification. Warming waters in rivers, estuaries, and the ocean, in concert with ocean acidification, water column stratification, deoxygenation, and SLR can interact with one another and with other stressors to cause complex and often unanticipated synergistic climate effects to species and habitats (Kirwan and Blum 2011; Waldbusser et al. 2011; Gobler et al. 2014; Pershing et al. 2018).

Extreme precipitation events over the past few decades are occurring more frequently and of greater intensity than long-term averages would predict. Between 1958 and 2012, the northeast region saw more than a 70% increase in the amount of precipitation falling as very heavy events (defined as the heaviest 1% of all daily events) (Horton et al. 2014). In addition, nor'easters in the northeast region have increased in intensity and their tracks have shifted northward (Vose et al. 2014; Wang et al. 2012).

These events are projected to occur more frequently in the future. The Fourth National Climate Assessment projects more extreme precipitation events in the Northeast U.S. and parts of New England with corresponding higher air temperature (Easterling et al. 2017). For example, under the high emissions scenario (RCP8.5) the number of extreme precipitation events (defined as events exceeding a 5-year return period) increases by two to three times the historical average in every region by the end of the 21st century, with the largest increases in the Northeast. In an assessment of four unregulated rivers in Maine, Hodgkins and Dudley (2013) reported increases in maximum peak river flows based on projected higher temperature and precipitation rates by the end of the century. More extreme precipitation and stream flows will affect the performance of culverts, bridges, and roads, and can have adverse effects on NOAA trust resources, including fish and invertebrate species, emergent wetlands, and other aquatic habitats that are already under multiple climate and non-climate threats. FHWA should consider these impacts within the EFH consultation process.

4.0 Transportation Actions and Activities

Transportation projects typically center on building and maintaining roads, bridges, and drainage culverts as well as occasional docks, piers, and other structures associated with waterway access. Associated activities may include establishing equipment and material staging areas, the installation of causeway fill, platforms and trestles to provide temporary access to a project area, cofferdam installation and dewatering, geologic sampling of substrata bearing capacity, site exploration using scientific devices, clearing and grubbing, grading, installing turbidity/sediment and erosion control measures, stormwater management, and outfall scour repair. The descriptions below are adapted from the NMFS GARFO/FHWA Best Management Practices (BMP) Manual.

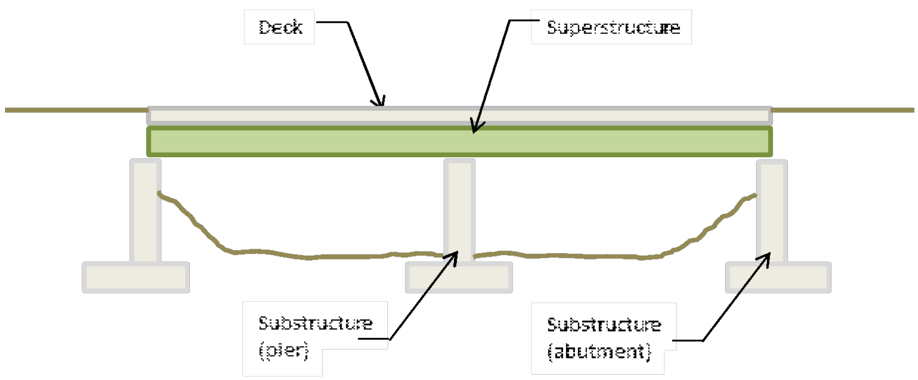
A more detailed description of select transportation activities as provided by FHWA and the state DOTs is contained in Appendix H. The programmatic EFH conservation recommendations in Appendix B contain descriptors and thresholds for the specific actions under the programmatic EFH consultation.

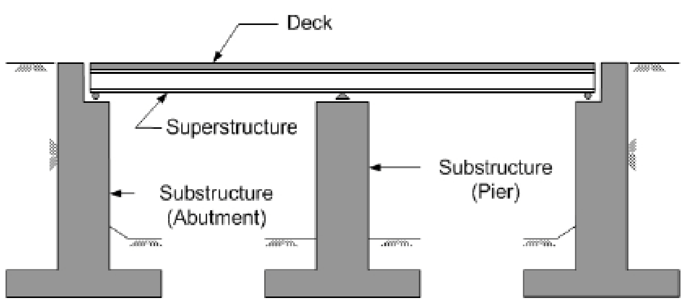
4.1 Transportation Actions

4.1.1 Bridge/Structure Repair, Maintenance, Demolition, and Replacement

Bridges may cross rivers, streams, or other water bodies as well as other transportation infrastructure. Bridge work may include structural repairs; pile driving and removal; fender replacement; demolition; excavation for and installation of bridge abutments; temporary fills; riprap placement; constructing bridge columns; constructing stormwater facilities; approach widening; paving with asphalt concrete; and complete replacement. Bridge construction may be a component of larger roadway construction or a standalone project. Bridge replacements tend to be long-term projects requiring one or more years to complete. Installation of replacement bridges may require construction of a temporary or detour bridge. The size of the stream crossed influences the construction means and methods used. For example, cofferdams that are used for abutment construction in streams that are >20 feet wide are often constructed around the abutments and not across the entire stream. Because of this, bypass systems such as pumps and diversion channels are not required. The construction of new bridges may be included in this consultation depending upon the amount and type of the habitats affected. Replacement bridges are generally eligible to use this consultation when meeting the thresholds listed in Appendix A, the FHWA Minimum Conservation Measures identified in Section 6.0 are implemented, and when the existing bridge will be removed as part of the proposed action

Figure 1. Bridge Structures





Credit: FHWA

Bridge maintenance activities may include but are not limited to riprap placement, structural repairs (e.g., beam ends on superstructures), temporary fills, maintenance of stormwater structures, approach widening, repointing joints, end wall and wing wall repair. In some instances, these activities may not involve any in-water work, or the in-water components may not result in any increases in underwater noise or turbidity.

Causeways are roads or railway routes across a broad body of water or wetland raised up on an embankment. Some causeways may only be usable at low tide and the distinction between causeways and bridges can become blurred when culverts are incorporated in the structure; a causeway is primarily supported on earth or stone, whereas a bridge is mainly supported by freestanding columns or arches.

Bridge repair, maintenance and replacement can be deconstructed into the following sub-activities: cofferdams/ dewatering, demolition, pile driving/removal, dredging/excavation, fill/ stabilization, vessel activities, habitat restoration, scientific measurement devices/survey activities, and staging area establishment. These activities may have both temporary and permanent adverse effects on EFH and other aquatic resources and habitats, but there may also be some long-term benefits if the activity results in improved habitat for aquatic resources.

Potential stressors produced by bridge repair, demolition, and replacement include underwater noise, impingement/entrainment, water quality/turbidity, habitat alteration, and vessel traffic. Potential habitat benefits associated with bridge replacement can include water quality improvements from creosote piling removal, improved tidal exchange from larger hydraulic openings, reduced channel fill resulting in more available habitat, and measures that increase long term stability resulting in less long term erosion issues.

4.1.2 Culvert Repair, Sliplining, and Replacement

Culverts are used to convey rivers, streams, and other water bodies under roadways or other fill. Conventional culverts may be made of concrete, corrugated metal, timber, and PVC piping. For the purposes of this programmatic EFH consultation, any culvert-like structure is considered to be a culvert and not a bridge, regardless of the length or size of the structure. This is due to the difference in installation methods and potential stressors. Culvert installation may occur independently or as part of a larger transportation improvement project. Work on culverts may involve vegetation and sediment removal, access roads for construction (temporary and removed after the completion of construction or and left in-place for future maintenance access), pavement and roadbed removal, culvert extraction, placing new culverts or outflow pipes, backfilling and patching the pavement, installing armoring and headwalls, planting/re-vegetating, and dewatering the work area and establishing a flow bypass prior to initiating work. The installation of new culverts in locations where one did not previously exist is not included in this consultation.

Culvert maintenance and repair activities may include but are not limited to riprap placement, structural repairs, temporary fills, headwall repair, and maintenance of stormwater structures. These activities typically have a minor footprint (less than 1000 square feet) and based on site conditions may be completed in short timeframes. The repairs to concrete and other structural elements that are below the water line may be completed behind a cofferdam or other BMPs such as seasonal work restriction may be used.

Culverts are sometimes rehabilitated with a method called “sliplining” and invert lining. This technique involves placement of a smaller diameter culvert or pouring a new concrete invert within the larger diameter failing culvert. The new sliplined culvert is subsequently stabilized with grout between the old and new structure. Invert lining includes placing concrete and rebar along the invert of the culvert. Sliplining is included in this consultation under certain limited circumstances as described in Appendix A.

Culvert replacement involves the complete removal and installation of the culvert structure. Once flow is diverted and the work area is dewatered, culvert removal and installation can commence. Culvert replacements are typically short-term projects that require less than a season to complete. The repair, rehabilitation, or replacement of culverts is also an opportunity to consider modifications or other options to improve fish passage. In 2007, FHWA issued Design For Fish Passage At Roadway-stream Crossings: Synthesis Report to provide guidance on culvert design to facilitate fish passage.

Work under this activity can be deconstructed into the following sub-activities: cofferdams/ dewatering, demolition, excavation, fill/stabilization, habitat restoration, scientific measurement devices/survey activities, and staging area establishment. Potential stressors include impingement/entrainment and entanglement, water quality/turbidity, habitat alteration, and negative impacts to migratory fish passage.

4.1.3 Docks, Piers, and Waterway Access Projects

Docks, piers, and waterway access projects may be associated with boardwalks, bicycle/ pedestrian paths or bridges, other docks and piers, boat ramps, overlooks, viewpoints, and/or historical markers. These activities may include at-grade or elevated trails including boardwalks (piles with decking), fill/ stabilization, and excavation. Decking may be made of plastic, timber, or steel. Docks, piers, and waterway access projects may be associated with other transportation projects or be an independent action. They can be standalone structures or incorporated into existing or replacement crossings. Projects advanced by DOTs may also include repairs to existing, serviceable docks, piers, moorings, or ferry terminals. These activities are included in this consultation provided they meet the thresholds listed in Appendix A and the FHWA Minimum Conservation Measures identified in Section 6.0 are implemented.

Work under this activity can be deconstructed into the following sub-activities: cofferdams/ dewatering, demolition, pile driving/removal, excavation, fill/stabilization, vessel activities, habitat restoration, scientific measurement devices/survey activities, and staging area establishment. Potential stressors include underwater noise, water quality/turbidity, habitat alteration, and vessel traffic.

4.1.4 Slope Stabilization

Slope stabilization is the protection of embankments at bridges, culverts, and roadways from erosive forces of flowing water. Stabilization techniques include placing or resetting riprap, abutment caps, bulkheads, scour countermeasures, concrete mattresses, or other structures to protect and restore eroded slopes or to protect slopes that are vulnerable to erosion. Non-structural shoreline stabilization measures that do not use hard components such as the placement of sand fill, coir logs, and/or native shell may also be incorporated. Stabilization structures can be installed from land, temporary structures, or water via shallow-draft barges.

Work under this activity can be deconstructed into the following sub-activities: cofferdams/ dewatering, pile driving/removal, excavation, fill/stabilization, vessel activities, habitat restoration, scientific measurement devices/survey activities, and staging area establishment. Potential stressors include water quality/turbidity and habitat alteration.

4.2 Activities Associated with Transportation Actions

The following are the specific activities generally associated with the Transportation Actions identified in 4.1 above. These activities have the potential to impact NMFS trust resources and habitats and result in the stressors and effects highlighted in section 5.0 below

4.2.1 Cofferdams/Dewatering

Cofferdams are often installed to create isolated work areas that can be dewatered for construction to allow work to be done in-the-dry. Cofferdams are also used to create diversion channels to divert water around an area. Cofferdams may consist of sandbags, causeways/earthen structures, and/or large casings or structures created out of sheet piles. They may be installed with hammers, by crane and excavator, or placed by hand, depending on size. Cofferdams are typically used temporarily during construction but are sometimes cut below the mudline and left in place as a permanent structure.

The potential stressors associated with cofferdams and dewatering include underwater noise, impingement/entrainment, water quality/turbidity, habitat alteration, and vessel traffic.

4.2.2 Demolition

Transportation projects may involve mechanical dismantling of structures from an adjacent structure or barge, or via land or through blasting. Structural components may be removed using a variety of methods such as cutting/sawing, blasting/chemical expansion (bentonite), hydraulic drilling, excavating, or by using a hoe ram, wrecking ball, clamshell dredge, or splitting wedges and hydraulic impact hammer. Demolition debris is typically mechanically removed and demolished structures are typically barged or trucked off site for disposal. Explosive demolition is excluded from the programmatic EFH consultation. The potential stressors associated with demolition include underwater noise, water quality/turbidity, habitat alteration, and vessel traffic.

4.2.3 Pile Driving/Removal

Piles support piers and abutments, provide temporary support during construction, serve as fenders and dolphins to protect structures, support navigation markers, and may support cofferdams, breakwaters, and bulkheads. They can be made of steel, concrete, wood, or plastic, and may be in the form of single piles or sheets. Piles can be driven into the substrate by impact or vibratory hammers, water jetting, or drilled/augured in by drilled shafts or rock sockets and may be removed by vibratory hammer, direct pull, clamshell bucket grab, cutting/breaking below the mudline, or mechanical demolition. Potential stressors produced by pile driving and removal include: underwater noise, water quality/turbidity, habitat alteration, and vessel traffic.

4.2.4 Minor Dredging, Excavation, and Debris Removal

Dredging and excavation are the two most common means of removing sediment or other materials from a water body, either while it is submerged (dredging) or after water has been diverted or drained (excavation). Dredging is typically done with hydraulic or mechanical equipment to remove naturally accreting sediment, deepen or widen a waterway, or to return an area to pre-construction conditions. Dredging or excavation may be associated with the installation of sub-structures, placement of erosion and scour control measures or utility lines or cables, or to remove debris. Excavation is often necessary to key in stabilization materials. Minor underwater dredging/excavation often employs mechanical equipment to assist DOTs with the installation of bridge foundations, removal of old foundations, culvert embedment, proper keying in of rip rap stabilization projects in uplands or during low tide in intertidal areas, or in areas behind sealed and dewater cofferdams, and installation of submarine cables.

Dredging, and in some cases excavation, can result in the loss of benthic communities, the entrainment of aquatic organisms in the dredge plant, changes in bottom sediment types and water depths such that the habitat characteristics of a site may be altered, increased is in suspended sediment in the water column and decreases in water quality. While most of these effects are temporary (increases in suspended sediment, water quality degradation), others may take longer for recovery to occur (benthic communities) and some may be long-lasting or permanent (depths) unless restored post-construction. Potential stressors produced by dredging /excavation include impingement/entrainment water quality/turbidity, habitat alteration, and vessel traffic.

4.2.5 Fill/Stabilization

Fill and grading may be required prior to stabilization. Construction of temporary access fills and roads may be required to provide a working platform or access for machinery. Scour repair measures including fill and stabilization structures may be necessary. Fill may also be associated with disposal of excavated or dredged material. Potential stressors associated with this sub-activity include water quality/turbidity and habitat alteration.

4.2.6 Vessel Activities

Construction and maintenance of transportation projects can increase vessel traffic. Equipment access may be from barges, depending on site characteristics. An increase in vessel traffic is usually temporary, ceasing when the construction is complete; however, in some cases, dredging is needed to allow vessels to access to an area that was previously inaccessible, existing water depths result in grounding of a vessel at low tides, or vessels traverse or moor in sensitive habitats such as SAV beds, shellfish or rocky bottom. The potential stressors associated with vessel traffic include water quality/turbidity and habitat alteration.

4.2.7 Habitat Restoration, Establishment, and Enhancement

Habitat restoration, establishment, or enhancement can restore areas impacted temporarily during the construction of a project, or be used as compensatory mitigation or to create mitigation banks. This may include excavation, fill, planting, invasive plant removal, channel reconstruction, shell placement, and living shorelines. Habitat restoration may also include demolition of abandoned or obsolete structures, debris removal, and/or sediment remediation.

While the overall goal of restoration, establishment, and enhancement is to improve the overall ecological conditions of a site, or offset adverse effects to ecological functions as the result of another action, adverse effects may occur during the construction. Potential stressors produced by restoration, establishment, and enhancement include water quality/turbidity, habitat alteration, and vessel traffic.

4.2.8 Scientific Measurement Devices/Survey Activities

The use of scientific measurement devices or survey activities may be necessary to collect data at a project site in advance of project design or construction or as a part of required monitoring. Such devices or survey activities may include staff or current gages, water recording and biological observation devices, soil borings, core sampling, historic resource surveys, and side scan sonar. Potential stressors produced include water quality/turbidity, habitat alteration, and vessel traffic.

4.2.9 Submarine Cable Installation

Submarine cables can be installed using a variety of methods depending upon a number of factors including the type of cable, the substrate, and length traversed. The methods include trenching, plowing, jetting and directional boring. Directional Boring/Horizontal Directional Drilling (HDD) can be used to cross any number of surface obstacles including roadways, railroads, wetlands, and water bodies of varying sizes/depths. Potential stressors produced include impingement/entrainment, water quality/turbidity, habitat alteration, and vessel traffic depending upon the method of construction.

4.2.10 Staging Area Establishment

Transportation activities may require the need for staging areas. Staging areas facilitate the delivery and storage of construction materials and equipment, contractor office and storage trailers, and parking. Staging areas vary in size and may require vegetation clearing, grubbing, grading, or excavation to level the site, and installation of drainage improvements. Potential stressors associated with the establishment of staging areas include water quality/turbidity, habitat alteration, and vessel traffic.

5.0 Stressors and Effects

The stressors produced by transportation activities may affect EFH and other NOAA-trust resources in a variety of ways including impeding migration, altering or degrading habitat, or by causing direct mortality. An adverse effect on EFH is any impact that reduces the quality and/or quantity of EFH and may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components. Adverse effects to EFH may result from actions occurring within EFH or outside of EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions. These effects can result from underwater noise/hydroacoustic energy, water quality changes (turbidity, sedimentation,) impingement and entrainment, and the alteration of habitat due to filling, dredging or other activities. Although all of the stressors presented here are also considered habitat alteration, the stressors were sectioned out to best reflect the mechanism leading to the effect. A more detailed discussion of stressors and effects is included in the NMFS GARFO/FHWA Best Management Practices (BMP) Manual.

5.1 Underwater Noise/Hydroacoustic Energy

Transportation activities involving in-water work may produce underwater noise and acoustic impacts. The duration of acoustic impacts is typically limited to the construction phases. Demolition may introduce significant acoustic impacts to the aquatic environment. Blasting represents a single point of disturbance with a restricted, and often predictable, mortality zone. Blast energy is generally focused towards fracturing rock substrate, preventing excess energy from releasing into the water column (Keevin et al. 1999).

Unlike blasting, pile driving and mechanical demolition create repeating sound disturbances that can last for extended periods of time. Factors that affect the type and intensity of sound pressure waves include the size and type of pile or material, firmness of the substrate, and the type of equipment/hammer used (Hanson et al. 2003; Johnson et al. 2008). Wood and concrete piles produce lower sound pressures than do steel piles. Pile driving in firmer substrates requires more energy and produces more intense sound pressures (Hanson et al. 2003; Johnson et al. 2008). As the distance from the source increases, underwater sound levels dissipate rapidly.

Dredging and disposal can produce continuous noise impacts for extended periods of time (Nightingale and Simenstad 2001b). The acoustic frequencies and sound attenuation depend on the type of equipment used, the depth and thermal variations in the surrounding water, bathymetry, and sediment composition (Nightingale and Simenstad 2001b; Stocker 2002). Mechanical and hydraulic dredges produce underwater sounds that are strongest at low frequencies and because of rapid attenuation of low frequencies in shallow water, dredge noise normally is undetectable underwater at ranges beyond 20 to 25 kilometers (Richardson et al. 1995). Although the noise levels from large vessels may exceed those from dredging, single vessels usually do not produce strong noise in one area for a prolonged period of time (Richardson et al. 1995).

5.1.1 Effects

In addition to physiological effects, underwater noise can interrupt migrating, foraging, overwintering/ sheltering, or spawning by managed species and other NOAA trust resources and/or forage species such as diadromous fish. This can temporarily cause aquatic organisms to avoid an area that would normally serve as foraging, spawning, nursery, or refuge habitat. Interruption of basic biological life stages could have cascading effects by reducing population levels or viability.

Fish detect and respond to sounds for many life history requirements, including locating prey, avoiding predation, spawning, and various social interactions (Myrberg 1972; Myrberg and Riggio 1985; Kalmijn 1988). Noise can cause fish to disperse from the acoustic source and may disrupt their feeding patterns (Marten et al. 2001). Underwater blasting and noise may alter fish distribution and behavior (Feist et al. 1996). Managed fish with air cavities are generally more susceptible to underwater blasts than those without (Keevin et al. 1999); smaller fish are more likely to be impacted by the shock wave of underwater blasts than are larger fish, and the eggs and embryos tend to be particularly sensitive. Fish larvae tend to be less sensitive to blasts than eggs or post-larvae fish, likely because the larvae do not yet possess air bladders (Wright 1982;

Keevin et al. 1999; Johnson et al. 2008); however, acoustic impact studies on larval fish are limited.

The behavioral response elicited by fish differs depending on the range of sound frequencies present within the water column. Fish respond to lower frequency sounds by displaying an avoidance response and not habituating to the sound despite repeated exposure (Dolat 1997; Knudsen et al. 1997; Sand et al. 2000). Fish may be initially startled by higher frequency sounds but eventually become habituated and no longer respond to the stimuli. Acclimation to the sound may place fish in more danger as they remain in range of potentially harmful sound pressure waves (Dolat 1997; Johnson et al. 2008). Temporary or permanent hearing loss may also result from loud underwater sounds, which can lead to reduced fitness and may increase vulnerability to predators. It can also result in reduced success in locating prey, an inability to communicate, or an inability to sense their physical environment (Illingworth and Rodkin, Inc. and Jones and Stokes 2009). Acoustic impacts also negatively affect the distribution of forage fish.

5.2 Impingement/Entrainment

Entrainment is the voluntary or involuntary movement of aquatic organisms from a water body into a surface diversion or through, under, or around screens and results in the loss of the organisms from the population. Impingement is the involuntary contact and entrapment of aquatic organisms on the surface of intake screens caused when the approach velocity exceeds the swimming capability of the organism (WDFW 1998). Dredges and water intakes, including those for water diversions and dewatering activities, can impinge or entrain aquatic organisms during routine operation. Hydraulic dredging can lead to entrainment of aquatic species in suction hoses and hydraulic intake equipment, such as dragheads. Cofferdams and other measures designed to contain work areas can entrap invertebrates and managed species and mismanaged or poorly designed turbidity curtains can become detached and entrap or entangle organisms.

5.2.1 Effects

Sessile organisms and some less mobile organisms, such as crustaceans and larval and juvenile fish, may be more susceptible (Nightingale and Simenstad 2001b) to impingement and entrainment. The susceptibility to entrainment for some pelagic species may be related to the degree of waterway constriction in the area, which makes it more difficult to avoid the dredge operation (Larson and Moehl 1990; McGraw and Armstrong 1990). Impingement/entrainment may cause injury or death in certain cases, such as by becoming entrapped in a dredge bucket or buried in sediment during dredging or when sediment is deposited into a dredge scow. Fish captured and emptied out of a dredge bucket can suffer stress or injury, which can lead to mortality.

Benthic infauna, which serve as forage for some managed species, are particularly vulnerable to entrainment by dredging, although some mobile epibenthic and demersal species, such as shrimp, crabs, and fish, are susceptible to entrainment as well (Nightingale and Simenstad 2001b). The susceptibility to entrainment for some pelagic species may be related to the degree of waterway constriction in the area of the dredging, which makes it more difficult for fish to avoid the dredge operation (Larson and Moehl 1990; McGraw and Armstrong 1990). Entrainment can also subject early life stages of fish to adverse conditions such as increased heat, physical abrasion, and rapid pressure changes. Although some temperate species of fish can tolerate exposure to extreme temperatures for short durations (Brawn 1960; Barker et al. 1981), fish and invertebrates entrained experience nearly 100% mortality from the stresses associated with altered temperatures, toxic effects of chemical exposure, and mechanical and pressure-related injuries from diversions/intakes (Enright 1977; Moazzam and Rizvi 1980; Barker et al. 1981; Richkus and McLean 2000; Johnson et al. 2008).

Entrainment and impingement of fish and invertebrates in water intake structures have immediate and future impacts to the riverine, estuarine, and marine ecosystems. Not only is fish and invertebrate biomass removed from the aquatic system, but the biomass that would be produced in the future is no longer available to predators (Rago 1984; Johnson et al. 2008); this negatively impacts the quality of EFH, as less forage is available. Fish and invertebrate populations may be adversely affected by intakes, as less mobile early life stages are particularly vulnerable and mortality of the early life stage often determines recruitment and strength of the year-class. Important habitat for aquatic organisms around water intakes may also become unavailable for recruitment and settlement (Travnichek et al. 1993; Johnson et al. 2008).

Vertical lines or other devices, such as turbidity curtains, may temporarily impact EFH and other NOAA-trust resources. Entanglement can cause aquatic organisms to become impaired or incapacitated, leading to starvation, drowning, increased vulnerability to predators, and physical wounds (Milliken and Lee 1990; Johnson et al. 2008). Lines or curtains could also prevent managed species from accessing spawning or forage areas. This impact is expected to be temporary, as access would be restored once the lines or curtains are removed.

5.3 Turbidity and Sedimentation

Transportation actions in or near aquatic habitats including cofferdam/pile installation and removal, bridge construction, riprap installation/removal, and demolition activities may increase rates of erosion, debris loads, turbidity, and sedimentation in streams, wetlands, or other aquatic habitats, and diminish floodplain storage capacity. Increased sedimentation can also result from changes in hydraulics caused by wave energy reflection in the nearshore coastal area. This can result in scour, and increased turbidity can reduce or eliminate SAV and other sensitive habitats adjacent to the structures (Williams and Thom 2001; Johnson et al. 2008).

Roads introduce an impervious surface into the landscape, which intercepts rain and increases runoff, carrying soil, sand, and other sediments (Ziegler et al. 2001) more readily into aquatic habitats. Sedimentation in aquatic habitats can be acute following precipitation events or chronic from improper road maintenance (Hanson et al. 2003). Road maintenance, including sanding to prevent icing or routine road repair, can also cause sedimentation in adjacent aquatic habitats. Sedimentation and turbidity impacts on riverine and estuarine habitats can be worsened by the loss and replacement of wetlands with impervious surfaces.

Transportation projects may include dredging for debris removal, channel restoration, or other maintenance during construction. Dredging and excavation result in greatly elevated levels of turbidity in the water column. Turbidity plumes produced by dredging are highly variable and dependent upon grain size and the type of dredge used. Mechanical dredging techniques such as clam shell or bucket dredges cause turbidity as sediment spills through the tops and sides of the dredge bucket when it contacts the bottom, during withdrawal of the bucket through the water column, and when it breaks the water's surface (Nightingale and Simenstad 2001b). Mechanical dredging generally produces more turbidity than hydraulic dredging techniques, such as hopper or cutterheads. However, hydraulic dredging can cause significant turbidity if the slurry is allowed to overflow from the barge and into the water column. This technique, called "economic loading," is often used to reduce the number of barge trips (Wilber and Clarke 2001).

Pile installation and removal disturbs bottom sediments and may temporarily increase suspended sediment. Directly pulling broken piles may suspend large amounts of sediment, as sediments clinging to the pile slough off as it is raised through the water column. Clamshell buckets may suspend additional sediment if they penetrate the substrate while grabbing the pile (Hanson et al. 2003). Vibratory pile removal can cause the sediments to slough off within the substrate, resulting in relatively lower levels of suspended sediments (Hanson et al. 2003). Breaking or cutting the pile below the mudline may suspend small amounts of sediment, if the stub is left in place and little digging is required. Sediment plumes may also occur around the piles during installation, although it is usually much less than the turbidity created during removal. Some turbidity may be generated when piles are installed or removed with hydraulic jets, although this technique is not widely used with piles in the GAR (Johnson et al. 2008).

Vessels, such as barge-mounted cranes, may be used to conduct general construction activities associated with transportation projects. Construction vessels operating in shallow water at a transportation project site may cause resuspension of bottom sediments and may physically disrupt shallow aquatic habitats, such as bank and shoreline through prop dredging (Barr 1993). The degree of sediment resuspension and turbidity produced in the water column from vessel activity is generally dependent on the wave energy and wake produced by the vessel, size of the sediment particles, water depth, and number of vessels passing through an area (Karaki and vanHoften 1975; Barr 1993). Sedimentation and turbidity impacts associated with vessel traffic may be more pronounced in shallow water habitats with fine sediments (Klein 1997; Johnson et al. 2008).

Improper design or use of certain erosion and sedimentation control measures can also result in increased turbidity and sedimentation. Turbidity/silt curtains may not be appropriate in some situations if the water velocity is too high. In some cases, the curtains can be pulled loose and do more damage to habitats than the turbidity it was meant to control. Pumping turbid water out of a dewatered area or sediment basin can also contribute to increased turbidity and sedimentation.

5.3.1. Effects

Shoreline alterations that occur as part of transportation activities can redirect wave energy, causing scouring and loss of adjacent areas including salt marsh vegetation or other sensitive habitats. Suspended sediments reduce the availability of sunlight to SAV, cover fish spawning areas and food supply, alter foraging patterns and success (Breitburg 1988), interfere with filtering capacity of filter feeders, clog and harm the gills of fish (U.S. EPA 2003), or lead to death (Wilber and Clarke 2001). The severity of suspended sediments effects on aquatic organisms often increases as a function of sediment concentration and duration of exposure (Newcombe and Jensen 1996), and the sensitivity of species to suspended sediments depends on the nature of the sediment and the life history stage of the species.

Early life stages and sessile organisms are the most sensitive to sedimentation impacts (Barr 1987; Wilber et al. 2005). Increased sedimentation can bury benthic organisms and demersal fish eggs. The depth of burial and the density of the substrate may limit the natural escape response of some organisms that are capable of migrating vertically through the substrate (Barr 1987; Wilber et al. 2005). In addition, anoxic conditions in the disturbed sediments may decrease the ability of benthic organisms to escape burial (Barr 1987). Short-term burial, where sediment deposits are promptly removed by tides or storm events, may have minimal effects on some species (Wilber et al. 2005); however, even thin layers of fine sediment have been documented to decrease gas exchange in fish eggs and adversely affect the settlement and recruitment of bivalve larvae (Wilber et al. 2005).

Turbidity can adversely affect diadromous fish, particularly during spring and fall migrations. Increased suspended sediments may degrade or eliminate spawning and rearing habitats, impede feeding, negatively affect the food sources of fish, severely alter the aquatic food web, and thus negatively affect the growth and survival of diadromous fish. Changes in stream morphology, such as the frequency and extent of bedload movement and the introduction of sediments, can remove spawning substrates, scour redds or "nests," result in a direct loss of eggs and young, or reduce their quality by deposition of increased amounts of fine sediments. These changes can affect the early life stages of Atlantic salmon, which show an affinity for specific habitat types (Fitzsimons et al. 1999; Hedger et al. 2005; Johnson et al. 2008). Sediments can eliminate refuge used by juvenile stages of salmon to avoid predators, create a homogeneous environment leading to lower fish densities, reduce macroinvertebrate abundance, and decrease the depth and area of pools used by juveniles and adults (Danie et al. 1984; Fay et al. 2006).

5.4 Water Quality (Dissolved Oxygen, Temperature, and Pollutants)

Transportation activities can degrade water quality in a number of ways including increases in suspended sediments and turbidity (as discussed in Section 5.3), decreases in dissolved oxygen (DO), changes in temperature, and the addition of pollutants all of which may interrupt the basic life history functions of aquatic species and contribute to the reduced productivity of fishery resources. Roads can alter the hydrology of a watershed which can affect water residence time, temperature, and salinity and increase vertical stratification of the water column, inhibiting the diffusion of oxygen into deeper water leading to lowered DO concentrations (Kennedy et al. 2002; Johnson et al. 2008). Undersized and/or improperly placed crossings can restrict tidal flow and cause flooding upstream, affecting upland and riparian habitat and can affect water quality by acting as dams, impounding water and increasing water temperature. As water flows through a structure, the temperature of the water can also rise, affecting aquatic organisms downstream; such effects can be exacerbated by climate change.

Projects conducted next to streams can also impact water temperature. Roads can alter natural temperature regimes in riverine and estuarine ecosystems because of radiant heating effects from the road surfaces (Johnson et al. 2008). Loss of riparian and salt marsh vegetation from transportation actions can increase the amount of solar radiation reaching streams and rivers and results in an increase in water temperatures of those water bodies (Moring 2005). Conversely, increased shading from transportation structures may unnaturally reduce local light levels, primary production rates, and water temperatures adjacent to the structures (Williams and Thom 2001; Johnson et al. 2008).

Transportation projects can alter water quality parameters and release contaminants and nutrients into the water column (Messieh et al. 1991; Newell et al. 1998; Johnson et al. 2008). Roads near aquatic habitats can be a source of chemical contaminants, such as deicing chemicals or salt, fertilizers, herbicides to control roadside vegetation, rubber/graphite residue from the wearing of tires, deposition from vehicle exhaust, heavy metals from brakes, and petroleum products from vehicles or from the road asphalt itself (Furniss et al. 1991; U.S. EPA 2005). Contaminants such as ammonia can also be released in the water column with the use of certain types of explosives. Other contaminants can be released from piles treated with creosote or other preservatives (Poston 2001; Kennish 2002; Weis and Weis 2002). The rate of preservatives leaching is highly variable and dependent on the age of the treated wood and other factors. Concrete or steel are relatively inert and do not leach contaminants into the water (Johnson et al. 2008); however, the interaction of raw concrete or grout and the water is a concern. Vessels and construction equipment can release oil or other pollutants into the aquatic environment. These hazardous materials can be released into the environment from fuel and oil related to vessel or equipment operations. Nutrients and contaminants can bind to fine particles in bottom sediments (Messieh et al. 1991; Newell et al. 1998) and the disturbance of these sediments can release metals, hydrocarbons, hydrophobic organics, pesticides, pathogens, and nutrients into the water column and allow them to become biologically available in the water column or through trophic transfer (Wilbur and Pentony 1999; U.S. EPA 2000; Nightingale and Simenstad 2001b).

5.4.1 Effects

Changes in water quality parameters including velocity, volume, temperature, and chemical constituents from discharges and other activities may adversely affect EFH, managed species, and other NOAA-trust resources. Reductions in water quality can impair and limit the ability of aquatic organisms to grow, feed, and reproduce (Deegan and Buchsbaum 2005; Johnson et al. 2008). Changes in the water velocity, volume, temperature, and chemical constituents all represent impacts on water quality as well as habitat (see section 5.5). Hydrological modifications from transportation activities can increase the quantity and quality of run-off entering the aquatic environment and may contribute to reduced fisheries productivity. Altered temperature regimes can affect the distribution, growth rates, survival, migration patterns, egg maturation and incubation success, competitive ability, and disease/parasite resistance of aquatic organisms (U.S. EPA 2003). In-water plumes (e.g., toxic chemical and thermal) resulting from transportation activities may interrupt migrating, foraging, overwintering/sheltering, or spawning of managed species, and/or forage species, such as diadromous fish, if aquatic organisms avoid an area that would normally serve as habitat. Interruption of basic biological life stages may also be caused by the physical presence of water quality containment measures (including turbidity curtains and cofferdams) (Spence et al. 1996).

Reduced water quality can cause habitat destruction in the case of prolonged stressors, as the habitat may no longer be usable or may become severely degraded. Elevated water temperatures in streams and rivers could lead to local extirpation of cold-water fish if temperature tolerance ranges are exceeded. Riparian vegetation removal can also have the effect of lowering water temperatures during winter, which can increase the formation of ice and delay the development of incubating fish eggs and alevins in salmonids (Hanson et al. 2003). Riparian vegetation is important to salmonids, providing shade for maintaining cool water temperatures, food supply, and channel stability and structure (Furniss et al. 1991).

Reduced DO concentrations can kill aquatic organisms or result in sub-acute effects such as reduced growth and reproductive success. Contaminated sediments can build up in aquatic organisms through bioaccumulation and biomagnification. These contaminants can affect marine organisms through uptake by wetland vegetation, adsorption by adjacent sediments, or directly through the water column (Weis and Weis 2002). They also affect the growth, reproduction and survival of shellfish, which provide forage for managed species.

Water quality issues such as eutrophication, pollution, and sedimentation resulted in large-scale declines to SAV in some areas of the northeastern U.S. (Goldsborough 1997; Deegan and Buchsbaum 2005; Wilber et al. 2005; Costello and Kenworthy 2011). Environmental effects of excess nutrients and sediments are the most common and significant causes of SAV decline worldwide (Orth et al. 2006). The resuspension of nutrients creates turbid conditions and decreases photosynthesis. The combination of decreased photosynthesis and release of organic material with high biological oxygen demand can result in short-term oxygen depletion to aquatic resources (Nightingale and Simenstad 2001b). The loss of SAV is linked to poor water quality from increased turbidity and nutrient loading (Deegan and Buchsbaum 2005; Wilber et al. 2005).

5.5 Habitat Alteration

Transportation activities may cause habitat alteration through increased suspended sediment loading, fill, dredging, excavation, shading, and introduction of chemical contamination. Habitat conversion or loss can result if substrates are removed, resulting in deeper habitats, scour, loss of bottom structure and complexity, and altered substrate type. Habitats can also be temporarily or permanently impacted by the physical presence of construction materials (e.g., turbidity curtains, cofferdams, piles, bridge piers and abutments, machinery) in the water (Spence et al. 1996). Habitat alteration may not be reversible and recovery times for degraded habitat depend on the nature of the agent causing the degradation and the physical characteristics of the habitat (Deegan and Buchsbaum 2005).

If improperly designed, stream crossings can alter, degrade, fragment, or eliminate aquatic habitat and potentially impede or eliminate passage for resident and migratory species (Evans and Johnston 1980; Belford and Gould 1989; Clancy and Reichmuth 1990; Furniss et al. 1991; U.S. GAO 2001; Jackson 2003). Scour protection around overwater structures can also lead to a conversion and loss of habitat (Johnson et al. 2008). Overwater structures also create shade that reduces the light levels below and around the structure. The size, shape, and intensity of the shadow cast by a structure depend on its height, width, construction materials, and orientation (Johnson et al. 2008). Piles can alter adjacent substrates by increased deposition of sediment from changes in current fields or shell material deposition from pile communities. Pile extraction can result in altered sediment composition and depressions, which may cause erosion and sediment loss. Bottom depressions may fill in with fine sediments and silt, changing the characteristics of the benthic habitat (Johnson et al. 2008).

Shallow water habitats may be impacted through burial of resources and/or alteration of habitats from fill placement, such as through shoreline armoring or dredge disposal. Transportation projects may include temporary fill in EFH that results in a temporal loss of ecological functions. Temporary fill associated with the construction of causeways can create hydraulic barriers. If not properly restored, ecological functions may be permanently lost. Potential foraging habitat may be permanently covered by riprap or compacted. Shoreline armoring can reduce the complexity and amount of intertidal habitats and negatively affect nearshore processes and the ecology of coastal species (Williams and Thom 2001; Johnson et al. 2008).

These impacts of climate change are widespread and vary by region, but sea level rise (SLR) is of primary importance to transportation projects in coastal areas of the GAR where NOAA-trust resources are present. Transportation projects that fail to incorporate SLR can lead to inadequately designed bridges and highways, resulting in significant costs due to redesigning, retrofitting, and potentially having to relocate or protect transportation infrastructure; this can also lead to increased impacts to environmental resources (TRB 2008; U.S. GCRP 2014). Changes due to climate change are expected to occur within the timeframe of the life expectancy of many transportation projects. Adequately incorporating potential climate change effects including SLR into transportation projects can improve the resilience of systems and maximize performance over time (USACE 2014).

5.5.1 Effects

Habitat alteration resulting from transportation activities may have temporary and permanent effects on EFH, managed species, and other NOAA-trust resources. Certain activities may affect the migration of mobile species and temporarily prohibit an area from use as foraging, spawning, nursery, or refuge habitat. Mobile species may leave an area for more suitable feeding or spawning grounds, or avoid migration paths because of turbidity plumes or noise created during construction activities. In-water construction activities could also impede species movement depending on the size of the work footprint and the presence of turbidity curtains or other exclusionary devices. Reduced habitat quality may be equally damaging to the biological community as a loss in habitat quantity. Gradual declines in habitat quality can result in complete loss of habitat structure and function (Deegan and Buchsbaum 2005). Losses of habitat quantity and quality may reduce the ability of an area to support healthy and productive fish populations and lead to stressed populations (Robinson and Pederson 2005).

During construction, managed species may be temporarily unable to use an area for forage or refuge habitat due to avoidance of construction activities and physical obstruction by temporary or permanent structures. Structures can also cause beach erosion and accretion in adjacent areas. Placing fill material onto intertidal habitats can dramatically alter tidal flow. These effects can change the geomorphology and current patterns of rivers and estuaries and adversely affect habitat suitability for certain species. Counter current flows set up by freshwater discharges into estuaries are important for larvae and juvenile fish entering those estuaries. Behavioral adaptations of marine and estuarine species allow larvae and early juveniles to concentrate in estuaries (Deegan and Buchsbaum 2005). Alterations in bottom sediments, bottom topography, and altered circulation and sedimentation patterns related to dredging and other transportation activities can also lead to shoaling and sediment deposition on benthic habitats such as spawning grounds, SAV, and areas containing shellfish (Wilber et al. 2005; MacKenzie 2007).

After dredging, sediments may be nearly devoid of benthic infauna, and those that are the first to recolonize are typically opportunistic species, which may have less nutritional value for consumers (Allen and Hardy 1980; Newell et al. 1998). Rates of benthic infauna recovery for disturbed habitats depend on the amount of material removed, the habitat affected and the fauna present at the site prior to dredging, the frequency of disturbances, and the degree of sedimentation that occurs following dredging (Greene 2002). The post-dredging benthic community may function very differently than the pre-dredging community (Greene 2002; Johnson et al. 2008). Dredging may also directly affect SAV through the physical removal of plants and indirectly affect SAV by the reduction in light penetration and burial, or smothering by turbidity plumes and sedimentation (Deegan and Buchsbaum 2005). While SAV may regrow in a dredged area if the exposure to excessive suspended sediments is not protracted and accumulated sediments are removed by currents and tides after dredging ceases (Wilber et al. 2005), SAV recolonization may be limited if the bottom sediments are destabilized or its composition is altered (Thayer et al. 1997). Even when bottom sediments are stabilized and conducive to SAV growth, deepening may result in the area not having enough light for SAV recolonization (Barr 1987). Dredging and excavation in intertidal habitats can also alter tidal flow, currents, and tidal mixing regimes of the dredged area and surrounding habitats, leading to changes in the environmental parameters necessary for successful nursery habitats (Barr 1987).

Overwater crossings can alter plant and animal assemblages in intertidal and shallow subtidal areas and interfere with key ecological functions such as spawning, rearing, and use of refuge sites. Site-specific factors such as water clarity, current, and depth, as well as the type and use of a given crossing determine the occurrence and magnitude of these impacts (Hanson et al. 2003; Johnson et al. 2008). The shading from these structures can lead to reductions in juvenile fish populations and reduced growth and survival of fish, compared to open habitats (Able et al. 1998; Duffy-Anderson and Able 1999). In addition, the use of artificial lighting on bridges creates unnatural nighttime conditions that can increase the susceptibility of some fish to predation and interfere with predator/prey interactions (Nightingale and Simenstad 2001a; Johnson et al. 2008). Overwater structures may also damage SAV and cause substrate scour (Kennish 2002). Shading can reduce prey organism abundance and the complexity of the habitat by reducing SAV and phytoplankton abundance (Haas et al. 2002). The disturbance of sediments and rooted vegetation decreases habitat suitability for fish and shellfish resources and can affect the spatial distribution and abundance of fauna (Nightingale and Simenstad 2001a; Uhrin and Holmquist 2003; Eriksson et al. 2004; Johnson et al. 2008).

Waterway crossings can reduce or eliminate upstream and downstream fish passage through improperly placed or slip-lined culverts at road crossings (Evans and Johnston 1980; Belford and Gould 1989; Clancy and Reichmuth 1990; Furniss et al. 1991). As described by FHWA (2010), many culverts currently in place were designed primarily with hydraulic conveyance in mind (Normann et al. 2005) and the culverts largely present barriers to fish passage and cause fragmentation and loss of ecological connectivity (Trombulak and Frissell 2000). Improperly designed stream crossings can adversely affect aquatic organisms by blocking access to spawning, rearing, and nursery habitat from perched culverts constructed with the bottom of the structure above the level of the stream, and hydraulic barriers to passage are created by undersized culverts which constrict flow and create excessive water velocities (Evans and Johnston 1980; Belford and Gould 1989; Furniss et al. 1991; Jackson 2003). Culverts and bridges can be plugged by debris or overtopped by high flows. Road damage, channel alteration, and extreme sedimentation from roads can cause streamflow to become too shallow for upstream fish movement through culverts. This can also lead to increased predation on fish.

Stream crossings and water diversions can alter natural freshwater flows (Boesch et al. 1997), reduce natural tidal flushing and interfere with natural nutrient and sediment-transport processes and sediment and nutrient transport processes (Christie et al. 1993; Fajen and Layzer 1993, Tyrrell 2005), hindering benthic processes and communities. Alteration of stream morphology is usually detrimental to fish habitat and can change stream velocity and increase sedimentation of the streambed, adversely affecting spawning and migration of anadromous fish (Furniss et al. 1991; Johnson et al. 2008). Water diversions can create a physical barrier to fish (Spence et al. 1996), and excessive water withdrawal can greatly reduce the usable river channel. Rapid reductions or increases in water flow can greatly affect fish migratory patterns. Depending on the timing of reduced flows, fish can become stranded within a stream channel, in pools, or just below the river in an estuary system (Johnson et al. 2008). Climate change can exacerbate all of these effects.

Tidal restrictions caused by tide gates, improperly designed bridges and culverts typically reduce upstream salinity and the maximum elevations of tidal flooding, which can transform the plant community and alter the entire upstream salt marsh. Invasive species, which are more tolerant of brackish conditions, such as the common reed, often displace native salt marsh vegetation and reduce plant diversity and vegetative structure. Changes in vegetation can cause major shifts in wildlife use, from diverse native salt marsh fauna to fewer, more generalist species (Cape Cod Commission 2001).

In addition, the loss and fragmentation of coastal wetlands by transportation infrastructure, tide gates, and other engineering structures, can reduce a wetland system's capacity to store floodwaters and to protect inland ecosystems and properties from storm damage. Consequently, the damages from major coastal storms are exacerbated as the structures impound storm water and increase the severity of flood events (Cape Cod Commission 2001). This can also be exacerbated by climate change. Wetland losses can interrupt the life history processes of managed species. Wetland impacts and hydrological modifications from transportation activities can increase the amount of run-off entering the aquatic environment and contribute to the reduced productivity of fishery resources. Wetlands serve as habitat for early life history stages of many species of fish, shellfish, crabs, and shrimp, which use the physical structure of marsh grasses as refuge from predators (Tyrell 2005). Smaller fish, such as mummichog, Atlantic silverside, sticklebacks, and sheepshead minnow, rely on salt marshes for parts of their life cycles. These species form the prey base of many larger, commercially important species such as flounder species, black sea bass, and bluefish (Collette and Klein-MacPhee 2002). Dredging and disposal can decrease the amount of detrital food source, important for aquatic invertebrates (Mitsch and Gosselink 1993; Johnson et al. 2008). Disposal and fill activities can also directly eliminate sessile or semi-mobile aquatic organisms by smothering (Larson and Moehl 1990; McGraw and Armstrong 1990; Barr 1993; Newell et al. 1998).

Around piles, native dominant communities typically associated with sand, gravel, mud, and SAV may be replaced by shell hash communities (Penttila and Doty 1990; Nightingale and Simenstad 2001a; Haas et al. 2002). In addition, changes to current fields around structures alter sediment distribution and topography creating depressions along pile lines (Penttila and Doty 1990)

Climate change (See Section 3.4) has wide-ranging impacts on all natural and human systems (Doll et al. 2012), including aquatic habitats. Climate change can result in changes such as sea level rise (SLR), increased temperatures, changes in precipitation and water quality, and flooding

5.6 Vessel Interaction

Construction and maintenance of transportation projects may result in increased vessel traffic from new vessels accessing the water at a project site, where there was previously no access, or through a temporary increase during construction. Direct disturbances to bottom habitat include propeller scouring and vessel wake impacts on sensitive benthic habitats and direct contact by grounding out. Increases in the speed, size, and density of vessel traffic may require increased frequency of maintenance dredging and produce secondary impacts, such as shoreline erosion, sedimentation, and turbidity as noted in other stressors and effects categories. Improvement dredging may occur in areas that have not previously been subjected to heavy vessel traffic and dredging activities.

5.6.1 Effects

Vessel operation can result in harassment and/or injury and can physically impact managed species in the action area. Vessel interactions may contribute to serious injury and mortality events through direct hits or collisions. The physical presence of vessels can interrupt migrating, foraging, overwintering/sheltering, or spawning by managed species, and/or forage species such as diadromous fish. Vessel operation and maintenance can also affect benthic habitat, through shading of SAV, vessel groundings, and fuel spills. Grounded vessels may physically damage and smother benthic habitats, change wave energy and sedimentation patterns, and scatter debris across sensitive habitats (Precht et al. 2001; Zelo and Helton 2005). Benthic, shoreline, and pelagic habitats may be disturbed or altered by vessel use, resulting in cumulative impacts in heavy traffic areas (Barr 1993). Propeller scouring can result in a loss of benthic habitat, decrease productivity, fragment SAV beds, and lead to further erosion and habitat degradation (Uhrin and Holmquist 2003). Vessels can directly and indirectly impact SAV, by dragging and tearing plant tissues from increased wave-action or hydraulic pumping, reducing light availability by elevated turbidity and resuspension of bottom sediments, and altering habitat and substrate causing plants to be uprooted and inhibiting recruitment (Eriksson et al. 2004; Johnson et al. 2008).

Wave energy caused by vessels can substantially impact aquatic shoreline and backwater areas, eventually causing the loss and disturbance of shoreline habitats (Karaki and vanHoften 1975; Barr 1993; Klein 1997). The degree of shoreline erosion caused by vessels generally depends on the wave energy and surge produced by the vessel and the slope of the shoreline, sediment type, type and amount of shoreline vegetation, characteristics of the water body (e.g., water depth and bottom topography), and distance between the vessel and shoreline (Karaki and vanHoften 1975; Barr 1993). Vessels could also temporarily exclude an area from being used by managed species if suitable clearances are not maintained from the bottom of the vessel to the substrate

6.0 FHWA Minimum Conservation Measures

Each of the following conservation measures have been identified by FHWA and states and are generally accepted as standard operating procedure (SOP) in highway-related transportation activities in order to avoid and minimize adverse impacts to EFH. To be eligible for this programmatic consultation, all of the following minimum conservation measures must be included as part of the project. There are no exceptions to these specific measures. FHWA/state DOTs must also include these measures in an enforceable document such as the project plans, contract language, or environmental commitment document.

Minimum Conservation Measures for all Activities:

- Turbidity control measures must be properly installed, secured and regularly monitored to ensure aquatic species are not entangled or trapped in the project area.
- No new permanent surface water withdrawal, water intakes, or water diversions.
    - Permanent surface water intakes do not include dry hydrants.
- Install soil erosion, sediment, and turbidity controls and maintain them in effective operating condition during construction. Remove controls upon completion of work, after all exposed soil and other fills, as well as any work waterward of ordinary high water or the high tide line, are permanently stabilized.
- Prevent construction debris and sediment from entering aquatic areas and remove all construction debris and excess/deteriorated materials and dispose of in an appropriate upland area.
- Dredged and/or excavated materials, including any fine-grained materials removed from inside culverts, shall either be moved to an upland location and stabilized to prevent reentry into the waterway or disposed of at a previously approved disposal site.
- Completely remove and do not reuse existing creosote piles that are affected by project activities and do not install new creosote piles. Piles that break or cannot be removed due to site conditions must be cut off at the mudline.

- Ensure that raw concrete does not contact the water; wet pours of concrete must be confined within sealed forms until the concrete is set or pre-cast members installed. Ensure grout bags are watertight.
- Use geotextile barriers prior to placement of temporary fill material to ensure complete removal.
- Return areas impacted by temporary activities, fills, or structures to pre-construction or better condition, including elevations and substrate, and replant with native species.
- Temporary monitoring devices, if used in-water as part of an activity, shall be removed and the substrate restored to pre-construction elevations no later than 24 months from initial installation, or upon completion of data acquisition.
- Pipelines and cables that cross a waterway must not rest on the substrate. They may be attached to an overwater structure or be buried to allow an area to return to preexisting conditions.
- Any fill, including planting media and placement of any seed shellfish, spatted-shell, or cultch must be free of all non-native or invasive species and/or contaminants. An invasive species control plan must be part of the project if the transportation agency cannot guarantee this.
- Prevent dislodging of coir logs, mats, or native oyster shell.
- Avoid propeller scour and grounding of all project vessels and floating docks.
- Lowermost section of floating docks and vessels must be ≥18 inches above the substrate at all times.

7.0 Programmatic EFH Conservation Recommendations

HESD evaluated the potential adverse effects to EFH and NOAA trust resources resulting from common transportation projects in the GAR and developed EFH conservation recommendations based on best available information including past consultations and the NMFS GARFO/FHWA Best Management Practices (BMP) Manual, to avoid and minimize impacts to EFH pursuant to Section 305(b)(2) of the MSA. Additionally, HESD analyzed and previously provided EFH CRs to FHWA/state DOT on substantially similar projects in the past, and is familiar with these types of projects. HESD evaluated a broad range of these activities in *Impacts to Marine Fisheries Habitat from Nonfishing Activities in the Northeastern United States* (Johnson et al. 2008), and *Shallow Water Benthic Habitats in the Gulf of Maine: A Summary of Habitat Use by Common Fish and Shellfish Species in the Gulf of Maine* (Stevenson et al. 2014). The EFH CRs and thresholds are consistent with those in other, existing programmatic consultations within the region for similar activities and stressors including the programmatic EFH consultation with the USACE New England District and the programmatic consultations completed for the USACE Nationwide Permit Program, Regional General Permits, and Statewide Programmatic General Permits in NY, NJ, PA, DE, MD, DC, and VA.

From 2018-2022, 135 projects were submitted under the FHWA programmatic consultation (Table 1). Cumulatively, DOTs reported seeking consultation for 680,356 ft^2 (15.6 acres of impacts to EFH (see FHWA 2023 Annual Report). It is anticipated that the number of FHWA/DOT projects submitted to this programmatic consultation will continue to grow over the next three years. FHWA surveyed State DOTs in 2023 to report on predicted future impacts and program growth. In 2024-2026 DOTs, foresee seeking coverage for 16.4 acres of temporary future EFH impacts and 9.8 acres of permanent impacts, respectively.

Table 1. Numbers/types of transportation projects engaging in EFH consultation 2018-2022

Activity Type	# of Transportation Projects in the FHWA GAR PA 2018-2022
Bridge repair, demolition, and replacement	91
Culvert repair and replacement	27
Docks, piers, and waterway access projects	10
Slope stabilization	7
Total Projects	135

HESD regards the programmatic EFH conservation recommendations as integral components of the proposed action and expects that they will be incorporated into transportation actions. FHWA/state DOTs should include EFH conservation recommendations as conditions in an enforceable document such as the project plans, contract language, or environmental commitment document.

The BMPs included in the NMFS GARFO/FHWA Best Management Practices (BMP) Manual should also be incorporated into the design and implementation of all transportation projects within GAR. The full list of programmatic EFH conservation recommendations for transportation projects eligible for this programmatic EFH consultation is provided in Appendix C.

8.0 Endangered Species Act (ESA) and Marine Mammal Protection Act (MMPA)

This programmatic EFH consultation applies only to EFH consultations in the GAR and does not obviate FHWA's responsibilities to consult with NMFS under either the ESA or Marine Mammal Protection Act (MMPA). Section 7(a)(2) of the ESA states that each federal agency shall ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat. Any discretionary federal action that may affect a listed species should undergo section 7 consultation. If a listed species may be present in a project area, FHWA must determine whether the proposed action is likely to affect any listed species. The MMPA prohibits, with certain exceptions, the take of marine mammals in U.S. waters and by U.S. citizens on the high seas. If the proposed action has the potential to take marine mammals, consultation should be undertaken and the appropriate authorization as issued under the MMPA should be obtained. More information regarding the ESA and MMPA is located on the GARFO PRD section 7 website.

9.0 Conclusion

In summary, this programmatic EFH consultation provides upfront EFH conservation recommendations projects funded or authorized through FHWA authorities. It provides an efficient method for FHWA and HESD to consult with each other on these routine minor impact transportation projects.

HESD evaluated potential adverse effects to EFH pursuant to section 305(b)(2) of the MSA for certain activities associated with bridge repair, demolition, and replacement; culvert repair and replacement; docks, piers, and waterway access projects; and slope stabilization. We have determined that these activities are eligible for consideration under the programmatic EFH consultation, consistent with measures, thresholds, and procedures identified within this document.

List of Appendices

Appendix A - Activities Requiring Project Specific Consultation and Thresholds

The following is a list of activities that are not eligible for the FHWA programmatic EFH consultation and will require project specific consultation with HESD. This is because the activity and/or the effects of such work are expected to be more than minimal and/or additional information will be required to determine the effects and provide recommendations to avoid and minimize effects to EFH and NOAA trust resources. Activities may be ineligible for the programmatic consultation due to the activity type, extent of impact or type of habitat impacted. FHWA/State DOTs should contact local HESD staff if there are any questions about the applicability of this consultation to a proposed project.

1. Any work (including anchoring) that results in temporary or permanent impacts to:
    - Existing or historically mapped submerged aquatic vegetation (SAV) beds or areas within 100 feet of existing or historically mapped SAV beds unless otherwise confirmed to be absent by survey.
    - ≥ 1,000 SF of tidal SAS (except tidal SAV, see 1 above), natural rocky habitats, or freshwater SAV.
2. Stream channelization.
3. Any temporary structures, construction access, and dewatering activities proposed to be in place for ≥ two years
4. Slip-lining or invert lining existing culverts in tidal waters or non-tidal waters that support diadromous fishes. Resources to assist in the identification of these waters can be found in Appendix H and from State fishery agencies.
5. Structures (docks, piers, walkways) or temporary structures: Less than 1:1 height/width ratio or wider than 4 ft. over salt marsh waterward of MHW. The height should be measured from the substrate to the bottom of the longitudinal support beam lowermost portion of the deck structure.
6. Construction of new or expansion of existing boating facilities. For the purposes of this programmatic EFH consultation, a boating facility is boat docking or mooring space for more than two non-commercial vessels.
7. Excavation for the purpose of establishing new or improved navigation channels (e.g. dredging), exceeding the thresholds listed under number 1 above.
8. Any nearshore disposal or beach nourishment activities.
9. New fill or stabilization structures placed below mean low water in excess of 200 linear feet (lf).
10. Replacement of:
    - slope stabilization structures > 200 lf. *and* waterward of the existing toe, or
    - vertical structures > 18 inches waterward of the existing face *and* > 200 lf.
11. Thin layer deposition as a part of wetland restoration.
12. Placement of any seed shellfish, spatted-shell, or cultch in the following sensitive habitats: fish and wildlife sanctuaries and refuges, mudflats, SAV beds, riffle/pool complexes, natural rocky habitats, intertidal areas, and areas containing shellfish.
13. In-water utility lines ≥100 linear feet (LF) installed by trench excavation; or where installed by jet-plow, fluidization or other direct burial methods: a) installed in mud, clay, or silt substrates; or b) ≥200 LF when installed in sandy substrates (e.g. >/= 90% coarse grained

sand habitats (Wentworth <35 ASTM No. US Standard)). Direct burial methods do not include jacking or directional drilling/boring.

14. Airgun seismic activities.
15. Any new permanent surface water withdrawal, water intakes, or water diversions.
16. All work to tide gates without a USACE-approved operation and maintenance plan or alterations to tide gates that will affect the hydraulic regime. This does not include work on tide gates (e.g., duckbills, flap gates, etc.) that solely convey stormwater and/or NPDES-permitted discharges. See The Effects of Tide Gates on New England Wetlands and Other Tidal Resources. Greater Atlantic Region Policy Series [23-01] for additional information on tide gates and associated BMPs.
17. In-water blasting that affects EFH or diadromous species habitat, or out-of-water blasting with the discharge of blasted material in water.
18. Construction of new bridges or culverts, where no crossing existed previously.
19. Any new or replacement causeways (raised roadways across waters or wetlands). Temporary causeways do not require project specific consultation (i.e., they are covered under the programmatic consultation), provided they do not exceed the above listed threshold or include other excluded activities.
20. Dam and flood control or levee repairs that will alter water levels or flood elevations during the diadromous time of year (TOY) restriction provided in App C.
21. Living shoreline >500 linear feet in length located below OHW or the HTL and/or includes beach nourishment/ land reclamation activities.
22. Living shorelines with structure and/or fill area that extends into the waterbody more than 30 FT from the MLW line, including sand fills, sills, breakwaters, or reefs, or any living shoreline that proposes to impact SAV.
23. Excavated materials, stored, deposited, and retained anywhere but an upland area that prevents sediments from reentering aquatic habitats, except as authorized/required by the terms of a USACE or USCG approval.

Note:

1. The limits for the thresholds are cumulative. Consider the following threshold: “Temporary & permanent adverse effects to >1000 square feet (SF) of tidal SAS, intertidal habitats, natural rocky habitats.” 600 SF of adverse effects to intertidal habitat + 600 SF of adverse effects to natural rocky habitat = 1200 SF. Therefore, project specific coordination would be required.
2. For all activities, all special aquatic sites (SAS), intertidal areas, and natural rocky habitats in the project area must be delineated in the field and identified on the project plans. Information on the historical or current presence of SAV can be determined with the online mapping resources in Appendix H. Submerged aquatic vegetation (SAV) delineations shall be performed within a 100-FT radius of activity activities that may produce secondary adverse effects for areas that have not been surveyed in the last three years. If the remote or online delineation shows Submerged Aquatic Vegetation (SAV) resources are present or have been historically present within five years, and the area has not been surveyed in the field in three years, an SAV field survey shall be performed. The survey shall encompass the area of direct effects and indirect effects within a 100-FT radius. Current SAV survey results should be conducted in accordance with the Joint

Federal Agency Submerged Aquatic Vegetation Survey Guidance, or other locally approved method, where appropriate.

3. Survey delineations for natural rocky habitat should distinguish between habitat containing epifauna/macroalgae and bare habitat and should be conducted according to Appendix E.

Appendix B Programmatic EFH Conservation Recommendations

Programmatic EFH conservation recommendations are provided below by stressor for all transportation activities deemed eligible for this consultation. The types of activities or impact thresholds that require project specific EFH consultation are also provided. All activities should be undertaken in accordance with the NMFS GARFO/FHWA Best Management Practices (BMP) Manual and FHWA Minimum Conservation Measures in Section 6 of the programmatic consultation as appropriate.

The potential stressors produced by a given activity are summarized in the table below.

Table 1. Potential stressors from each transportation action

Project type	**Potential Stressor**				
	Underwater noise	**Impingement/ Entrainment**	**Water Quality/ Turbidity**	**Habitat Alteration**	**Vessel Interaction**
Bridge Repair, Maintenance, Demolition, and Replacement	X	X	X	X	X
Culvert Repair and Replacement	X	X	X	X	
Docks, piers, and waterway access projects	X	X	X	X	X
Slope Stabilization			X	X	

Table 2. Potential Stressors from Each Transportation Activity

Sub Activity	**Potential Stressor**				
	Underwater Noise	**Impingement/ Entrainment**	**Water Quality/ Turbidity**	**Habitat Alteration**	**Vessel Interaction**
Cofferdams/ Dewatering	X	X	X	X	X
Demolition	X		X	X	X
Pile Driving/ Removal	X		X	X	X
Dredging/ Excavation		X	X	X	X
Fill/Stabilization			X	X	
Vessel Activities			X	X	X
Habitat Restoration, Establishment, and Enhancement			X	X	X
Scientific Measuring Devices/Survey Activities	X	X	X	X	
Submarine Cable Installation			X	X	X
Staging Area Establishment				X	

Programmatic Conservation Recommendations by Stressor

The following EFH conservation recommendations are provided to minimize adverse effects to EFH and NOAA trust resources from underwater noise produced by transportation activities. While it is expected that these EFH conservation recommendations will be incorporated into all transportation projects deemed eligible covered under this consultation, a project will not be deemed ineligible for this consultation if all the applicable EFH conservation recommendations are not followed. As part of the annual report, FHWA/State

DOTs must identify which projects did not include all the applicable EFH conservation recommendations and provide a brief justification explaining why the relevant EFH conservation recommendations were not incorporated into the project.

Underwater Noise

1. Use a vibratory hammer to the maximum extent practicable.

2. For impact driving, an initial set of three strikes would be made by the hammer at 40 percent energy, followed by a 1-minute wait period, then two subsequent 3-strike sets at 40 percent energy, with 1-minute waiting periods, before initiating continuous impact driving. In addition to a soft start at the beginning of the day for impact pile driving, a soft start must also be used at any time following cessation of impact pile driving for a period of thirty minutes or longer and if any increase in pile installation or removal intensity is required. Build up power slowly from a low energy start-up over a 20-minute period to warn fish to leave the vicinity. This buildup shall occur in uniform stages to provide a constant increase in output. This should be done in accordance with the methods outlined in the NMFS GARFO/FHWA Best Management Practices (BMP) Manual

3. Avoid the use of hollow steel pipe piles when possible.

4. Do not undertake noise-generating work in diadromous streams within the spring diadromous fish TOY restriction listed in Appendix C unless it is isolated behind sealed, dewatered cofferdams, to avoid impeding fish migration.

Impingement and Entrainment

The following EFH conservation recommendations are provided to minimize adverse effects to EFH and NOAA trust resources from impingement/entrainment from transportation activities.

1. Install and operate temporary intakes related to construction in accordance with the NMFS GARFO/FHWA Best Management Practices (BMP) Manual and equip intakes with mesh size screening and approach velocity appropriate for the species and life stage anticipated to be present during construction. Temporary pumping/intakes related to construction water handling will be based on the resource present and be in accordance with state fisheries consultation (with documentation provided) where such consultation is available. In addition,

    a) Per the NMFS Anadromous Salmonid Passage Facility Design manual, screen openings must not exceed 3/32 inch and screen approach velocity must be less than 0.25 feet per second (ft. /sec) in waters supporting anadromous salmonids.
    b) The use of 2 millimeter (mm) wedge wire screens must be used with a maximum intake velocity of 0.5 feet per second (ft. /sec).
    c) In Virginia, a 1 mm wedge wire screen with a maximum intake velocity of 0.25 ft. /sec) is required.

Water Quality/Turbidity

The following EFH conservation recommendations are provided to minimize adverse effects to EFH and NOAA trust resources from reduced water quality and/or increased turbidity from transportation activities. Activities that affect water quality and increase turbidity should be undertaken in accordance with the NMFS GARFO/FHWA Best Management Practices (BMP) Manual and the FHWA Minimum Conservation Measures in Section 6 of the programmatic consultation. In addition:

1. Install and remove any in-water soil erosion, sediment, and turbidity controls outside of the TOY restrictions listed in Appendix C.

2. Conduct in-water work that produces turbidity or sedimentation in diadromous streams or EFH outside of the TOY restriction(s) in Appendix C.

3. Do not use any creosote, coal tar epoxy, or other hydrocarbon-based coatings on any in-water structures or overwater structures.
    - Dispose of any demolished structures treated with creosote, coal tar epoxy, or other hydrocarbon-based coatings in an approved upland disposal site.
4. In NJ only, in areas mapped as shellfish beds pursuant to N.J.A.C 7:7-9.2
    - all structures should be constructed with alternative materials, such as plastic, natural cedar or other untreated wood, or pressure-treated wood, coated offsite with an impact resistant, biologically inert substance to minimize leachate into shellfish areas.
    - Coat any chemically or pressure treated piles (CCA, ACQ, etc.) with an impact-resistant, biologically inert substance. Coating should be applied during the manufacturing process, not post-manufacturing by a third party or contractor.

Habitat Alteration

There are a number of different habitat alterations that may be covered under this programmatic consultation including the filling of aquatic habitat to create uplands, the conversion of one aquatic habitat type to another (e.g., intertidal to subtidal or intertidal/subtidal to wetlands). The applicable EFH conservation recommendations depend upon the type of alteration, as well as the duration of effects be it temporary or permanent. All activities should be undertaken in accordance with the NMFS GARFO/FHWA Best Management Practices (BMP) Manual and FHWA Minimum Conservation Measures in Section 6 of the programmatic consultation.

The following EFH conservation recommendations are provided to minimize adverse effects to EFH and the habitat of NOAA trust resources produced by transportation activities.

1. Provide compensatory mitigation for all permanent impacts to aquatic habitats and for temporary impacts in place over 12 months to address the temporal loss of aquatic habitat functions. This could include a contribution to an existing in-lieu fee

program. Because compensatory mitigation is intended to offset adverse effects of an action, it cannot be viewed separately from an action causing the effect.

When impacts are unavoidable:

- Conduct a pre-biological survey to map the coverage of the sensitive habitats;
- Develop a compensatory mitigation plan for biological resource losses, including success criteria, monitoring and adaptive management plans, and long-term maintenance plan. Use the 2008 Final Rule, Compensatory Mitigation for Losses of Aquatic Resources under Clean Water Act Section 404 (33 CFR Parts 325 and 332, 40 CFR Part 230) and NOAA's Mitigation Policy as guides for the development of the compensatory mitigation plan.
- Undertake compensatory mitigation prior to or concurrent with any impacts to sensitive habitat.

2. Prior to construction, identify and mark in the field any SAV and wetlands at the project site. An SAV survey is required for activities adjacent to mapped or known SAV if a survey has not been conducted in the previous three years.

3. Locate temporary structures, anchors, spud barges, and construction, access, and dewatering activities outside of special aquatic sites.

4. All in-water work, including dredging or discharge of fill material will be undertaken at, or approximating, low tide and using low ground pressure equipment to prevent compaction. Low ground pressure is defined as < 3 psi. Where construction requires heavy equipment operation in or across wetlands or mudflats, the equipment shall be placed on construction timber mats that are adequate to support the equipment; be operated on dry or frozen wetlands such that shear pressure does not cause subsidence of the wetlands immediately beneath equipment and upheaval of adjacent wetlands. Construction mats must not be dragged into position.

5. Remove temporary and/or obsolete structures and fills in their entirety, unless the structure or fill is to be left in place in order to comply with conditions imposed by other state or federal permits. Obsolete structures do not include any structures that are repurposed or preserved to prevent habitat degradation (e.g., abutments or sheet piling that remain in place for habitat or scour protection).

6. If rock relocation is necessary, move them to an area of equivalent depth and substrate.

7. The height of docks and piers must be at least four feet above salt marsh substrate and must be greater than or equal to the width of the deck to minimize shading impacts. The height must be measured from the marsh substrate to the bottom of the longitudinal support beam.

8. The lowermost part of floating docks must be greater than or equal to 18 inches above the substrate at all times to avoid grounding and propeller scour and to provide adequate circulation and flushing.

9. Habitat restoration or mitigation projects must not result in a permanent conversion or loss of sensitive habitats such as SAV, natural rocky habitats, areas containing shellfish, mudflats, and riffle and pool complexes.

10. Grain size of any sediment used as part of habitat restoration must be the same size or larger than the native material at the site. Material must be free from toxic chemicals (in excess of ERM values in NOAA SQuiRT tables), asphalt, and other trash or anthropogenic debris.

10. The following buffers apply between the following habitats and the top of slope of the area to be dredged/excavated. :

a) In New England, setbacks of 100 ft. from tidal SAV or 25 ft. from natural rocky habitats, Special Aquatic Sites (wetlands, mudflats, riffle/pool complexes) and areas containing shellfish.
b) In NY, NJ, DE and PA, dredging shall not occur within 25 ft. from the edge of vegetated wetlands.
c) In NY and NJ, dredging shall not occur within 500 ft. of SAV in sediments greater than or equal to 90% sand and 250 ft. of SAV if sediments are less than 90% sand during the growing season (April 15-October 15) to minimize impacts to SAV due to turbidity.
d) In Virginia and Maryland, dredging shall not occur in areas within the distance from wetlands equal to four times the depth of the dredging.
e) In Maryland, dredging shall not occur within 500 yds. of a natural oyster beds between December 16 to March 14 and June 1 to September 30

11. Do not discharge new or proposed outlets directly into sensitive habitats and redirect upgrades to existing outlets away from sensitive habitats.

Fish Passage/Migration Habitat

1. Design replacement crossings to provide anadromous and resident fish and aquatic organism passage to the maximum extent possible. Use the Federal Interagency Nature-like Fishway Passage Design Guidelines for Atlantic Coast Diadromous Fishes and Culvert Design For Aquatic Organism Passage FHWA-HIF-11-008) for design guidance. In addition, structures must:
    - provide sufficient water depth and maintain suitable water velocities during migration periods; and
    - maintain or replicate natural stream channel and flow conditions.

2. Replaced or upgraded crossings must be a similar or improved structure type and must be designed to provide diadromous and resident fish organism passage by providing sufficient water depth, maintaining suitable water velocities during migration periods, and maintaining or replicating natural stream channel and flow conditions. Upgraded crossings must be designed in accordance with the order of preference set out in NMFS' Anadromous Salmonid Passage Facility Design, unless such design is otherwise approved by the State Fisheries Agency.

3. For activities that require soil erosion, sediment, and turbidity controls, prevent impeding the run by incorporating the following:

   a) in non-tidal streams containing diadromous fish

      i. the activities must not encroach >25% of the stream width measured from ordinary high water during the anadromous TOY restriction unless such encroachment is otherwise approved by State Fisheries; and

      ii. In waterways supporting diadromous fish, the activities must maintain safe, timely, and effective downstream fish passage throughout the project.

   b) in tidal waters:

      i. The activities must not encroach >50% of a tidal stream's width as measured from mean high water unless such encroachment is otherwise approved by the State Fisheries Agency.

4. Incorporate climate change and sea level rise projections into the project design as appropriate to address changing hydrologic conditions (increased precipitation and stream flow, altered tidal regimes, etc.). Guidance can be found in NOAA Fisheries' national Procedure for Addressing Climate Change in NMFS Essential Fish Habitat Consultations and GARFO's Guidance for Integrating Climate Change Information in Greater Atlantic Region Habitat Conservation Division Consultation Processes, including the recommendation to use relevant local or regional climate prediction models where available as well as emission and climate projection scenarios on a global scale from the Intergovernmental Panel on Climate Change (IPCC). The use of a "high" (e.g., RCP/SSP8.5) and an "intermediate" (e.g., RCP/SSP 4.5 or RCP 6.0) scenario (IPCC 2021) is suggested. For SLR projections, at a minimum the 1.0 m mean global scenario is recommended with the relevant downscaled projections for the closest tide gauge location identified in Sweet et al. (2022).

Vessel Interactions

The following EFH conservation recommendations are provided to minimize adverse effects to EFH and NOAA trust resources produced by vessels activities.

1. Project vessels shall be operated in adequate water depths in the action area to avoid propeller scour and grounding at all tides. Shallow draft vessels will be used in shallow areas to maximize the navigational clearance between the vessel and the bottom substrate. Spuds may be used to elevate the vessel.

2. Project vessels shall not be moored in or use spuds in SAV or be located in such a way that the vessel could shade SAV.

3. Vessels transit through SAV shall be done at high tide.

Appendix C - Recommended Time of Year Restrictions

Time of year (TOY) restrictions are provided for each state in the GAR so that in-water work (i.e., turbidity producing activities) is avoided during sensitive life stages of managed species. These standard restrictions consider the breeding, nursery, and migration stages of managed species which are especially vulnerable to in-water silt-producing activities, noise impacts, or activities which may encroach greater than 25% into a waterway interfering with migration.

State	TOY Restrictions
Maine	Winter Flounder: March 15 to June 30 Diadromous Fish: April 1 to June 30 and September 1 to November 15* Shellfish: June 1 to October 31
New Hampshire	Winter Flounder: March 15 to June 30 Diadromous Fish: March 15 to June 30 and September 1 to November 15* Shellfish: June 1 to October 31
Massachusetts[1]	Winter Flounder: January 15 to June 30 or the TOY restriction for winter flounder provided in TR-47 for the area in which the project is located. Diadromous Fish: March 1 or June 30 and September 1 to November 30* or the TOY restrictions for diadromous fish provided in the MassMapper for the area in which the project is located. Shellfish: June 1 to October 31 The MA Division of Marine Fisheries developed Technical Report TR-47, “Recommended Time of Year Restrictions (TOYs) for Coastal Alteration Projects to Protect Marine Fisheries Resources in Massachusetts.” This provides site-specific TOY restrictions for waterbodies in MA. The MassMapper contains updated diadromous TOY restrictions that were previously in TR-47.
Rhode Island	Winter Flounder: February 1 to June 30 Diadromous Fish: March 15 to June 30 and September 1 to November 30* Shellfish: May 1 to October 14
Connecticut	Winter Flounder: January 1 to May 31 Diadromous Fish: April 1 to June 30 and September 1 to November 30* Shellfish: May 1 to September 30
New York	Winter Flounder: January 15 to May 31 Diadromous Fish: March 1 to June 30 and September 1 to November 30* SAV: April 15 to October 15 Overwintering Blue Crab: November 15 to April 15 (Channel areas in Raritan/Sandy Hook Bay and some coastal inlets) Overwintering Striped Bass: November 15 to April 15 (Lower Hudson River)

	Horseshoe Crab: May 15 to July 15 (Long Island beaches where spawning occurs)
New Jersey	Winter Flounder: January 1 to May 31 (north of Absecon Inlet 39° 22' N or the Atlantic City Expressway). Diadromous Fish: March 1 to June 30 and September 1 to November 30* SAV: April 15 to October 15 Overwintering Blue Crab: November 15 to April 15 (Channel areas in Raritan/Sandy Hook Bay and some coastal inlets.) Overwintering Striped Bass: November 15 to April 15 (Lower Hudson River) Sandbar Shark: April 15 to September 15 (Delaware Bay and Great Bay/Little Egg Inlet) Horseshoe Crab: April 15 to September 15 (Delaware Bay)
Pennsylvania	Diadromous Fish: March 15 to June 30 and September 1 to November 30*
Delaware	Diadromous Fish: March 15 to June 30 and September 1 to November 30* SAV: April 15 to October 15 Sandbar Shark: April 15 to September 15 (Delaware Bay) Horseshoe Crab: April 15 to September 15 (Delaware Bay)
Maryland	Diadromous Fish: February 15 to June 15 and September 1 to November 30* SAV: April 15 to October 15 Dredging within 500 yards of a natural oyster bar (NOB) boundary: December 16 to March 14 and June 1 to September 30
Virginia	Diadromous Fish: February 15 to June 30 SAV: April 1 to October 15 Shellfish reefs: June 1 to September 30

*All anadromous areas: Use the fall TOY restriction in cases where an action will substantially block the waterway in the fall.

[1] The Massachusetts Division of Marine Fisheries (MA DMF) developed site-specific TOY restrictions by waterbody. Refer to the MA DMF TOY document for applicable locations.

Appendix D. FHWA/State DOT Standard Operating Procedures

Federal Highway Administration (FHWA) and State Departments of Transportation (DOT) Standard Operating Procedures

For

NOAA's National Marine Fisheries Service (NMFS), Greater Atlantic Regional Fisheries Office, Programmatic Essential Fish Habitat (EFH) Consultations

I. Initial Screening Process

FHWA/state DOT or local government transportation agency will screen the project for the presence of Essential Fish Habitat (EFH) and federally managed species using the EFH mapper. FHWA/state DOT or local government transportation agency will also determine whether anadromous fish or other NOAA trust resources are present using the information and resources in Appendix H.

If EFH may be present within the project action area, then FHWA/state DOT or local government transportation agency will review the programmatic EFH consultation to determine whether the project conforms to the activity description and the specified criteria and limitations. For any EFH consultation on Federal-Aid Highway Program projects, FHWA shall be the lead federal agency for the purposes of the consultation.

State DOTs are not required to consult with HESD if FHWA is not providing funding for the proposed action. However, consultation by the lead federal agency, such as the US Army Corps of Engineers of the US Coast Guard, may be still required if action adversely affects EFH or other NOAA trust resources.

II. Impact Determination and Consultation Type

Once there is sufficient information on the project design relation to effects to EFH (See the Consultation Process Guide), FHWA/state DOT will make an EFH determination on the project effects using the following standards. This determination will consider the definition of adverse effect in the EFH Final Rule as:

- "Any impact which reduces the quality and/or quantity of EFH;"
- An adverse effect may include direct or indirect physical, chemical or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat and other ecosystems components, and may result from actions occurring within EFH or outside EFH;
- An adverse effect may also include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions.

In order for there to be sufficient information to determine effects, FHWA/state DOTs should have information on potential the means, methods, and materials that may be used for the proposed actions, the timing and project schedule, areal extent of impacts to aquatic habitats including SAS and EFH, impact avoidance and minimization methods to be employed, and any conceptual compensatory mitigation plan needed to offset unavoidable adverse impacts. As discussed in Section 2.4 of the programmatic consultation, because compensatory mitigation is intended to offset adverse effects of an action, it cannot be viewed separately from an action causing the effect.

A. Determination of No Adverse Effects to EFH

If the proposed action does not adversely affect EFH (including non-EFH trust resources) temporally or spatially, FHWA/state DOT may determine that an action will not adversely affect EFH, and no EFH consultation is required. It is not necessary to notify HESD or seek NMFS' concurrence with the determination if there is no adverse effect to EFH or NOAA trust resources. When considering this determination, FHWA/State DOTs must consider the definition of "adverse effect" described above and in the EFH final rule published in the Federal Register on January 17, 2002 (50 CFR 600.810). HESD staff should be contacted if there are any questions regarding the determination of effects.

B. Determination of Adverse Effects to EFH

If the proposed action adversely affects EFH (including non-EFH-trust resources), then FHWA/state DOT will determine if the action is eligible for under the programmatic consultation, or if individual EFH consultation with HESD is required. HESD staff should be contacted if there are any questions about the level of consultation needed.

1. For activities that are eligible for the programmatic consultation or General Concurrence additional coordination with HESD is not required. These actions must still be tracked by FHWA/state DOTs and reported in the Annual Report.

    a. To be eligible for the programmatic consultation, the proposed action should incorporate all of the relevant FHWA Minimum Conservation Measures described in Section 6 of the programmatic consultation.

    b. Actions that do not include all of the applicable programmatic EFH Conservation Recommendations identified in Appendix B, may still be eligible for the programmatic consultation, but information on these specific actions must be included in the Annual Report. A project information sheet for each of these actions must be included in an appendix to the report. Information in the appendix should include the name and location of the project, the type of activities proposed, and the EFH conservation recommendations that were not followed and the rationale.

2. Activities Requiring Project Specific Consultation

    a. FHWA/state DOT will initiate project specific EFH consultation with HESD for any excluded activity or impact above the thresholds listed in Appendix A. The thresholds for requiring project specific EFH consultation are based upon single and complete projects and all direct, secondary, and indirect impacts. Any compensatory mitigation is considered part of the single and complete project.

b. Project specific consultation can be either abbreviated or expanded. See definitions in Appendix E.

c. FHWA/state DOT will email an EFH consultation initiation request with all of the necessary information to HESD will email the EFH consultation request to HESD's New England (ME, NH, MA, CT, RI) or Mid-Atlantic (NY, NJ, PA, DE, MD, DC, VA) Branch Chief and the regional biologist listed on the Contact Regional Office Staff section on the HESD EFH consultation website.

d. The level of detail in an EFH assessment should be commensurate with the complexity and magnitude of the potential adverse effects of the action. For example, for relatively simple actions involving minor adverse effects on EFH, the assessment may be very brief. Actions that may pose a more serious threat to EFH warrant a correspondingly more detailed EFH Assessment. The information required for both abbreviated and expanded individual EFH consultation includes:

    i. A full and complete EFH assessment that includes an analysis of potential adverse effects on EFH and managed species as well as measures to avoid, minimize or mitigate the impacts. Mandatory contents of an EFH assessment include:

        1. A complete description of the action.
        2. An analysis of the potential adverse effects of the action on EFH and the managed species.
        3. The FHWA/state DOT's conclusions regarding the effects of the action on EFH.
        4. Proposed mitigation, if applicable
        5. Additional information. If appropriate, the assessment should also include:
            a. The results of an on-site inspection to evaluate the habitat and the site-specific effects of the project.
            b. The views of recognized experts on the habitat or species that may be affected.
            c. A review of pertinent literature and related information.
            d. An analysis of alternatives to the action. Such analysis should include alternatives that could avoid or minimize adverse effects on EFH.
            e. Other relevant information.
        6. Project plans showing existing and proposed conditions as well as all waters of the U.S. on the project site, mean low water and mean high water clearly marked, and sensitive habitats mapped, including special aquatic sites (SAS),

natural rocky habitats, intertidal areas, and/or areas containing shellfish;

7. Current SAV survey results conducted in accordance with the Joint Federal Agency Submerged Aquatic Vegetation Survey Guidance, or other locally approved method, where appropriate.
8. Current shellfish survey results conducted within the project area where appropriate;
9. Site photographs, if available.

e. Upon receiving a complete EFH assessment, HESD will respond to FHWA/state DOT within 30 calendar days for an abbreviated consultation and within 60 calendar days for an expanded consultation by providing one of the following:
   i. EFH conservation recommendations for the activity;
   ii. Concurrence that impacts are not more than minimal and conservation recommendations are not necessary for the activity; or
   iii. A request for additional information to better understand the project and/or determine the effects to be able to complete consultation.

Appendix E. Definitions

Abbreviated Consultation: Abbreviated consultation allows NMFS to determine quickly whether, and to what degree, a federal action may adversely affect EFH. Federal actions that may adversely affect EFH should be addressed through the abbreviated consultation procedures when those actions do not qualify for a General Concurrence, but do not have the potential to cause substantial adverse effects on EFH. For example, the abbreviated consultation procedures should be used when the adverse effect(s) of an action could be alleviated through minor modifications. (50 CFR 600.920(h))

Adverse effect: 50 CFR 600.810(a) states, "Adverse effect means any impact that reduces quality and/or quantity of EFH. Adverse effects may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH. Adverse effects to EFH may result from actions occurring within EFH or outside of EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions." Examples of adverse effects to natural rocky habitats include alteration to habitat utility such as beach nourishment over natural rocky habitat or chain scour to sites containing epifauna/macroalgae.

Anadromous fish: The Magnuson-Stevens Fishery Conservation and Management Act, Sec. 3 Definitions, states, "The term "anadromous species" means species of fish which spawn in fresh or estuarine waters of the United States and which migrate to ocean waters."

The following anadromous fish species occur within the Greater Atlantic Region

- American shad: *Alosa sapidissima*
- Blueback herring: *Alosa aestivalis*
- Alewife: *Alosa pseudoharengus*
- Hickory shad: *Alosa mediocris*
- Striped bass: *Morone saxatilis*
- Rainbow smelt: *Osmerus mordax*
- Atlantic salmon: *Salmo salar*
- Atlantic sturgeon: *Acipenser oxyrhynchus oxyrhynchus*
- Shortnose sturgeon: *Acipenser brevirostrum*

Anadromous fish provide a food source for several federally managed species (Buckel and Conover 1997, Steimle et al. 2000, McDermott et al. 2015). Anadromous species, including blueback herring, alewife, and American shad have been declining in numbers over the last several decades, largely due to fishing pressure and habitat loss (ASMFC 2009). Anadromous fish can be significantly impacted by waterway blockages during their upstream or downstream migrations. Blockages to fish movement can be caused by physical structures in the waterway such as dams or fill. Fish migration can also be blocked by turbidity plumes, thermal plumes or acoustic events. Suspended sediment can mask pheromones used by migratory fishes to reach their spawning grounds, impede their migration, and can smother immobile benthic organisms and newly settled juvenile demersal fish (Auld and Schubel 1978; Breitburg 1988; Newcombe and MacDonald 1991; Burton 1993; Nelson and Wheeler 1997). Anadromous fish serve as prey for a number of federally managed species and are therefore considered a component of EFH pursuant to the MSA. Actions that reduce the availability of prey species, either through direct harm or capture or through adverse impacts to the prey species' habitat are considered adverse effects on EFH.

Appropriate soil erosion, sediment and turbidity controls: These include, but are not limited to, cofferdams, bypass pumping around barriers immediately up and downstream of the work footprint (i.e., dam and pump), installation of sediment control barriers (i.e., silt turbidity curtains, filter tubes, geotextile silt fences or other devices) waterward of the work area, retention of existing vegetated buffers, and/or phased construction. Note: Filter tubes and other such devices that incorporate a filter material inside a casing should be composed of fully biodegradable materials or installed in a manner (e.g. on top of filter fabric or mats) that allows for full removal of all non-biodegradable material.

Eligible Transportation Activities: Eligible transportation activities are those activities that are funded or authorized by FHWA that may adversely affect EFH and/or other NOAA trust resources, but due to the nature and scale of the impacts, the required EFH consultation can be completed using the programmatic EFH consultation.

Essential Fish Habitat (EFH): Per 50 CFR 600.10, EFH is defined as, "Those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of essential fish habitat: "Waters" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers a species full life cycle." For more info see: https://www.fisheries.noaa.gov/national/habitat-conservation/essential-fish-habitat#essentially,-fish-habitat
and https://www.fisheries.noaa.gov/new-england-mid-atlantic/habitat-conservation/essential-fish-habitat-consultations-greater-atlantic-region.

Expanded Consultation: Expanded consultation allows maximum opportunity for NMFS and the federal agency to work together to review the action's impacts on EFH and to develop EFH Conservation Recommendations. Expanded consultation procedures must be used for Federal actions that would result in substantial adverse effects to EFH. (50 CFR 600.920(i))

Habitat Area of Particular Concern (HAPC): The Magnuson-Stevens Act, HAPCs are now defined as subsets of EFH that exhibit one or more of the following traits: rare, stressed by development, provide important ecological functions for federally managed species, or are especially vulnerable to anthropogenic (or human impact) degradation. They can cover a specific location (a bank or ledge, spawning location) or cover habitat that is found at many locations (e.g., coral, nearshore nursery areas, or pupping grounds).

Industrial Sandbag Water Diversions are large bags made of a heavy poly material that can be filled with sand and are effective at stopping water flow. Each bag is filled with sand and then lowered in place with heavy equipment. A sheet of plastic is sometimes incorporated under and in front of the sandbag enclosure to aid in sealing of water flow. The contractor may choose to create portions of the cofferdam out of small sandbags, jersey barriers or concrete blocks. Water depths may dictate that multiple sandbags are stacked on top of one another.

Ineligible Transportation Activities: Ineligible transportation projects are those activities that are funded or authorized by FHWA that may adversely affect EFH and/or other NOAA trust resources, but due to the nature and scale of the impacts, the required EFH consultation cannot be completed using the programmatic EFH consultation. These activities are listed in Appendix A, and require project specific consultation. Project specific consultation may either be an Abbreviated Consultation or an Expanded Consultation depending upon the nature and scale of the adverse effects to EFH.

Intertidal Habitat: The area between HTL and MLLW. Intertidal habitats are exposed during low tides.

Permanent adverse effects: Permanent adverse effects mean waters of the U.S. that are permanently affected by filling, flooding, excavation or drainage because of the regulated activity. Permanent adverse effects include permanent discharges of dredged or fill material that change an aquatic area to dry land, increase the bottom elevation of a waterbody, or change the use of a waterbody.

Sandbag cofferdams are a more cost effective and turbidity limiting method of isolating an in-water work site compared to other cofferdam options but are generally limited to water depths less than 6 feet. If a project requires excavation of more than ~2 feet (for bridge abutment removal or forming of a spread footing) sheet piles can be driven into the substrate to cut water inflow off a deeper level and result in a more structurally sound/safer work area. From past construction experience, FHWA estimates that for crossing replacements <20 feet in width, sandbags are used 95 percent of the time and sheet piles are used 5 percent of the time. For crossing replacements that are >20 feet sheet piles are used 60 percent of the time and sandbags are used 40 percent of the time. The increase in use of sheet piles for large bridges is due to the increases in water depths (greater than 6 feet) at larger crossings.

Sheet piling is an earth retention and excavation support technique that retains soil and reduces groundwater inflow using steel sheet sections with interlocking edges. Sheet pile retaining walls are usually used in soft soils and tight spaces. Sheet pile walls are made out of steel, vinyl or wood planks that are driven into the ground. For a quick estimate, the material is usually driven 1/3 above ground and 2/3 below ground, but this may be altered depending on the environment and substrate. Sheet piles are particularly challenging to drive under low bridge decks as clearance for heavy machinery needed to lift and drive the piles is limited.

Special aquatic sites: These include inland and saltmarsh wetlands, mud flats, vegetated shallows, sanctuaries and refuges, coral reefs, and riffle and pool complexes. These are defined at 40 CFR 230.3 and listed in 40 CFR 230 Subpart E.

Temporary impacts: Temporary impacts include, but are not limited to, waters of the U.S. that are temporarily filled, flooded, excavated, or drained because of the regulated activity.

Appendix F. Habitat Descriptions

Areas Containing Shellfish

Shellfish provide an important ecological role through water column filtration, sediment stabilization, and supplying habitat for multiple fish species (Zimmerman et al. 1989; Dame and Libes 1993; Coen et al. 1999; Nakamura and Kerciku 2000; Forster and Zettler 2004; Newell 2004; Coen and Grizzle 2007; McDermott et al. 2008). They are also an important food source for federally managed species (Steimle et al. 2000). Shellfish are susceptible to elevated levels of suspended sediments, which can interfere with spawning success, feeding, and growth for species such as mussels, clams, and oysters (Wilber and Clarke 2001). Sessile species and life history stages such as shellfish or demersal eggs of winter flounder are highly vulnerable to smothering and activities that may result in dislodgement of recently settled individuals. The water quality classification or whether or not shellfish harvesting is permitted or prohibited in a particular area is not relevant for the purposes of EFH or FWCA consultation

Calcifying marine organisms, including mollusks, are particularly sensitive to changes in pH, carbonate ion concentration, and the saturation state of calcium carbonate minerals – collectively known as ocean acidification (Gazeau et al. 2007; Talmage and Gobler 2010; Gazeau et al. 2013; Waldbusser et al. 2015). Gulf of Maine coastal areas are particularly susceptible to ocean acidification because cool water temperature and river discharges containing low alkalinity waters reduce the buffering capacity of estuarine and coastal waters (Gledhill et al. 2015; Salisbury et al. 2008).

Intertidal Habitat

The area between the high tide line (HTL) and mean low lower water (MLLW). Intertidal habitats are exposed during low tides. Intertidal habitats support distinct marine communities and provide important foraging habitats and areas of refuge from predation for juvenile fish during periods of high tide (Helfman et al. 2009). Intertidal habitats include salt marsh, mud and sandflats, sandy beaches, and rocky shorelines. The functional value of these habitats may be adversely impacted by activities that result in increased erosional rates, changes in slope profiles, habitat conversions, and/or decreased connectivity with shallow water subtidal habitats.

Intertidal Mudflats

Mudflats, also known as tidal flats, are exposed during low tides. In tidal areas, mudflats exist waterward of salt marshes and next to sand flats in sheltered areas/protected parts of estuaries (river mouths to the head of tidal influence, coves and bays) with low wave action where sediment-laden water can sit and fine particles can drop out. Mudflats serve as EFH for multiple managed fish species during spawning, juvenile, and/or adult life history stages. The U.S. Environmental Protection Agency designated mudflats as an SAS under Section 404(b)(1) of the Clean Water Act, due to their important role in the marine ecosystem for spawning, nursery cover, and forage areas for fish and wildlife. Juvenile fish and invertebrates seek shelter in mudflats by burrowing into the soft sediments. Mudflats support distinct benthic communities that provide important prey and foraging habitat for managed fish species (Cargnelli et al. 1999; Chang et al. 1999; Pereira et al. 1999; Stevenson et al. 2014). These habitats are particularly vulnerable to disturbances that may result in turbidity or scouring impacts. Compensatory mitigation for impacts to intertidal mudflat habitat can be difficult to implement, making this habitat especially vulnerable to permanent loss.

The 404(b)(1) Guidelines (40 CFR 230.42) state:

> (a) Mud flats are broad flat areas along the sea coast and in coastal rivers to the head of tidal influence and in inland lakes, ponds, and riverine systems. When mud flats are inundated, wind and wave action may resuspend bottom sediments. Coastal mud flats are exposed at extremely low tides and inundated at high tides with the water table at or near the surface of the substrate. The substrate of mud flats contains organic material and particles smaller in size than sand. They are either unvegetated or vegetated only by algal mats.
>
> (b) Possible loss of values: The discharge of dredged or fill material can cause changes in water circulation patterns which may permanently flood or dewater the mud flat or disrupt periodic inundation, resulting in an increase in the rate of erosion or accretion. Such changes can deplete or eliminate mud flat biota, foraging areas, and nursery areas. Changes in inundation patterns can affect the chemical and biological exchange and decomposition process occurring on the mud flat and change the deposition of suspended material affecting the productivity of the area. Changes may reduce the mud flat's capacity to dissipate storm surge runoff.

Natural Rocky Habitats/Hard Bottom Habitat

Natural rocky habitats are intertidal and subtidal substrates composed of pebble-gravel, cobble, boulder, or rock ledge and outcrops. Manufactured stone (e.g., cut or engineered rip-rap) is not considered a natural rocky habitat. Natural rocky habitats are found either as pavement (consolidated pebble-gravel, cobble or boulder areas) or as a mixture with fines (i.e., clay and sand) and other substrates.

Rocky habitats as EFH are defined as follows:

1) All pebble-gravel, cobble or boulder pavements
2) Pebble-gravel mixed with fines: Mixed substrate of pebble-gravel and fines where pebble-gravel is an evident component of the substrate (either through visual observation or within sediment samples). Sediment samples with a content of 10% or more of pebble-gravel in the top layer (6- 12 inches) should be delineated.
3) Scattered cobble, scattered boulder, scattered cobble/boulder: Mixed substrate of cobble and/or boulder and other substrates. The aerial extent of cobbles and/or boulders should be delineated.
4) All rock ledge/outcrops: Area should be delineated along the edge of the ledge/outcrop.

Structural complexity of habitats such as gravel, cobble, and boulders provide important functional value for fish as shelter and refuge from predators (Auster 1998; Auster and Langton 1999; NRC 2002; Stevenson et al. 2006). The relationship between benthic habitat complexity and demersal fish community diversity has been positively correlated (Malek et al. 2010). Multiple managed fish species have life-history stages that are dependent on, or mediated by, hard bottom habitats and attributes (Gotceitas et al.1995; Lindholm et al. 1999; Klein-MacPhee 2002; Auster 2001; Auster 2005; Methratta and Link 2006). Hard bottom habitats provide a substrate for epibenthic growth, which serves as additional refuge for juvenile fish and has been shown to significantly increase survivorship of juvenile cod (Lindholm et al. 1999 and 2001). These complex benthic substrates are vulnerable to disturbances that reduce complexity, particularly due to their extended recovery times (Bradshaw et al. 2000; Collie et al. 2005; Tamsett et al. 2010). Due to their susceptibility to impacts, long recovery times, and importance in the juvenile life history of Atlantic cod as well as other managed fish species, the *New England Fishery Management Council* has designated hard bottom habitats extending from MHW to depths of 20 meters from Maine through Rhode Island as a nearshore HAPC for juvenile cod.

Applicability of Juvenile Atlantic cod HAPC:

In order to determine if a rocky habitat is consistent with the juvenile Atlantic cod HAPC, natural rocky habitats should be defined and delineated as described above. In addition, the presence or absence of attached epifauna and macroalgae is also necessary. All special aquatic sites (SAS) in the project area must also be delineated in the field, remotely or using online tools, as appropriate, and identified on the project plans. Information on the historical or current presence of SAV can be determined with the online mapping resources in Appendix H.

<u>Photographic examples</u>

Pebble-gravel pavement (left) and cobble/boulder pavement with macroalgae (right). Credit: K. Shaw

Cobble/boulder pavement (not including groin) Credit: K. Shaw

Cobble/boulder pavement (borderline "scattered")
Credit: K. Shaw

"Scattered" cobble/boulders
Credit: K. Shaw

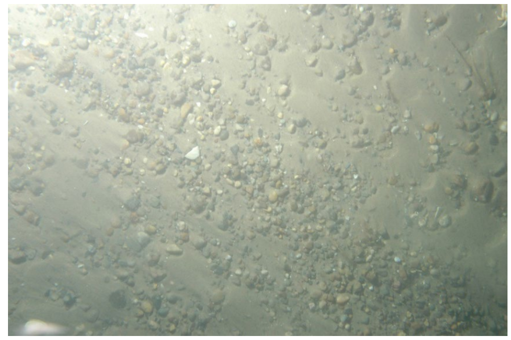
Pebble-gravel pavement (bottom), "scattered" area of cobble/boulder left, sand and patches of pebble- gravel (top). Credit: K. Shaw

Pebble-gravel pavement. Credit: K. Shaw

"Scattered" boulders/cobble, but underlying pebble- gravel pavement. Credit: K. Shaw

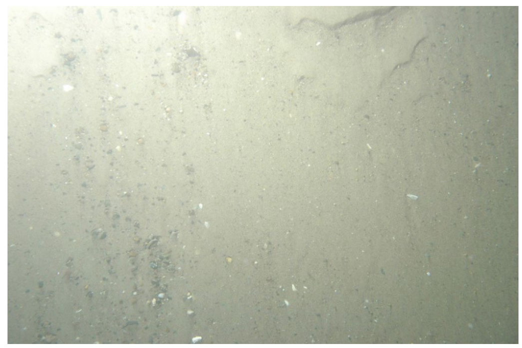
"Scattered" boulders, but underlying pebble-gravel pavement. Credit: K. Shaw

"Scattered" boulders/cobble and pebble-gravel patches. Credit: K. Shaw



Patch of pebble-gravel pavement (middle band), mixed gravel right-top and left-bottom, define as pavement unless sampling determines less than 10% pebble-gravel content. Credit: K. Shaw

Pebble-gravel and cobble pavement area. Credit: K. Shaw



Define as sand, low percent pebble-gravel content. Credit: K. Shaw

Diadromous Fish/Prey Species

Diadromous fish migrate between salt and freshwater to complete their complex life histories. They also provide a food source for many federally managed species (Buckel and Conover 1997; Steimle et al. 2000; McDermott et al. 2015). Diadromous species, including blueback herring, alewife, rainbow smelt, and American shad have declined in numbers over the last several decades, largely due to fishing pressure and habitat loss (ASMFC 2009). Diadromous fish are significantly impacted by waterway blockages during their upstream or downstream migrations. Physical structures in the waterway can block fish movement, and fish migration can also be blocked by turbidity plumes, thermal plumes, or acoustic events. Suspended sediment can mask pheromones used by migratory fish to reach their spawning grounds, impede fish migration, and can smother immobile benthic organisms and newly settled juvenile demersal fish (Auld and Schubel 1978; Breitburg 1988; Newcombe and MacDonald 1991; Burton 1993; Nelson and Wheeler 1997). Dredging, as well as the intake of water for various construction and dewatering activities can result in the impingement and entrainment of eggs, larvae and free swimming organisms, including anadromous fish, which can lead to injury and mortality. Diadromous fish are considered a component of EFH pursuant to the MSA because they serve as prey for a number of federally managed species. Actions that reduce the availability of prey species, either through direct harm or capture or through adverse impacts to the prey species' habitat, are considered adverse effects on EFH.

Salt Marsh and Tidal Wetlands

Tidal wetlands are important for healthy fisheries and coastlines. Salt marshes and tidal creeks provide food, refuge, and nursery habitat for several federally managed species. These systems support many forage fish and invertebrates that serve as prey for commercially and recreationally valuable fish (Steimle et al. 2000). Salt marshes also protect shorelines from erosion by buffering wave action and trapping sediments. They reduce flooding by absorbing rainwater and protect water quality by filtering runoff and metabolizing excess nutrients. Given the importance of this habitat, impacts to tidal wetlands will significantly affect a variety of species and habitats.

Tidal wetlands can also sequester atmospheric carbon dioxide in soils for centuries to thousands of years, making these habitats important in mitigating climate change. Stored carbon often is released to the atmosphere when wetlands are destroyed or converted to a different habitat type (Chmura et al. 2003; Duarte and Cebrián 1996; Pendleton et al. 2012). Mcleod et al. (2011) reported estimates of global mean organic carbon burial rates for salt marsh wetlands to be 4.8–87.2 teragrams (Tg) of carbon per year, respectively (1 Tg = 1 million metric tons).

Salt marshes and other coastal wetlands face degradation and loss from a number of anthropogenic causes, including stormwater pollution, eutrophication and general water quality degradation, navigational dredging, shoreline hardening, dredging and filling for coastal development, and the spread of invasive species, and climate change (Deegan and Buchsbaum 2005; Lotze et al. 2006; Johnson et al. 2008; Johnson et al. 2019; Kennish et al. 2014; Smith et al. 2017). Many coastal emergent wetlands in the Northeast U.S. have failed to keep pace with SLR over the past few decades (Kolker et al. 2010; Crosby et al. 2016; Carey et al. 2017; Watson et al. 2017), leading to erosion and submergence of marsh platforms, and loss of coastal wetland habitat (Scavia et al. 2002; Nicholls and Cazenave 2010). The mean rate of SLR in the Northeast U.S. over the 20th and 21st centuries has been approximately 2–6 mm per year (NOAA 2021), and could increase to approximately 11-14 mm per year by the end of the century under a 1.0 m global SLR scenario (Sweet et al. 2022). Some studies in the northeast U.S. have reported maximum vertical accretion rates for coastal emergent wetlands of around 5–7 mm per year (Cahoon et al. 2009; Carey et al. 2017; Donnelly and Bertness 2001; Kirwan et al. 2010), suggesting that many coastal emergent wetlands may become inundated by rising sea levels in the second half of the 21st century unless migratory pathways for wetlands is provided. However, coastal areas hardened by shoreline structures can restrict the capacity of wetlands to migrate inland with increasing SLR (Nicholls et al. 1999; Kennedy et al. 2002; Titus et al. 2009). A climate vulnerability assessment conducted for habitats in the Northeast U.S. coast found emergent tidal wetlands as having very high climate vulnerability (Farr et al. 2021).

Shallow Water Habitat

Shallow water coastal, marine, and estuarine habitats are important for multiple managed fish species for spawning, juvenile, and/or adult life history stages (Cargnelli et al. 1999; Chang et al. 1999; Pereira et al. 1999; Stevenson et al. 2014). Because of their shallow depths, seasonally warm water temperatures, and proximity to nutrients derived from river runoff, these habitats are highly productive (Stevenson et al. 2014). Each shallow water habitat type provides EFH for multiple managed fish species. Mud and sand habitats support distinct benthic communities that serve as EFH for managed fish species by directly providing prey and foraging habitat, or through emergent fauna providing increased structural complexity and shelter from predation. Habitat attributes within fine- grained substrates also provide important functions for managed fish species including shelter, foraging, and prey (Wicklund 1966; Ogren et al. 1968; Stanley 1971; Shepard et al. 1986; Able and Fahay 1998). Sand waves and ridges in shallow areas serve as valuable habitat for refuge and shelter, as well as habitat for spawning and juvenile development for a variety of managed species. Gravel, cobble, and boulder habitats provide structural complexity for managed fish species that require shelter and seek refuge from predation (Auster 1998; Auster and Langton 1999; NRC 2002; Stevenson et al. 2006; Stevenson et al. 2014). Due to their proximity to the coast, these shallow water habitats are vulnerable to degradation and loss from human activity.

Submerged Aquatic Vegetation (SAV)

SAV, including estuarine species (e.g., eelgrass, widgeon grass) and freshwater species (e.g., wild celery, curly pondweed, slender pondweed), plays a critical ecosystem role. The U.S. Environmental Protection Agency designated SAV (known as vegetated shallows) as an SAS under Section 404(b)(1) of the Clean Water Act, due to its important role in the aquatic ecosystems for nesting, spawning, nursery cover, and forage areas for fish and wildlife. SAV provides important ecological services including fish and shellfish habitat, shore-bird feeding habitats, nutrient and carbon cycling, sediment stabilization, and biodiversity (Thayer et al. 1984; Fonseca and Cahalan 1992; Fonseca et al. 1998; Kenworthy et al. 1988; Orth et al. 2006). Furthermore, the Mid-Atlantic Fishery Management Council designated SAV, including estuarine and freshwater species, as a HAPC for summer flounder EFH. The New England Fishery Management Council has also identified SAV as an important habitat for winter flounder in their Omnibus Essential Fish Habitat Amendment 2.

In many locations along the east coast of the U.S., eelgrass coverage has declined by 50% or more since the 1970’s (Thayer et al. 1975; Short et al. 1993; Short and Burdick 1996). Loss of eelgrass is attributed to reduced water quality and clarity resulting from elevated inputs of nutrients or other pollutants such as suspended solids and disturbances such as excavation (Kemp et al. 1983; Short et al. 1993; Short and Burdick 1996; Orth et al. 2006). The environmental effects of excess nutrients and elevated suspended sediments are the most common and significant causes of SAV decline worldwide (Orth et al. 2006).

Eelgrass may also be adversely affected through shading and burial or smothering resulting from turbidity and subsequent sedimentation (Deegan and Buchsbaum 2005; Duarte et al. 2005; Johnson et al. 2008). In Massachusetts, surveys from 1995 to 2007 show statewide declines in seagrass cover in 90% of the embayments where it was studied (Costello and Kenworthy 2011). In New Hampshire, eelgrass distribution throughout the entire Great Bay Estuary has declined precipitously since 1996, with a loss of 76% in the Great Bay and extirpation of nearly all beds in the Piscataqua River during that time (Short 2013). Large scale SAV declines have also occurred in Chesapeake Bay in Maryland and Virginia, where overall abundance was reduced by 90% during the 1960s and 1970s (Goldsborough 1997). Although a modest recovery of historic SAV distribution was seen in Chesapeake Bay over the past few decades, reduced light penetration in the water column from nutrient enrichment and sedimentation continues to impede substantial restoration.

In addition, there is growing evidence that climate change may be having additional negative cumulative effects on SAV through warming waters, reduced dissolved oxygen, sea level rise, and changes in salinity (Björk et al. 2008; Short and Neckles 1999; Short et al. 2016). SAV is also important in sequestering atmospheric carbon dioxide, providing an important service in addressing climate change. SAV occupies less than 0.2% of the area in the world's oceans, yet sequesters approximately 10% of the annual organic carbon burial in the oceans (Duarte et al. 2005). The mean global long-term rate of carbon sequestration in SAV sediments is an order of magnitude greater than terrestrial forests (Mcleod et al. 2011).

Given the widespread decline in eelgrass beds in the GAR, any additional loss of this habitat will significantly affect the resources that depend on these beds. Successful compensatory mitigation for impacts to SAV can be costly and difficult to implement, making this habitat especially vulnerable to permanent loss.

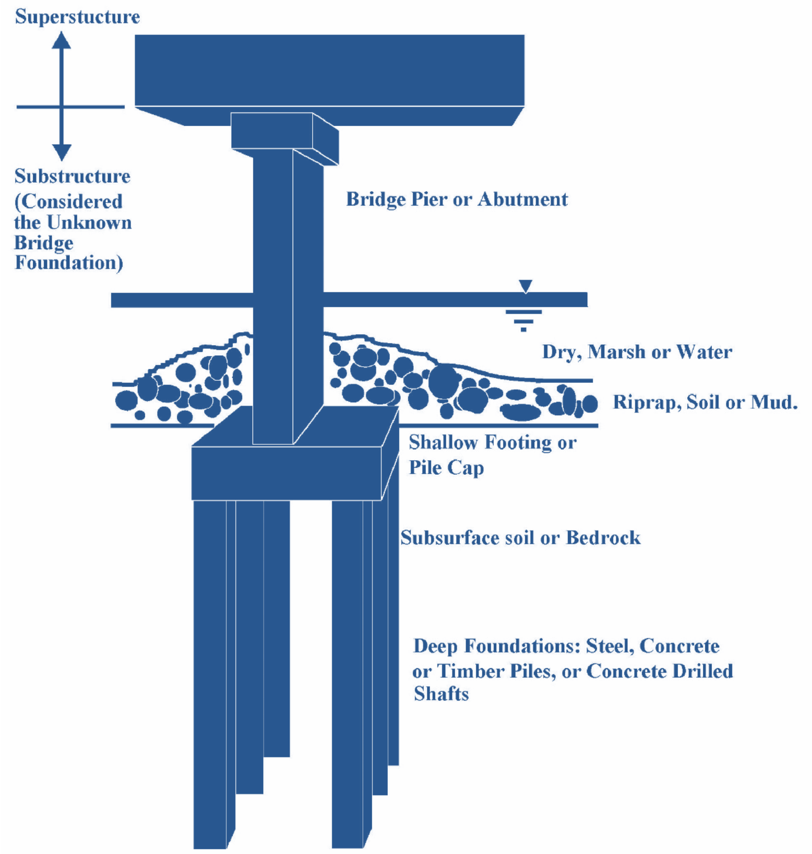
Appendix G. Detailed Description of Select Transportation Activities

Bridge/Structure Demolition

Transportation projects may involve mechanical dismantling of structures from an adjacent structure or barge, or via land. Structural components are removed using mechanical demolition methods. Demolition debris is typically removed mechanically and demolished structures are typically barged or trucked off site for disposal. Bridge demolition often begins by cutting the bridge deck into pieces that can be removed with an excavator. Measures are taken to contain debris including lifting the bridge away from the river and containing debris with items such as tarps or shielding hanging under the bridge. The contractor must submit a demolition plan for approval prior to starting. The plan will include measures the contractor plans to implement to contain demolition debris.

Typical abutment removal involves pulling material away from the stream channel (which is confined from the work area) using an excavator bucket to avoid demolished material falling into flowing water. An excavator mounted hydraulic breaker may also be used to break large pieces of concrete to facilitate removal and hauling. The amount of excavation around the abutment is dependent upon the design for the replacement bridge.

Figure 1. Bridge Structure Example



Credit: FHWA

After the bridge deck has been removed, the contractor will isolate the demolition work areas from the regulated areas, then remove the existing support piles. Piles may be removed one of the following three ways:

- Using a vibratory extractor;
- Pulled out using an excavator;
- Cut flush with or below the surrounding substrate using an underwater saw.

'Pulling' a pile may generate higher levels of turbidity than the other two options. If pulling is the chosen method, the work will be completed using a BMP specifically for minimizing turbidity, such as a turbidity curtain.

A hoe ram is often used to demolish concrete bridge piers. Concrete piers typically consist of large rebar cages, so a hoe ram may be required to break the piers apart. Hoe rams use a series of impacts with the breaker portion of the machinery to break the concrete up into smaller pieces (4-5 feet) that can be removed. The hoe ram is typically attached to the arm of an excavator. In-water demolition that involves excavation and hoe ram use often occurs in an isolated work area (see 4.2.1).

Bridge/Structure Replacement

Much of the in-water work in EFH focuses on foundation work. This will take place behind a cofferdam as Standard Specifications do not allow fresh concrete in contact with a waterbody.

Major abutment types include integral abutments and vertical abutments founded on spread footings or piles. Integral abutments that are founded on piles or abutments that are on a spread footing. Footings can also be founded directly on bedrock that must be flattened prior to construction. To flatten the ledge, a hydraulic breaker may be used to remove ledge to a consistent elevation. A spread footing foundation that is not founded on a ledge requires a large mass of concrete to be placed at approximately 6 feet below the thalweg of the stream. This may require excavation, primarily outside or adjacent to the stream.

After the abutments are complete, the superstructure will be constructed and attached to the abutments. If in-water piers are part of the replacement design, they are typically either concrete spread footing piers, pile bents or drilled shafts.

Sliplining/Invert Lining

Aging corrugated metal culverts that convey streams and stormwater conveyances under major highways require repair or replacement. In many cases, culverts are covered by significant amounts (greater than 20 ft.) of earthen fill and are located under high traffic volume roads. Complete culvert removal can be expensive and present a multitude of construction and traffic issues since removal of culverts under large amounts of fill require large open trench cuts.

Culverts are sometimes rehabilitated with a method called “sliplining” and invert lining. This technique involves placement of a smaller diameter culvert or pouring a new concrete invert within the larger diameter failing culvert. The new sliplined culvert is subsequently stabilized with grout between the old and new structure. Invert lining includes placing concrete and rebar along the invert of the culvert. These scopes effectively raise the invert of an existing culvert by 4-6 inches. DOTs try to avoid possible results of typical sliplining designs, such as perched outlets, shallow water depth or increased water velocities, which make upstream fish passage challenging. In many cases, this scope includes measures that improve fish passage conditions over the existing conditions. This is accomplished by using design practices to increase water depths with weirs or baffles, decrease water depths with weirs or baffles, and by placing grade controls downstream of the structure. In the last decade, DOTs have gained significant experience incorporating aquatic organism passage design modifications into sliplining projects.

Culvert Replacement

Culvert replacement involves the complete removal and installation of the culvert structure. Once flow is diverted and the work area is dewatered, culvert removal and installation can commence. At this point, crews are working within the contained area and there is no sediment release into the stream. All pumps, hoses, dams, and the sediment basin are monitored closely and maintained throughout construction. The old culvert will be removed and the new one placed in the dry. When the crossing and riprap installation are complete, all headwalls, disturbed areas, and permanent road drainage ditches are stabilized with final treatments, using temporary erosion control BMPs as necessary. Seasonal in-water work restrictions may also be used to avoid or minimize aquatic resource impacts.

A culvert replacement will follow the process explained below, which begins after a typical cofferdam installation process.

- Clear and grub projects limits

- Install erosion & sedimentation controls
- Construct access roads to the existing culvert inlet and outlet
- Install water-handling cofferdam systems to bypass watercourse from work area
- Remove the old culvert
- Excavate and place fill for foundation of new culvert.
- Place a new culvert
- Construct riprap scour pad at end of new culvert crossing
- Wash fine sediment material into new backfill to ensure water flow remains on top on newly constructed stream substrate
- Stop pumps, restore flow, and then remove cofferdams
- Complete final grading, establish turf, and plant project site.

Culvert replacement can result in improved fish passage and stream connectivity in freshwater areas as well as improved tidal exchange and passage in areas subject to tidal flow. These improvements are made by replacing smaller culverts with larger culverts, embedding (countersinking) new culverts, installation of streambed material in culverts, and placement of weirs and baffles in culverts as needed. Design guidance for these methods can be found in (ref).

Slope Stabilization

All DOT crossing projects require the contractor to complete and submit plans detailing the approach to erosion and sedimentation control and to water handling. DOTs rely on support from the environmental field representatives to review and approve erosion control plans. The plan typically contains the contractors proposed cofferdam locations, cofferdam materials, dirty water treatment design and location, downstream flow maintenance plan, and temporary soil erosion control methods. In many instances, the Contractor is required to submit an E&S Control Plan and/or Water Handling Plan prior to the start of construction. These plans are reviewed and approved by an Environmental Coordinator. The DOT also ensures these plans are consistent with the authorized regulatory approval (i.e. State DEP and Army Corps). Turbidity control measures are properly secured and inspected on all FHWA-funded DOT sites

Cofferdams/Dewatering

The installation of cofferdam systems is a typical practice for in-water work. Cofferdams enclose a work area and reduce sediment pollution generated from construction work. Typical cofferdams are placed to keep water out of the work area by blocking flow both upstream and downstream. Cofferdams can also be used to divert flow away from one side of a flowing waterbody. The area inside of the cofferdams is ‘dewatered’, however some seepage occurs. Water levels inside of the cofferdam are kept low by pumping into a contained system.

The downstream portion of the cofferdam provides a safeguard against a failure of the upstream portion. Typically, the entirety of the disturbed habitat area will be within the bounds of a cofferdam.

Cofferdams on DOT sites may potentially include, but are not limited to, the following types: sandbag, industrial sandbag, sheet piles and portable cofferdams.

Cofferdam Placement for Spans Less Than 20 Feet

If a structure is less than a 20-foot span, typically the project will be completed using a cofferdam that spans the entire stream. Hydrology of the upstream catchments may also influence water handling plans. Structures of this size typically are culverts that have a bottom. They cannot be installed unless the water is diverted from the location of the replacement culvert. Even if an open bottom bridge is to be installed, a 20-foot or less span is not enough room to excavate and construct bridge abutments. Water flow is maintained using one of the methods explained in the State's BMP procedures. Seasonal in-water work restrictions may also be necessary to avoid and minimize impact to migrating fish species.

The following list explains a typical cofferdam installation process when stream flow is totally blocked by an upstream sandbag cofferdam and water flow is maintained by a bypass pump or a diversion channel.

1. The upstream cofferdam/water diversion will be installed first.
2. The contractor will then begin pumping upstream water flow around the coffer dammed area. This water will be pumped directly into the stream downstream of the planned downstream cofferdam location. At the outlet of the pumps, high velocity (>5 feet per second) water will be returned to the stream. This water has the potential to disturb the stream substrate and cause a turbidity release. BMPs will be implemented to prevent scour and reduce energy at the point of discharge and prevent elevating turbidity levels.
3. The downstream cofferdam will then be installed in the same manner as the upstream cofferdam. This second cofferdam is a safeguard against a failure of the upstream cofferdam and backflow into tidal tributaries.
4. Once both cofferdams have been installed, the contractor will begin to dewater the area between the cofferdams. If the water still appears turbid from the installation activities, it will be pumped to a dirty water treatment system. If the water inside of the cofferdam visually appears to be as turbid as the water flowing into the upstream cofferdam, it will be pumped downstream of the downstream cofferdam.
5. The inside of the cofferdam is then dewatered using pumps to create a "dry" work area.
6. Most cofferdams leak to a small degree, so a pump is typically placed between the cofferdams to catch accumulating water, which will then be pumped into the "Dirty Water" Treatment System.

Cofferdam Placement for Spans More than 20 Feet Wide

Typically, spans greater than 20 feet will have a different construction plan to support bypassing larger volumes of water in the stream. These cofferdams are likely to be confined to bridge elements that are being constructed or removed. Even in situations where water flow is maintained between two cofferdams, significant portions of the channel may be occupied by cofferdams to ensure proper construction and safety of the workers. The percentage of the channel that is blocked varies with the width of the stream where the work is being completed. The size of the cofferdam varies with the depth of the construction activity. It is reasonable to assume that most cofferdams extend 20 feet into the water from the planned permanent impacts.

The fish passage conditions resulting during construction can be highly variable. Some sites will allow for cofferdam installation and maintenance of flows and depths conducive to fish passage throughout the periods of construction (Table 1). Projects can be planned and timed such that cofferdam placement does not significantly impede key fish migrations through coordination with state and federal resources agencies.

Table 1

Activity or structure type	Typical in-water Construction Duration (working days)	Typical Cofferdam Stream Blockage
Stream Crossing Replacement/Demo		
Spans < 10 feet	3 to 5 days	Full Span
Spans 10 to ≤ 20 feet	10 to 60 days	Full Span
Spans > 20 feet	75 to 250 days	>25 % of the stream width
Bridge Maintenance		
Spans < 20 feet	2 to 30 days	>25% of the stream width
Spans > 20 feet	30 to 120 days	>25% of the stream width

Submarine Cable Installation

Submarine cables can be installed using a variety of methods depending upon a number of factors including the type of cable, the substrate, and length traversed. The methods include trenching, plowing, jetting and directional boring. Cable installation using trenching is usually completed using an excavator that is working from a barge. The excavator digs to the desired depth and side casts the materials leaving them directly adjacent to the area of cable placement or places the dredged material into a barge for placement elsewhere. The cable is then placed in the trench. In some cases, the material that was side cast is moved back on top of the cable to bury it, but sometimes the trench is allowed to fill in naturally, or new material is brought in to cap the trench. Commercial cable installation equipment also exists that allows for a single piece of equipment to use water jetting to move substrate while simultaneously placing a cable at the desired depth. The same piece of equipment then buries the cable as it moves by. Horizontal directional drilling (HDD) is another means of installing submarine cables. It is generally accomplished in three principal phases. First, a small diameter pilot hole is drilled along a directional path from one surface point to another. Next, the bore created during pilot hole drilling is enlarged to a diameter that will facilitate installation of the desired pipeline or conduit. Lastly, the pipeline is pulled into the enlarged hole, thus creating a continuous segment of pipe underground exposed only at the two initial endpoints. Directional Boring/HDD can be used to cross any number of surface obstacles including roadways, railroads, wetlands, and water bodies of varying sizes/depths.

Appendix H. Information and Resource List

The links provided below are available to transportation agencies to use to obtain general resource information at a project site. If any of the maps or data contained in the links below indicate that sensitive habitat may be present at a project site, further site-specific investigations will provide more information.

Useful Links
USFWS National Wetland Inventory
EPA's National Estuaries Program
Northeast Regional Ocean Council (NROC) Data Portal
Mid-Atlantic Regional Council on the Ocean (MARCO) Data Portal

Resources by State

Maine
Maine Geolibrary
Maine Department of Natural Resources
Casco Bay Estuary Partnership
Maine GIS Stream Habitat Viewer

New Hampshire
NH's Statewide GIS Clearinghouse
NH Department of Environmental Services
State of NH Shellfish Program

Massachusetts
MA Shellfish Sanitation and Management Program
MassMapper – includes SAV and diadromous fish streams
MA DMF Recommended TOY Restrictions Document
Massachusetts Bays National Estuary Program
Buzzards Bay National Estuary Program
Massachusetts Division of Marine Fisheries
Massachusetts Office of Coastal Zone Management

Rhode Island
RI Department of Environmental Management – data and maps
RI Shellfish and Aquaculture
RI GIS Data
Narraganset Bay Estuary Program
Rhode Island Division of Marine Fisheries
Rhode Island Coastal Resources Management Council

Connecticut
CT Shellfish and Aquaculture Mapping Atlas
CT GIS Resources
Long Island Sound Study
CT Department of Energy and Environmental Protection

Connecticut River Conservancy (formerly the CT River Watershed Council)

New York
New York GIS Clearinghouse
NYDEC Hudson Valley Resource Mapper
Long Island River Revival Map
Peconic Estuary Partnership
NY/NJ Harbor Estuary Program
Long Island Sound Study

New Jersey
NJ GeoWeb
NJ DEP Map and Guidance Documents including SAV and Shellfish Maps
Rutgers Submerged Aquatic Vegetation Mapping
NJ American Shad and River Herring Waters
EPA's Delaware River SAV Mapping
Barnegat Bay Partnership
Partnership for the Delaware Estuary

Pennsylvania
PA Department of Environmental Protection
PA DEP GIS Mapping Tools
PA Fish and Boat Commission
EPA's Delaware River SAV Mapping
Partnership for the Delaware Estuary

Delaware
Delaware First Map
Delaware Department of Natural Resources and Environmental Control
Center for Inland Bays
Partnership for the Delaware Estuary
Nanticoke Watershed Alliance

Maryland
Submerged Aquatic Vegetation Mapping MERLIN
Maryland Coastal Atlas
Freshwater Network Chesapeake Fish Passage Prioritization Tool
Chesapeake Bay Program Anadromous Mapping

Virginia
VDWR-Anadromous Fish Use Areas
VDWR-TOYR and Other Guidance
VIMS-Submerged Aquatic Vegetation
USFWS-Virginia Field Office-IPaC
VMRC-Shellfish Grounds
Virginia Joint Permit Application

Appendix I. References

Able KW and Fahay MP. 1998. First year in the life of estuarine fishes in the middle Atlantic Bight. Rutgers University Press, New Brunswick, NJ.

Allyn AJ, Alexander MA, Franklin BS, Massiot-Granier F, Pershing AJ, Scott JD, et al. 2020. Comparing and synthesizing quantitative distribution models and qualitative vulnerability assessments to project marine species distributions under climate change. PLoS One 15(4): e0231595. doi: 10.1371/journal.pone.0231595. PMID: 32298349.

Allen KO, Hardy JW. 1980. Impacts of navigational dredging on fish and wildlife a literature review. Washington (DC): Biological Services Program, U.S. FWS.

Atlantic States Marine Fisheries Commission (ASMFC). 2009. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. Habitat Management Series #9. January 2009.

Auld AH and Schubel JR. 1978. Effects of suspended sediments on fish eggs and larvae: a laboratory assessment. Estuarine, Coastal and Marine Science 6: 153-164.

Auster PJ. 1998. A conceptual model of the impacts of fishing gear on the integrity of fish habitats. Conservation Biology 12: 1198-1203.

Auster PJ. 2005. Are deep-water corals important habitats for fishes? In: Cold-water corals and ecosystems. Springer Berlin Heidelberg. pp 747-760.

Auster PJ, Joy K, Valentine PC. 2001. Fish species and community distributions as proxies for seafloor habitat distributions: the Stellwagen Bank National Marine Sanctuary example (Northwest Atlantic, Gulf of Maine). Environmental Biology of Fishes 60(4): 331-346.

Auster PJ and Langton R. 1999. The effects of fishing on fish habitat. American Fisheries Society Symposium 22: 150-187.

Barker SL, Townsend DW, Hacunda JS. 1981. Mortalities of Atlantic herring, Clupea h. harengus, smooth flounder, Liopsetta putnami, and rainbow smelt, Osmerus mordax, larvae exposed to acute thermal shock. Fisheries Bulletin 79(1):1981.

Barr BW. 1987. The Dredging Handbook: A primer for dredging in the coastal zone of Massachusetts. Publication No. 14,870-181-500-6-87-CR. Massachusetts Coastal Zone Management Program.

Barr BW. 1993. Environmental impacts of small boat navigation: vessel/sediment interactions and management implications. In: Magoon OT, editor. Coastal Zone '93: proceedings of the eighth symposium on coastal and ocean management; 1993 Jul 19-23; New Orleans, LA. American Shore and Beach Preservation Association. p 1756-70.

Belford DA, Gould WR. 1989. An evaluation of trout passage through six highway culverts in Montana. North American Journal of Fisheries Management 9(4):437-45.

Björk M, Short F, Mcleod E, Beer S. 2008. Managing seagrasses for resilience to climate change. The International Union for the Conservation of Nature and Natural Resources (IUCN)/The Nature Conservancy. p. 1-56.

Boesch DF, Anderson DM, Horner RA, Shumway SE, Tester PA, Whitledge TE. 1997. Harmful algal blooms in coastal waters: options for prevention, control and mitigation. Silver Spring (MD): NOAA Coastal Ocean Office. NOAA Coastal Ocean Program Decision Analysis Series No. 10. 46 p + appendix.

Bradshaw C, Veale LO, Hill AS, Brand AR. 2000. The effects of scallop dredging on gravelly seabed communities. In: Kaiser MJ and de Groot SJ, editors. Effects of fishing on non-target species and habitats. Blackwell Scientific Publications, Oxford, UK. pp 83-104.

Brawn VM. 1960. Temperature tolerance of unacclimated herring (Clupea harengus L.). Journal of the Fisheries Research Board of Canada 17(5):721-3.

Breitburg DL. 1988. Effects of turbidity on prey consumption by striped bass larvae. Transactions of the American Fisheries Society 117: 72-77.

Buckel JA and Conover DO. 1997. Movements, feeding periods, and daily ration of piscivorous young-of-the-year bluefish, *Pomatomus saltatrix*, in the Hudson River estuary. Fisheries Bulletin 95(4): 665-679.

Burton WH. 1993. Effects of bucket dredging on water quality in the Delaware River and the potential for effects on fisheries resources. Prepared for: Delaware Basin Fish and Wildlife Management Cooperative, by Versar Inc., Columbia MD.

Cahoon DR, Reed DJ, Kolker AS, Brinson MM, Stevenson JC, Riggs S, Christian R, Reyes E, Voss C, Kunz D. 2009. Coastal wetland sustainability. Coastal sensitivity to sea-level rise: A focus on the Mid-Atlantic Region. [Titus JG, Anderson KE, Cahoon DR, Gesch DB, Gill SK, Gutierrez BT, Thieler ER, Williams SJ (eds)]. Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. Synthesis and Assessment Product 4.1. p. 57-72.

Cape Cod Commission. 2001. Cape Cod atlas of tidally restricted salt marshes. Cape Cod, Massachusetts.

Carey JC, Moran SB, Kelly RP, Kolker AS, Fulweiler RW. 2017. The declining role of organic matter in New England salt marshes. Estuaries and Coasts 40(3):626-39.

Cargnelli LM, Griesbach SJ, Packer DB, Berrien PL, Johnson DL, Morse WW. 1999. Essential Fish Habitat Source Document: Pollock, Pollachius virens, Life History and Habitat Characteristics. NOAA Technical Memorandum NMFS-NE-131.

Chang S, Berrien PL, Johnson DL, Morse WW. 1999. Essential Fish Habitat Source Document: Windowpane, *Scophthalmus aquosus*, Life History and Habitat Characteristics. NOAA Technical Memorandum NMFS-NE-137.

Chmura GL, Anisfeld SC, Cahoon DR, Lynch JC. 2003. Global carbon sequestration in tidal, saline wetland soils. Global Biogeochemical Cycles 17(4):1-12.

Christie RW, Allen DE, Jobsis GJ. 1993. Diversions. In: Bryan CF, Rutherford DA, editors. Impacts on warmwater streams: guidelines for evaluation. Little Rock (AR): Southern Division, American Fisheries Society. p 181-6.

Church JA, Clark PU, Cazenave A, Gregory JM, Jevrejeva S, Levermann A, Merrifield MA, Milne GA, Nerem RS, Nunn PD, Payne AJ, Pfeffer WT, Stammer D, Unnikrishnan AS. 2013. Sea level change. Climate change 2013. The physical science basis. Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. [Stocker TF, Qin D, Plattner G-K, Tignor M, Allen SK, Boschung J, Nauels A, Xia Y, Bex V, Midgle PM (eds)]. Intergovernmental Panel on Climate Change. p. 1137-216.

Church JA, White NJ, Aarup T, Wilson WS, Woodworth PL, Domingues CM, Hunter JR, Lambeck K. 2008. Understanding global sea levels: past, present and future. Sustainability Science 3(1):9-22.

Clancy CG, Reichmuth DR. 1990. A detachable fishway for steep culverts. North American Journal of Fisheries Management 10(2):244-6.

Collette BB and Klein-MacPhee G. 2002. Bigelow and Schroeder's Fishes of the Gulf of Maine. Smithsonian Institution Press, Washington, DC.

Coen LD and Grizzle RE. 2007. The importance of habitat created by molluscan shellfish to managed species along the Atlantic coast of the United States. Atlantic States Marine Fisheries Commission. Habitat Management Series #8.

Coen LD, Luckenbach MW, Breitburg DL. 1999. The role of oyster reefs as essential fish habitat: a review of current knowledge and some new perspectives. American Fisheries Society Symposium 22: 438–454.

Collie JS, Hermsen JM, Valentine PC, Almeida FP. 2005. Effects of fishing on gravel habitats: Assessment and recovery of benthic megafauna on Georges Bank. American Fisheries Society Symposium 41: 325-343.

Connecticut Department of Energy and Environmental Protection. Brook Trout Fish Passage Assessment and Monitoring Study: Culvert Sliplining Project, Tributary to Lyman Brook. Marlborough, CT. Final Report May 2020.

Costello CT and Kenworthy WJ. 2011. Twelve-year mapping and change analysis of eelgrass (*Zostera marina*) areal abundance in Massachusetts (USA) identifies statewide decline. Estuaries and Coasts 34:232-242.

Crosby SC, Sax DF, Palmer ME, Booth HS, Deegan LA, Bertness MD, et al. 2016. Salt marsh persistence is threatened by predicted sea-level rise. Estuarine, Coastal and Shelf Science 181: 93-99. doi: 10.1016/j.ecss.2016.08.018.

Dame R and Libes S. 1993. Oyster reefs and nutrient retention in tidal creeks. Journal of Experimental Marine Biology and Ecology 171: 251-258.

Danie DS, Trial JG, Stanley JG. 1984. Species profiles: life histories and environmental requirements of coastal fish and invertebrates (North Atlantic)-Atlantic salmon. Washington

(DC): U.S. Fish and Wildlife Service, FWS/OBS-82/11.22 and the U.S. Army Corps of Engineers, TR EL-82-4. 19 p.

Deegan LA and Buchsbaum RN. 2005. The effect of habitat loss and degradation on fisheries. In: Buchsbaum R, Pederson J, and Robinson WE, editors. The decline of fisheries resources in New England: evaluating the impact of overfishing, contamination and habitat degradation.

Cambridge (MA): MIT Sea Grant College Program; Publication No. MITSG 05-5. pp 67-96.

Dolat SW. 1997. Acoustic measurements during the Baldwin Bridge demolition. Waterford (CT): Prepared for White Oak Construction by Sonalysts. 34 p + appendices.

Doll C, Chu J, Ramjerdi F, and Kuhn K. 2012. Special issues on infrastructures in a changing environment. Journal of Infrastructure Systems 18: 229-231.

Donnelly JP, Bertness MD. 2001. Rapid shoreward encroachment of salt marsh cordgrass in response to accelerated sea-level rise. Proceedings of the National Academy of Sciences 98(25): 14218. doi: 10.1073/pnas.251209298.

Duarte CM, Cebrián J. 1996. The fate of marine autotrophic production. Limnology and Oceanography 41(8):1758-66.

Duarte CM, Fourqurean JW, Krause-Jensen D, Olesen B. 2005. Dynamics of seagrass stability and change. In Larkum A, Orth RJ, and Duarte C, editors. Seagrass Biology. Netherlands. pp 271-294.

Duarte CM, Middelburg JJ, Caraco N. 2005. Major role of marine vegetation on the oceanic carbon cycle. Biogeosciences 2(1):1-8.

Duffy-Anderson JT, Able KW. 1999. Effects of municipal piers on the growth of juvenile fishes in the Hudson River estuary: a study across a pier edge. Marine Biology 133(3):409-18.

Easterling DR, Kunkel KE, Arnold JR, Knutson T, LeGrande AN, Leung LR, Vose RS, Waliser DE, F. WM. 2017. Precipitation change in the United States. Climate Science Special Report: Fourth National Climate Assessment. [Wuebbles DJ, Fahey DW, Hibbard KA, Dokken DJ, Stewart BC, Maycock TK (eds)]. U.S. Global Change Research Program. p. 207-30.

Enright JT. 1977. Power plants and plankton. Marine Pollution Bulletin 8(7):158-61.

Eriksson BK, Sandstrom A, Iscus M, Schreiber H, Karas P. 2004. Effects of boating activities on aquatic vegetation in the Stockholm archipelago, Baltic Sea. Estuarine, Coastal and Shelf Science 61(2):339-49.

Evans WA, Johnston B. 1980. Fish migration and fish passage: a practical guide to solving fish passage problems. Washington (DC): U.S. Department of Agriculture, Forest Service. 163 p.

Fajen OF, Layzer JB. 1993. Agricultural practices. In: Bryan CF, Rutherford DA, editors. Impacts on warmwater streams: guidelines for evaluation. Little Rock (AR): Southern Division, American Fisheries Society. p 257-67.

Farr ER, Johnson MR, Nelson MW, Hare JA, Morrison WE, Lettrich MD, et al. 2021. An assessment of marine, estuarine, and riverine habitat vulnerability to climate change in the Northeast U.S. PLoS ONE 16(12): e0260654. https://doi.org/10.1371/journal.pone.0260654

Fay C, Bartron M, Craig S, Hecht A, Pruden J, Saunders R, Sheehan T, Trial J. 2006. Status review for anadromous Atlantic salmon (Salmo salar) in the United States. Report to the National Marine Fisheries Service and U.S. Fish and Wildlife Service. 294 p.

Feist BE, Anderson JJ, Miyamoto R. 1996. Potential impacts of pile driving on juvenile pink (Oncorhynchus gorbuscha) and chum (O. keta) salmon behavior and distribution. Seattle (WA): Fisheries Research Institute-University of Washington. FRI-UW-9603. 58 p.

Fitzsimons JD, Brown SB, Honeyfield DC, Hnath JG. 1999. A review of early mortality syndrome in Great Lakes salmonids and its relationship with thiamine. Ambio, 28: 9- 15.

Fonseca MS and Cahalan JA. 1992. A preliminary evaluation of wave attenuation by four species of seagrass. Estuarine, Coastal and Marine Science 35: 565-576.

Fonseca MS, Kenworthy WJ, Thayer GW. 1998. Guidelines for the Conservation and Restoration of Seagrasses in the United States and Adjacent Waters. NOAA Coastal Ocean Program. Decision Analysis Series No. 12.

Forster S and Zettler ML. 2004. The capacity of the filter-feeding bivalve *Mya arenaria L*. to effect water transport in sandy beds. Marine Biology 144: 1183-1189.

Furniss MJ, Roelofs TD, Yee CS. 1991. Road construction and maintenance. In: Meehan WR, editor. Influences of forest and rangeland management on salmonid fishes and their habitats. Special Publication 19th ed. Bethesda (MD): American Fisheries Society. p 297-323.

Gazeau F, Parker LM, Comeau S, Gattuso J-P, O'Connor WA, Martin S, Pörtner H-O, Ross PM. 2013. Impacts of ocean acidification on marine shelled molluscs. Marine Biology 160(8):2207-45.

Gazeau F, Quiblier C, Jansen JM, Gattuso J-P, Middelburg JJ, Heip CHR. 2007. Impact of elevated CO_2 on shellfish calcification. Geophysical Research Letters 34(7).

Gedan KB, Altieri AH, Bertness MD. 2011. Uncertain future of New England salt marshes. Marine Ecology Progress Series 434:229-37.

Gledhill D, White M, Salisbury J, Thomas H, Misna I, Liebman M, Mook B, Grear J, Candelmo A, Chambers RC, Gobler C, Hunt C, King A, Price N, Signorini S, Stancioff E, Stymiest C, Wahle R, Waller J, Rebuck N, Wang Z, Capson T, Morrison JR, Cooley S, Doney S. 2015. Ocean and coastal acidification off New England and Nova Scotia. Oceanography 25(2):182-97.

Gobler CJ, DePasquale EL, Griffith AW, Baumann H. 2014. Hypoxia and acidification have additive and synergistic negative effects on the growth, survival, and metamorphosis of early life stage bivalves. PLoS One 9(1):e83648.

Gotceitas V, Fraser S, Brown JA. 1995. Habitat use by juvenile Atlantic cod (*Gadus morhua*) in the presence of an actively foraging and non-foraging predator. Marine Biology 123(3): 421-430.

Goldsborough WJ. 1997. Human impacts on SAV- a Chesapeake Bay case study. In: Stephan CD, Bigford TE, editors. Atlantic coastal submerged aquatic vegetation: a review of its ecological role, anthropogenic impacts, state regulation, and value to Atlantic coastal fisheries. Washington (DC): ASMFC Habitat Management Series #1. 68 p + appendices.

Greene K. 2002. Beach Nourishment: A Review of the Biological and Physical Impacts. ASMFC Habitat Management Series #7. Washington DC. 118 pp.

Haas MA, Simenstad CA Jr, Cordell JR, Beauchamp DA, Miller BS. 2002. Effects of large overwater structures on epibenthic juvenile salmon prey assemblages in Puget Sound, WA. Seattle (WA): Washington State Transportation Center (TRAC), University of Washington, and Washington State Department of Transportation. Final Research Report WA-RD 550.1. 114 p.

Hare JA, Alexander MA, Fogarty MJ, Williams EH, Scott JD. Forecasting the dynamics of a coastal fishery species using a coupled climate–population model. Ecological Applications. 2010; 20(2): 452-464. doi: 10.1890/08-1863.1.

Hare JA, Manderson JP, Nye JA, Alexander MA, Auster PJ, Borggaard DL, Capotondi AM, Damon-Randall KB, Heupel E, Mateo I, O'Brien L, Richardson DE, Stock CA, Biegel ST. 2012. Cusk (Brosme brosme) and climate change: assessing the threat to a candidate marine fish species under the US Endangered Species Act. ICES Journal of Marine Science 69(10):1753-68.

Hedger RD, Dodson NE, Bergeron NE. 2005. Habitat selection by juvenile Atlantic salmon: the interaction between physical habitat and abundance. Journal of Fish Biology 67:1054-1071.

Helfman G, Collette BB, Facey DE, Bowen BW. 2009. The diversity of fishes: biology, evolution, and ecology. John Wiley & Sons.

Hodgkins GA, Dudley RW. 2013. Modeled future peak streamflows in four coastal Maine rivers. U.S. Department of the Interior, U.S. Geological Survey. U.S. Geological Survey Scientific Investigations Report 2013-5080. p. 1-18.

Horton R, Yohe G, Easterling W, Kates R, Ruth M, Sussman E, Whelchel A, Wolfe D, Lipschultz F. 2014. Chapter 16: Northeast. Climate change impacts in the United States. The Third National Climate Assessment. [Melillo JM, Richmond TC, Yohe GW (eds)]. U.S. Global Change Research Program. p. 371-95.

Howard J, Babij E, Griffis R, Helmuth B, Himes-Cornell A, Niemier P, Orbach M, Petes L. 2013. Ocean and marine resources in a changing climate. Oceanography and Marine Biology: An Annual Review. [Hughes RN, Hughes D, Smith IP (eds)]. CRC Press. p. 71-192.

Illingworth and Rodkin, Inc. and Jones and Stokes. 2009. Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish. Prepared for California Department of Transportation.

Intergovernmental Panel on Climate Change (ICCP). 2021. Climate change 2021: the physical science basis.Contribution of working group I to the sixth assessment report of the intergovernmental panel on climate change. [Masson-Delmotte Panmao Z, Valérie, Pirani A, Connors SL, Péan C, Chen Y, Goldfarb L, Gomis MI,Matthews JBR, Berger S, Huang M, Yelekçi O, Yu R, Zhou B, Lonnoy E, Maycock TK, Waterfield T, Leitzell K, CaudN (eds)]. p. 2391.

Intergovernmental Panel on Climate Change (IPCC). 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, RK Pachauri and LA Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

Jackson SD. 2003. Design and construction of aquatic organism passage at road-stream crossings: ecological considerations in the design of river and stream crossings. In: Irwin CL, Garrett P, McDermott KP, editors. 2003 Proceedings of the International Conference on Ecology and Transportation; 2003 Aug 24-29; Lake Placid, NY. Raleigh (NC): Center for Transportation and the Environment, NC State University. p 20-9.

Johnson, M.R., Hutchins, E., 2023. The Effects of Tide Gates on New England Wetlands and OtherTidal Resources.Greater Atlantic Region Policy Series [23-01]. NOAA Fisheries Greater Atlantic Regional Fisheries Office - https://www.greateratlanticfisheries.noaa.gov/policyseries/.30 p

Johnson M.R, Boelke C, Chiarella LA, Colosi PD, Greene K, Lellis-Dibble K, Ludeman H, Ludwig M, McDermott S, Ortiz J, Rusanowsky D, Scott M, Smith J. 2008. Impacts to marine fisheries habitat from nonfishing activities in the northeastern United States. NOAA Technical Memorandum NMFS-NE-209. Woods Hole, MA.

Johnson, M.R, Boelke, C, Chiarella, L.A, and Greene, K. 2019. Guidance for Integrating Climate Change Information in Greater Atlantic Region Habitat Conservation Division Consultation Processes. Greater Atlantic Region Policy Series 19-01. NOAA Fisheries Greater Atlantic Regional Fisheries Office - www.greateratlantic.fisheries.noaa.gov/policyseries/. 235p.

Kearney MS, Rogers AS, Townshend JRG, Rizzo E, Stutzer D, Stevenson JC, Sundborg K. 2002. Landsat imagery shows decline of coastal marshes in Chesapeake and Delaware Bays. Eos, Transactions American Geophysical Union 83(16):173-8.

Kalmijn AJ. 1988. Hydrodynamic and acoustic field detection. In: Atema J, Fay RR, Popper AN, Tavolga WN, editors. Sensory biology of aquatic animals. New York (NY): Springer Verlag. p 83-130.

Karaki S, vanHoften J. 1975. Resuspension of bed material and wave effects on the Illinois and upper Mississippi Rivers caused by boat traffic. St. Louis (MO): U.S. Army Engineer District. Cont. No. LMSSD 75-881.

Keevin TM, Gaspin JB, Gitschlag GR, Hempen GL, Linton TL, Smith M, Wright DG. 1999. Underwater explosions: natural resource concerns, uncertainty of effects, and data needs. In: Proceedings of the twenty-fifth annual conference on explosives and blasting technique; 1999

Feb 7-10; Nashville, TN. Cleveland (OH): International Society of Explosive Engineers. p 105-16.

Kemp WM, Boynton WR, Stevenson JC, Twilley RR, Means JC. 1983. The decline of submerged vascular plants in upper Chesapeake Bay: Summary of results concerning possible causes. Marine Technology Society Journal 17: 78-89.

Kennedy VS, Twilley RR, Kleypas JA, Cowan JHJ, Hare SR. 2002. Coastal and marine ecosystems and global climate change: Potential effects on U.S. resources. Arlington, VA: Pew Center on Global Climate Change.

Kennish MJ, Brush MJ, Moore KA. 2014. Drivers of change in shallow coastal photic systems: an introduction to a special issue. Estuaries and Coasts 37 (Suppl 1):S3–S19. doi: 10.1007/s12237-014-9779-4.

Kennish MJ. 2002. Impacts of motorized watercraft on shallow estuarine and coastal marine environments. Journal of Coastal Research Special Issue 37:1-202.

Kenworthy WJ, Thayer GW, Fonseca MS. 1988. The utilization of seagrass meadows by fishery organisms. In: Hook DD, McKee WH, Smith HK, Gregory J, Burrell VG, DeVoe MR, Sojka RE, Gilbert S, Banks R, Stolzy LH, Brooks C, Matthews TD, and Shea, TH, editors. The Ecology of Wetlands: Volume 1. pp. 548-560.

Kirwan ML, Blum LK. 2011. Enhanced decomposition offsets enhanced productivity and soil carbon accumulation in coastal wetlands responding to climate change. Biogeosciences 8(4):987-93.

Kirwan ML, Guntenspergen GR, D'Alpaos A, Morris JT, Mudd SM, Temmerman S. 2010. Limits on the adaptability of coastal marshes to rising sea level. Geophysical Research Letters 37(23):1-5.

Kirwan ML, Mudd SM. 2012. Response of salt-marsh carbon accumulation to climate change. Nature 489(7417): 550-553. doi: 10.1038/nature11440. PMID: 23018965.

Klein R. 1997. The effects of marinas and boating activities upon tidal waters. Owing Mills (MD): Community and Environmental Defense Services. 23 p.

Kleisner KM, Fogarty MJ, McGee S, Hare JA, Moret S, Perretti CT, et al. 2017. Marine species distribution shifts on the U.S. Northeast Continental Shelf under continued ocean warming. Progress in Oceanography 153: 24-36. doi: https://doi.org/10.1016/j.pocean.2017.04.001.

Knudsen FR, Schreck CB, Knapp SM, Enger PS, Sand O. 1997. Infrasound produces flight and avoidance responses in Pacific juvenile salmonids. Journal of Fish Biology 51:824-9.

Kolker AS, Kirwan ML, Goodbred SL, Cochran JK. 2010. Global climate changes recorded in coastal wetland sediments: Empirical observations linked to theoretical predictions. Geophysical Research Letters 37(14):5.

Kopp RE, Kemp AC, Bittermann K, Horton BP, Donnelly JP, Gehrels WR, Hay CC, Mitrovicak JX, Morrowa ED, Rahmstorf S. 2016. Temperature-driven global sea-level variability in the Common Era. Proceedings of the National Academy of Sciences of the United States of America 113(11):E1434-41.

Kunkel KE, Stevens LE, Stevens SE, Sun L, Janssen E, Wuebbles D, Rennells J, DeGaetano A, Dobson JG. 2013. Regional climate trends and scenarios for the U.S. National Climate Assessment: Part 1. Climate of the Northeast U.S. National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Service. NOAA Technical Report NESDIS 142-1. p. 1-87.

Larson K, Moehl CE. 1990. Entrainment of anadromous fish by hopper dredge at the mouth of the Columbia River. In: Simenstad CA Jr, editor. Effects of dredging on anadromous Pacific coast fishes. Seattle (WA): Washington Sea Grant, University of Washington. p 102-12.

Lindholm J, Auster PJ, Kaufman L. 1999. Habitat-mediated survivorship of juvenile (0-year) Atlantic cod (*Gadus morhua*). Marine Ecology Progress Series 180: 247–255.

Lindholm J, Auster PJ, Ruth M, Kaufman L. 2001. Modeling the effects of fishing and implications for the design of marine protected areas: juvenile fish responses to variations in seafloor habitat. Conservation Biology 15: 424-437.

Lotze HK, Lenihan HS, Bourque BJ, Bradbury RH, Cooke RG, Kay MC, Kidwell SM, Kirby MX, Peterson CH, Jackson JBC. 2006. Depletion, degradation, and recovery potential of estuaries and coastal seas. Science 312:1806-9.

MacKenzie CL Jr. 2007. Causes underlying the historical decline in eastern oyster (Crassostrea virginica Gmelin, 1791) landings. Journal of Shellfish Research 26(4):927-38.

Malek A, LaFrance M, Collie J, King J. 2010. Fisheries Ecology in Rhode Island and Block Island Sounds for the Rhode Island Ocean Special Area Management Plan. University of Rhode Island, November 30, 2010.

Marten K, Herzing D, Poole M, Newman-Allman K. 2001. The acoustic predation hypothesis: Linking underwater observations and recordings during Odontocete predation and observing the effects of loud impulsive sounds on fish. Aquatic Mammals 27(1):56-66.

McDermott S, Bransome NC, Sutton SE, Smith BE, Link JS, Miller TJ. 2015. Quantifying alosine prey in diets of marine piscivores in the Gulf of Maine. Journal of Fish Biology 86: 1811- 1829.

McDermott S, Burdick D, Grizzle R, Greene J. 2008. Restoring ecological functions and increasing community awareness of an urban tidal pond using blue mussels. Ecological Restoration 26(3): 254-262.

McGraw K, Armstrong D. 1990. Fish entrainment by dredges in Grays Harbor, Washington. In: Simenstad CA Jr, editor. Effects of dredging on anadromous Pacific coast fishes. Seattle (WA): University of Washington Sea Grant. p 113-31.

Mcleod E, Chmura GL, Bouillon S, Salm R, Björk M, Duarte CM, Lovelock CE, Schlesinger WH, Silliman BR. 2011. A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO2. Frontiers in Ecology and the Environment 9(10):552-60.

Messieh SN, Rowell TW, Peer DL, Cranford PJ. 1991. The effects of trawling, dredging and ocean dumping on the eastern Canadian continental shelf seabed. Continental Shelf Research 11(8- 10):1237-63.

Methratta ET and Link JS. 2006. Evaluation of quantitative indicators for marine fish communities. Ecological Indicators 6(3): 575-588.Milliken AS, Lee V. 1990. Pollution impacts from recreational boating: a bibliography and summary review. Narragansett (RI): Rhode Island Sea Grant. National Sea Grant Depository Publication # RIU-G-002.

Mitsch WJ, Gosselink JG. 1993. Wetlands. 2nd ed. New York (NY): Van Nostrand Reinhold. 722 p.

Moazzam M, Rizvi SHN. 1980. Fish entrapment in the seawater intake of a power plant at Karachi coast. Environmental Biology of Fishes 5:49-57.

Moring J. 2005. Recent trends in anadromous fishes. In: Buchsbaum R, Pederson J, Robinson WE, editors. The decline of fisheries resources in New England: evaluating the impact of overfishing, contamination, and habitat degradation. Cambridge (MA): MIT Sea Grant College Program; Publication No. MITSG 05-5. p 25-42.

Morley JW, Selden RL, Latour RJ, Frölicher TL, Seagraves RJ, Pinsky ML. 2018. Projecting shifts in thermal habitat for 686 species on the North American continental shelf. PLoS One 13(5): e0196127. doi: 10.1371/journal.pone.0196127. PMID: 29768423.

Myrberg AA Jr. 1972. Using sound to influence the behavior of free-ranging marine mammals. In: Winn HE, Olla BL, editors. Behavior of marine animals. Vol. 2: Vertebrates. New York (NY): Plenum Press. p 435-68.

Myrberg AA Jr, Riggio RJ. 1985. Acoustically mediated individual recognition by a coral reef fish (Pomacentrus partitus). Animal Behaviour 33:411-6.

Nakamura Y and Kerciku F. 2000. Effects of filter-feeding bivalves on the distribution of water quality and nutrient cycling in a eutrophic coastal lagoon. Journal of Marine Systems 26(2): 209- 221.

National Marine Fisheries Service (NMFS). 2018. FHWA Programmatic Essential Fish Habitat Consultation for Select Transportation Actions in the NMFS Greater Atlantic Region. Greater Atlantic Regional Fisheries Office. Gloucester, MA

National Oceanic and Atmospheric Administration (NOAA). 2021. [Internet]. NOAA Tides and Currents, Sea Level Trends. Accessed April 1, 2021. https://tidesandcurrents.noaa.gov/sltrends/sltrends.html.

Natural Research Council (NRC). 2002. Effects of trawling and dredging on seafloor habitat. National Academy Press, Washington, District of Columbia.

Nelson EJ, Kareiva P, Ruckelshaus M, Arkema K, Geller G, Girvetz E, Goodrich D, Matzek V, Pinsky M, Reid W, Saunders M, Semmens D, Tallis H. 2013. Climate change's impact on key ecosystem services and the human well-being they support in the US. Frontiers in Ecology and the Environment 11(9):483-893.

Nelson DA and Wheeler JL. 1997. The influence of dredging-induced turbidity and associated contaminants upon hatching success and larval survival of winter flounder, *Pleuronectes americanus*, a laboratory study. Final report, Grant CWF #321-R, to Connecticut Department Environmental Protection, by National Marine Fisheries Service, Milford CT.

Newcomb CP and Jenson JO. 1996. Channel Suspended Sediment and Fisheries: A Synthesis for Quantitative Assessment of Risk and Impact. North American Journal of Fisheries Management. 16: 693-727.

Newcombe CP and MacDonald DD. 1991. Effects of suspended sediments on aquatic ecosystems. North American Journal of Fisheries Management 11: 72-82.

Newell RC, Seiderer LJ, Hitchcock DR. 1998. The impact of dredging works in coastal waters: a review of the sensitivity to disturbance and subsequent recovery of biological resources on the sea bed. In: Ansell AD, Gibson RN, Barnes M, editors. Oceanography and marine biology: an annual review. Vol. 36. Oban, Argyll (Scotland): UCL Press. p 127-78.

Newell RIE. 2004. Ecosystem influences of natural and cultivated populations of suspension feeding bivalve molluscs: a review. Journal of Shellfish Research. 23:51-61.

Nicholls RJ, Cazenave A. 2010. Sea-level rise and its impact on coastal zones. Science 328(5985):1517-20.

Nicholls RJ, Hoozemans FMJ, Marchand M. 1999. Increasing flood risk and wetland losses due to global sea-level rise: regional and global analyses. Global Environmental Change 9: S69-S87. doi: https://doi.org/10.1016/S0959-3780(99)00019-9.

Nightingale BJ, Simenstad CA Jr. 2001a. Overwater structures: marine issues. Olympia (WA): Washington Department of Fish and Wildlife. White Paper. 133 p + appendices.

Nightingale B, Simenstad CA Jr. 2001b. Dredging activities: marine issues. Olympia (WA): Washington Department of Fish and Wildlife. White Paper. 119 p + appendices.

Normann JM, Houghtalen RJ, Johnston WJ. 2005. "Hydraulic Design Series No. 5, 2nd Edition, rev.: Hydraulic Design of Highway Culverts." Rep. No. FHWA-NHI-01-020, Federal Highway Administration.

Ogren L, Chess J, and Lindenberg J. 1968. More notes on the behavior of young squirrel hake, *Urophycis chuss*. Underwater Naturalist 5(3): 38-39.

Orth RJ, Carruthers TJB, Dennison WC, Duarte CM, Fourqurean JW, Heck KL, Hughes AR, Kendrick GA, Kenworthy WJ, Olyarnik S, Short FT, Waycott M, Williams SL. 2006. A global crisis for seagrass ecosystems. BioScience 56(12): 987-996.

Pendleton L, Donato DC, Murray BC, Crooks S, Jenkins WA, Sifleet S, Craft C, Fourqurean JW, Kauffman JB, Marbà N, Megonigal P, Pidgeon E, Herr D, Gordon D, Baldera A. 2012. Estimating global "blue carbon" emissions from conversion and degradation of vegetated coastal ecosystems. PLoS One 7(9):e43542.

Penttila D, Doty D. 1990. Results of 1989 eelgrass shading studies in Puget Sound. Olympia (WA): Washington Department of Fisheries. Draft Progress Report. 41 p.

Pereira JJ, Goldberg R, Ziskowski JJ, Berrien PL, Morse WW, Johnson DL. 1999. Essential Fish habitat source document: winter flounder, Pseudopleuronectes americanus, life history and characteristics. NOAA Technical Memorandum NMFS-NE-I38. Northeast Fisheries Science Center, Woods Hole, MA.

Pershing AJ, Griffis RB, Jewett EB, Armstrong CT, Bruno JF, Busch DS, et al. 2018. Oceans and Marine Resources. Washington, DC, USA: U.S. Global Change Research Program.

Poston T. 2001. Treated wood issues associated with overwater structures in freshwater and marine environments. Olympia (WA): Washington State Departments of Transportation, Fish and Wildlife, and Ecology. White Paper. 85 p.

Precht WF, Aronson RB, Swanson DW. 2001. Improving scientific decision-making in the restoration of ship-grounding sites on coral reefs. Bulletin of Marine Science 69(2):1001-12.

Rago PJ. 1984. Production forgone: an alternative method for assessing the consequences of fish entrainment and impingement losses at power plants and other water intakes. Ecological Modelling 24(1-2):79-111.

Richardson WJ, Greene CR, Malme CI, Thomas DH. 1995. Marine mammals and noise. San Diego (CA): Academic Press. 576 p.

Richkus WA, McLean R. 2000. Historical overview of the efficacy of two decades of power plant fisheries impact assessment activities in Chesapeake Bay. Environmental Science and Policy 3(Supplement 1):283-93.

Robinson WE, Pederson J. 2005. Contamination, habitat degradation, overfishing - An "either-or" debate? In: Buchsbaum R, Pederson J, Robinson WE, editors. The decline of fisheries resources in New England: evaluating the impact of overfishing, contamination, and habitat degradation. Cambridge (MA): MIT Sea Grant College Program; Publication No. MITSG 05-5. p 1-10.

Salisbury J, Green M, Hunt C, Campbell J. 2008. Coastal acidification by rivers: a threat to shellfish? Eos, Transactions American Geophysical Union 89(50):513-28.

Sand O, Enger PS, Karlsen HE, Knudsen F, Kvernstuen T. 2000. Avoidance responses to infrasound in downstream migrating European silver eels, Anguilla anguilla. Environmental Biology of Fishes 57(3):327-36.

Scavia D, Field JC, Boesch DF, Buddemeier RW, Burkett V, Cayan DR, et al. 2002. Climate change impacts on US coastal and marine ecosystems. Estuaries 25(2): 149-164. doi: 10.1007/Bf02691304. PMID: WOS:000175754500001.

Shepard AN, Theroux RB, Cooper RA, Uzmann JR. 1986. Ecology of Ceriantharia (Coelenterata, Anthozoa) of the northwest Atlantic from Cape Hatteras to Nova Scotia. Fishery Bulletin 84: 625-646.

Short FT. 2013. Eelgrass distribution in the Great Bay Estuary for 2012. A Final Report to the Piscataqua Region Estuaries Partnership. 8pp.

Short FT and Burdick DM. 1996. Quantifying eelgrass habitat loss in relation to housing development and nitrogen loading in Waquoit Bay, Massachusetts. Estuaries 19: 730-739.

Short FT, Burdick DM, Wolfe J, Jones GE. 1993. Eelgrass in estuarine research reserve along the East Coast, USA, Part I: Declines from pollution and disease and Part II: Management of eelgrass meadows. NOAA-Coastal Oceans Program Publication.

Short FT, Kosten S, Morgan PA, Malone S, Moore GE. 2016. Impacts of climate change on submerged and emergent wetland plants. Aquatic Botany 135:3-17.

Short FT, Neckles HA. 1999. The effects of global climate change on seagrasses. Aquatic Botany 63(3):169-96.

Smith SL. Cunniff SE, Peyronnin NS, Kritzer JP. 2017. Prioritizing coastal ecosystem stressors in the Northeast United States under increasing climate change. Environmental Science & Policy 78: 49-57.

Stanley DJ. 1971. Fish-produced markings on the outer continental margin east of the Middle Atlantic States. Journal of Sedimentary Petrology 41: 159-170.

Staudt A, Leidner AK, Howard J, Brauman KA, Dukes JS, Hansen LJ, et al. The added complications of climate change: understanding and managing biodiversity and ecosystems. Frontiers in Ecology and the Environment. 2013; 11(9): 494-501. doi: 10.1890/120275.

Steimle FW, Pikanowski RA, McMillan DG, Zetlin CA, Wilk SJ. 2000. Demersal fish and American lobster diets in the Lower Hudson-Raritan Estuary. NOAA Technical Memorandum NMFS-NE-161. Woods Hole, MA.

Stevenson D, Chiarella L, Stephan D, Reid R, Wilhelm K, McCarthy J, Pentony M. 2006. Characterization of the fishing practices and marine benthic ecosystems of the northeast US shelf, and an evaluation of the potential effects of fishing on essential habitat. NOAA Tech Memo NMFS NE 181.

Stevenson DK, Tuxbury S, Johnson MR, Boelke C. 2014. Shallow Water Benthic Habitats in the Gulf of Maine: A Summary of Habitat Use by Common Fish and Shellfish Species in the Gulf of Maine. Greater Atlantic Region Policy Series 14-01. NOAA Fisheries Greater Atlantic Regional Fisheries Office.

Stocker M. 2002. Fish, mollusks and other sea animals' use of sound, and the impact of anthropogenic noise in the marine acoustic environment. Journal of Acoustical Society of America 112(5):2431.

Sweet WV, Hamlington BD, Kopp RE, Weaver CP, Barnard PL, Bekaert D, Brooks W, Craghan M, Dusek G, Frederikse T, et al. 2022. Global and regional sea level rise scenarios for the United States: updated mean projections and extreme water level probabilities along U.S. coastlines. NOAA Technical Report NOS 01. National Oceanic and Atmospheric Administration, National Ocean Service, Silver Spring, MD, 111 pp. https://oceanservice.noaa.gov/hazards/sealevelrise/noaa-nos-techrpt01-global-regional-SLR-scenarios-US.pdf

Talmage SC, Gobler CJ. 2010. Effects of past, present, and future ocean carbon dioxide concentrations on the growth and survival of larval shellfish. Proceedings of the National Academy of Sciences of the United States of America 107(40):17246-51.

Tamsett A, Heinonen KB, Auster PJ, Linholm J. 2010. Dynamics of hard substratum communities inside and outside of a fisheries habitat closed area in Stellwagen Bank National Marine Sanctuary (Gulf of Maine, NW Atlantic). Marine Sanctuaries Conservation Series ONMS-10-05. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD.

Thayer WG, Fonseca MS, Kenworthy JW. 1997. Ecological value of seagrasses: a brief summary for the ASMFC habitat committee's SAV subcommittee. In: Stephan CD, Bigford TE, editors. Atlantic coastal submerged aquatic vegetation: a review of its ecological role, anthropogenic impacts, state regulation, and value to Atlantic coastal fisheries. Washington, DC: ASMFC Habitat Management Series #1. p 68 + appendices.

Thayer GW, Kenworthy WJ, Fonseca MS. 1984. The ecology of eelgrass meadows of the Atlantic Coast: a community profile. U.S. Fish and Wildlife Service, FWS/OBS-84/02.

Thayer GW, Wolfe DA, Williams RB. 1975. The impact of man on seagrass systems. American Scientist 63: 288-296.

Titus JG, Hudgens DE, Trescott DL, Craghan M, Nuckols WH, Hershner CH, Kassakian JM, Linn CJ, Merritt PG, McCue TM, O'Connell JF, Tanski J, Wang J. 2009. State and local governments plan for development of most land vulnerable to rising sea level along the US Atlantic coast. Environmental Research Letters 4(4):1-7.

Transportation Research Board (TRB). 2008. Potential Impacts of Climate Change on U.S. Transportation. Special Report 290.

Travnichek VH, Zale AV, Fisher WL. 1993. Entrainment of ichthyoplankton by a warmwater hydroelectric facility. Transactions of the American Fisheries Society 122(5):709-16.

Trombulak SC, Frissell CA. 2000. "Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities." Conservation Biology, 14(1), 18-30.

Turek, J, Haro A, Towler, B. 2016. Federal Interagency Nature-like Fishway Passage Design Guidelines for Atlantic Coast Diadromous Fishes. Interagency Technical Memorandum. 47 pp.

Tyrrell MC. 2005. Gulf of Maine marine habitat primer. Gulf of Maine Council on the Marine Environment. vi + 54 p.

Uhrin AV, Holmquist JG. 2003. Effects of propeller scarring on macrofaunal use of the seagrass Thalassia testudinum. Marine Ecology Progress Series 250:61-70.

[U.S. ACOE] U.S. Army Corps of Engineers. 2014. 2014. Procedures to evaluate sea level change: impacts, responses and adaptation. 2014. Engineering Technical Letter. CECW-CE; CECW-P. Technical Letter No 1100-2-1.

U.S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration (USFWS and NOAA). 2012. National Fish, Wildlife and Plants Climate Adaptation Partnership. National Fish, Wildlife and Plants Climate Adaptation Strategy. Association of Fish and Wildlife Agencies, Council on Environmental Quality, Great Lakes Indian Fish and Wildlife Commission, National Oceanic and Atmospheric Administration, and U.S. Fish and Wildlife Service. Washington, DC.

[U.S. GCRP] U.S. Global Change Research Program. 2014. Climate Change Impacts in the United States: The Third National Climate Assessment. Melillo JM, Richmond T, Yohe GW. Eds. 841 pp.

Vose RS, Applequist S, Bourassa MA, Pryor SC, Barthelmie RJ, Blanton B, Bromirski PD, Brooks HE, DeGaetano AT, Dole RM, et al. 2014. Monitoring and understanding changes in extremes: extratropical storms, winds, and waves. Bulletin of the American Meteorological Society 95(3):377-86.

Washington Department of Fish and Wildlife (WDFW). 1998. White Paper submitted to Washington Department of Fish and Wildlife, Washington Dept. of Ecology, Washington Dept. of Transportation. Sequim (WA): Battelle Memorial Institute. 99 p.

Waldbusser GG, Hales B, Langdon CJ, Haley BA, Schrader P, Brunner EL, Gray MW, Miller CA, Gimenez I, Hutchinson G. 2015. Ocean acidification has multiple modes of action on bivalve larvae. PLoS One 10(6):e0128376.

Waldbusser GG, Voigt EP, Bergschneider H, Green MA, Newell RIE. 2011. Biocalcification in the eastern oyster (*Crassostrea virginica*) in relation to long-term trends in Chesapeake Bay pH. Estuaries and Coasts 34:221-31.

Wang XL, Feng Y, Compo GP, Swail VR, Zwiers FW, Allan RJ, Sardeshmukh PD. 2012. Trends and low frequency variability of extra-tropical cyclone activity in the ensemble of twentieth century reanalysis. Climate Dynamics 40(11-12):2775-800.

Watson EB, Wigand C, Davey EW, Andrews HM, Bishop J, Raposa KB. 2017. Wetland loss patterns and inundation-productivity relationships prognosticate widespread salt marsh loss for southern New England. Estuaries and Coasts 40(3):662-81.

Weis JS, Weis P. 2002. Contamination of saltmarsh sediments and biota by CCA treated wood walkways. Marine Pollution Bulletin 44:504-10.

Wicklund R. 1966. Observations on the nursery grounds of young squirrel hake, *Urophycis chuss*. Underwater Naturalist 4(1): 33-34.

Wilber D, Brostoff W, Clarke D, Ray G. 2005. Sedimentation: potential biological effects of dredging operations in estuarine and marine environments. DOER Technical Notes Collection. Vicksburg (MS): U.S. Army Engineer Research and Development Center. ERDC TN-DOER-E20. 14 p.

Wilber DH and Clarke DG. 2001. Biological Effects of Suspended Sediments: A Review of Suspended Sediment Impacts on Fish and Shellfish with Relation to Dredging Activities in Estuaries. North American Journal of Fisheries Management 21: 855-875.

Wilbur AR, Pentony MW. 1999. Human-induced nonfishing threats to essential fish habitat in the New England region. American Fisheries Society Symposium 22:299-321.

Williams GD, Thom RM. 2001. Marine and estuarine shoreline modification issues. White paper submitted to Washington Department of Fish and Wildlife, Washington Dept. of Ecology, Washington Dept. of Transportation. Sequim (WA): Battelle Memorial Institute. 99 p.

Wright DG. 1982. A discussion paper on the effects of explosives on fish and marine mammals in the waters of the Northwest Territories. Winnipeg (Manitoba): Western Region, Department of Fisheries and Oceans. Canadian Technical Report of Fisheries and Aquatic Sciences No. 1052.

Zelo I, Helton D. 2005. Removal of grounded, derelict or abandoned vessels as site restoration. In: Abandoned Vessel Program (AVP) Conference Proceedings-International Oil Spill Conference; 2005 May 15-19; Miami Beach, FL. Seattle (WA): NOAA Ocean Service Office of Response and Restoration. 15 p.

Ziegler AD, Sutherland RA, Gaimbelluca TW. 2001. Interstorm surface preparation and sediment detachment by vehicle traffic on unpaved mountain roads. Earth Surface Processes and Landforms 26(3):235-50.

Zimmerman RT, Minello J, Baumer T, Castiglione M. 1989. Oyster reef as habitat for estuarine macrofauna. NOAA Tech. Memo. NMFS-SEFC-249.