PREFACE

The genesis of this report was a technical workshop held in Mystic, CT, on January 10-12, 2005 entitled "Workshop on Impacts to Coastal Fishery Habitat from Nonfishing Activities." The workshop and report were conceived by the Northeast Region Essential Fish Habitat Steering Committee which is composed of representatives from NOAA National Marine Fisheries Service Northeast Regional Office (NERO), NOAA National Marine Fisheries Service Northeast Fisheries Science Center (NEFSC), New England Fishery Management Council (NEFMC), Mid-Atlantic Fishery Management Council (MAFMC), and the Atlantic States Marine Fisheries Commission (ASMFC). The workshop was sponsored jointly by NOAA National Marine Fisheries Service, NEFMC and ASMFC.

The original intent of the workshop was to provide the necessary information to the NEFMC and MAFMC to assist them in updating the nonfishing impact analyses within their Fishery Management Plans as required by the Essential Fish Habitat (EFH) regulations. As work progressed, we realized that this information would be extremely useful to a much larger audience of agencies, consultants, and components of the public involved in marine and aquatic habitat assessment activities, and so this comprehensive report was developed. For this reason, the scope of impact assessment for this report was expanded to include a more general approach to coastal fishery habitat and is not limited to EFH. Our goal is to ensure that the best scientific information is available for use in making sound decisions with respect to the various environmental reviews and permitting processes conducted within the marine environment.

The comprehensive nature of this report required extensive collaboration among the authors, which includes NOAA National Marine Fisheries Service staff within the NERO Habitat Conservation Division and Headquarters Office of Habitat Conservation (OHC). We would like to thank the participants of the technical workshop who graciously provided their time and expertise towards identifying and assessing the range of impacts that threaten coastal resources in the northeast region of the United States (see appendix for list of participants). We would particularly like to thank the following individuals for their advice, time, and valuable assistance in the preparation and review of this report: Claire Steimle, Northeast Fishery Science Center (NEFSC) – Library Assistance; numerous staff of the NOAA Library; numerous reviewers, including Jen Costanza, Kathi Rodrigues, Dr. David Stevenson, and David Tomey– NOAA National Marine Fisheries Service, NERO; Jeanne Hanson – NOAA National Marine Fisheries Service, Alaska Regional Office; Joanne Delaney – NOAA National Marine Sanctuaries Program; and Ruth M. Ladd –US Army Corps of Engineers, New England District. In addition, we appreciate the advice provided by the technical and editorial reviewers at the NEFSC: Donna A. Busch, Dr. Jarita Davis, Dr. Ashok Deshpande, Dr. David Dow, Laura Garner, Dr. Jon Hare, Clyde L. MacKenzie, Jr., Donald G. McMillan, Dr. Thomas Noji, Dave Packer, and Dr. Robert Reid.

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ACRONYMS AND ABBREVIATIONS

ACZA	ammoniacal copper zinc arsenate
ANS	aquatic nuisance species
ATOC	Acoustic Thermometry of Ocean Climate
AVS	acid volatile sulfides
BMP	best management practice
BOD	biological oxygen demand
C	Celsius
CCA	chromated copper arsenate
cm	centimeters
CSOs	combined sewer overflows
CWA	Clean Water Act
dB	decibel
DC	direct current
DDE	dichlorodiphenyl dichloroethylene
DDT	dichlorodiphenyl trichloroethane
DNA	deoxyribonucleic acid
DO	dissolved oxygen
ELMR	Estuarine Living Marine Resources
EMF	electromagnetic field
EEZ	Exclusive Economic Zone
EFH	essential fish habitat
ESP	electric service platform
F	Fahrenheit
FMP	fishery management plan
ft	feet or foot
GIS	geographic information system
HAB	harmful algal bloom
HARS	Historic Area Remediation Site
HEA	Habitat Equivalency Analysis
Hz	Hertz
IPCC	Intergovernmental Panel on Climate Change
km	kilometer
L	liter
LC50	chemical concentration which causes the death of 50% of the experimental test animals
LFAS	low frequency active sonar
LNG	liquefied natural gas
LWD	large woody debris
m	meter
MARPOL	International Convention for the Prevention of Pollution from Ships
ml	milliliter
mm	millimeter
MMS	Minerals Management Service
MOA	Memorandum of Agreement
MPRSA	Marine Protection, Research, and Sanctuaries Act

MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSD	marine sanitation device
NATO	North Atlantic Treaty Organization
NEFMC	New England Fishery Management Council
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	nonpoint source
NS&T	National Status and Trends
NRC	National Research Council
OCS	Outer Continental Shelf
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyl
pH	the measure of acidity or alkalinity of a solution
POP	persistent organic pollutant
PPCP	pharmaceuticals and personal care products
ppt	parts per thousand
s	second
SAV	submerged aquatic vegetation
SCUBA	self-contained underwater breathing apparatus
SURTASS	Surveillance Towed Array Sensor System
TBT	tributyltin
THC	thermohaline circulation
TOC	total organic carbon
TOY	time-of-year
US ACE	United States Army Corps of Engineers
US EPA	United States Environmental Protection Agency
μA	microamp
μg	micrograms
μV	microvolt

GLOSSARY OF TERMS

alevins	young salmonid fish distinguished by an attached yolk sac
alkalinity	the quantitative capacity of water to neutralize an acid
amnesic shellfish poisoning	caused by domoic acid, an amino acid, as the contaminant of shellfish
anadromous	migrating from the sea to fresh water to spawn
anoxia	complete absence of oxygen in aquatic habitats
anthropogenic	effects, processes, or materials that are derived from human activities
aquatic nuisance species	introduced (nonnative) organisms that produce harmful impacts on aquatic natural resources
autotrophic	a class of organism that produces organic compounds from carbon dioxide as a carbon source, by using either light or reactions of inorganic chemical compounds, as a source of energy; also known as a producer in a food chain
beach nourishment	the replacement of sand on an eroded beach from an outside source such as an offshore sand deposit, an inlet tidal delta, or an upland sand quarry
benthic	in or associated with the seafloor
benthos	organisms living on, in, or near the bottom of water bodies
bioaccumulation	the accumulation of substances, such as pesticides, methylmercury, or other organic chemicals in an organism or part of an organism
biocide	a chemical substance capable of killing different forms of living organisms (e.g., pesticide)
borrow pit	an excavation dug to provide material for fill elsewhere; used in aggregate or mineral mining and in beach nourishment
carcinogenic substance	cancer causing agent
catadromous	migrating from fresh water to the sea to spawn
climax community	a community of organisms the composition of which is more or less stable and in equilibrium with existing natural environmental conditions

creosote	a brownish oily liquid consisting chiefly of aromatic hydrocarbons obtained by distillation of coal tar and used especially as a wood preservative
cytolysis	the dissolution or destruction of a cell
demersal	dwelling at or near the bottom of a body of water
denitrification	the process of reducing nitrate and nitrite (highly oxidized forms of nitrogen available for consumption by many groups of organisms) into gaseous nitrogen
desalination	any of several processes that remove the excess salt and other minerals from water in order to obtain fresh water suitable for consumption or irrigation
diadromous	migratory between fresh and salt waters
diel	occurring on a daily basis, such as vertical migrations in some copepods and fish
dissolved oxygen	a measure of the amount of gaseous oxygen dissolved in an aqueous solution
echolocation	the biological sonar used by dolphins and whales for navigation and foraging
ecosystem	a natural unit consisting of all plants, animals, and microorganisms in an area functioning together with all the nonliving physical factors of the environment
endocrine disruptor	an exogenous (outside the body) agent that interferes with the production, release, transport, metabolism, binding, action, or elimination of natural hormones in the body responsible for the maintenance of homeostasis and the regulation of developmental processes
entrainment	the voluntary or involuntary movement of aquatic organisms from the parent water body into a surface diversion or through, under, or around screens, resulting in the loss of the organisms from the population
epibiota	attached plants and animals that settle and grow on natural or artificial surfaces
epipelagic	part of the open ocean comprising the water column from the surface down to approximately 200 meters
estrogenic substances	compounds that mimic female steroid hormones or inhibit male steroid hormones

eutrophication	enrichment of nutrients causing excessive plant growth that can reduce oxygen concentration and kill aquatic organisms
extirpate	to eliminate completely certain populations within the range of a given species
gas supersaturation	the overabundance of gases in turbulent water, such as at the base of a dam spillway, which can cause a fatal condition in fish
genotype	the genetic constituents in each cell of an organism
glacial till	an unsorted, unstratified mixture of fine and coarse rock debris deposited by a glacier
hardpan	a layer of hard subsoil or clay
headwater	the source of water for a river or stream
heterotrophic	a class of organism that requires organic substrates to get its carbon for growth and development; also known as a consumer in the food chain
hydrophobicity	the property of being water-repellent or tending to repel and not absorb water
hyperplasia	an increase in the number of the cells causing an organ or tissue to increase in size
hypersaline	salinity well in excess of that of sea water
hypertrophy	an increase in the size of an organ or in a select area of the tissue caused by an increase in the size of cells, while the number stays the same
hyporheic zone	saturated zone under a river or stream, composed of substrates with interstices filled with water
hypoxia	a low oxygen condition in aquatic habitats
ichthyoplankton	eggs and larvae of fish that drift in the water column
immunotoxicity	adverse effects on the functioning of the immune system that result from exposure to chemical substances
impingement	involuntary contact and entrapment of aquatic organisms on the surface of intake screens caused by the approach velocity exceeding the swimming capability of the organism
littoral zone	also called the intertidal zone, it lies between the high tide mark and the low tide mark

lotic	pertaining to running water, as opposed to lentic or still waters
macroinvertebrate	an animal lacking a backbone and visible without the aid of magnification
meroplankton	organisms that are planktonic for only a part of their life cycles, usually the larval stage
methylmercury	formed from inorganic mercury by the action of anaerobic organisms that live in aquatic systems and sediments; a bioaccumulative environmental toxin
mutagenic	agent causing genetic mutations
neurotoxic shellfish poisoning	shellfish poisoning caused by exposure to a group of polyethers called brevetoxins
oligohaline	brackish water with a salinity of 0.5 to 5.0 parts per thousand
organochlorides	a large, diverse group of organic compounds containing at least one covalently bonded chlorine atom, some of which are considered to be persistent organic pollutants and are harmful to the environment (e.g., PCB, DDT, chlordane, dioxins)
organometal	A member of a broad class of compounds whose structures contain both carbon and a metal (e.g., methylmercury and tetra-ethyl lead) - persistent and bioaccumulative environmental toxins
osmoregulation	the physiological mechanism for the maintenance of an optimal and constant fluid concentration and pressure in and around the cells
paralytic shellfish poisoning	caused by a group of toxins elaborated by planktonic algae (dinoflagellates, in most cases) upon which the shellfish feed
parr	developmental stage of young salmonid fish that follows the fry and lasts for one to three years in their native stream before becoming smolts
pelagic	associated with the water column
phytoplankton	microscopic plants that drift in the water column
planktivorous	feeding on plankton (e.g., most fish larvae and many pelagic fishes)
pycnocline	a layer of rapid change in water density with depth mainly caused by changes in water temperature and salinity
radionuclide	an atom with an unstable nucleus that can occur naturally but can also be artificially produced; also known as radioisotope

redd	an area in gravel where salmonids bury their eggs; also known as nests or gravel nests
reflective turbulence	changes in water velocity caused by wave energy reflection from solid structures in the nearshore coastal area, resulting in increased turbidity
riparian	land directly adjacent to a stream, lake, or estuary
salmonid	belonging to, or characteristic of the family salmonidae, which includes salmon, trout, and whitefish
sedimentation	the deposition by settling of suspended solids
siltation	sedimentary material consisting of very fine particles intermediate in size between sand and clay
smoltification	a suite of physiological, morphological, biochemical, and behavioral changes, including development of the silvery color of adults and a tolerance for seawater, that take place in young salmonid fish they prepare to migrate downstream and enter the sea
soil infiltration	the passage of water through the surface of the soil into the soil profile via pores or small openings
spermatogenesis	the process by which male gametes are formed in many sexually reproducing organisms
synergistic	combined effects being greater than the sum of individual effects
tailwater	an area immediately below a dam where the river water is cooler than normal and rich in nutrients
tannins	astringent, plant polyphenol compounds that bind and precipitate proteins; used in manufacturing inks and dyes
thermocline	a vertical temperature gradient in some layer of a body of water that is appreciably greater than the gradients above and below it
time-of-year restrictions	seasonal constraints for dredging to avoid or minimize impacts of sensitive periods in the life-history of an organism, such as spawning, egg development, and migration
tonne	sometimes referred to as a metric tonne, the measurement of mass equal to 1,000 kilograms
trophic level	the position that an organism occupies in a food chain

turbidity	the cloudiness or haziness of water caused by individual particles or suspended solids
volitional fish passage	any type of structure that provides fish passage over, through, or around an obstruction in a river or stream (e.g., dam) that can be successfully achieved under the fish's own power (as opposed to trap and truck methods)
xenobiotic	a chemical which is found in an organism but which is not normally produced or expected to be present in it (e.g., pollutants, such as dioxins or PCB congeners)

INTRODUCTION

Report Purpose

This report stems from a workshop entitled "Technical Workshop on Impacts to Coastal Fishery Habitat from Nonfishing Activities," which was held January 10 – 12, 2005 in Mystic, CT. The workshop convened a group of experts in the field of environmental, marine habitat, and fisheries impact assessment from federal and state government agencies. The goals of the workshop were to: (1) describe known and potential adverse effects of human induced, nonfishing activities on fisheries habitats; (2) create a matrix of the degree of impacts associated with various activities in riverine, estuarine, and marine habitats; and (3) develop a suite of best management practices (BMPs) and conservation recommendations that could be used to avoid or minimize adverse impacts to fisheries habitats. Refer to Chapter One-Technical Workshop on Impacts to Coastal Fisheries Habitat from Nonfishing Activities, for a detailed summary of the technical workshop.

The general purpose and goals of this report are to:

1. Identify human activities that may adversely impact Essential Fish Habitat (EFH) and other coastal fishery habitat. As Stevenson et al. (2004) characterized the impacts to EFH from fishing activities in the northeast region, the focus of this report is on nonfishing activities.
2. Review and characterize existing scientific information regarding human-induced impacts to EFH and other coastal fishery habitat.
3. Provide BMPs and conservation measures that can be implemented for specific types of activities that avoid or minimize adverse impacts to EFH and other coastal fishery habitat.
4. Provide a comprehensive reference document for use by federal and state marine resource managers, permitting agencies, professionals engaged in marine habitat assessment activities, the regulated community, and the public.
5. Ensure that the best scientific information is available for use in making sound decisions with respect to project planning, environmental assessment, and permitting.

The National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service is mandated to protect and conserve fishery resources, an activity which includes engaging in consultation with federal agencies on actions that may adversely affect NOAA's trust resources. It is anticipated that the information in this report will be used to assist federal agencies and their consultants in the preparation of impact assessments for EFH and other NOAA's trust resources. In addition, this report will assist National Marine Fisheries Service habitat specialists in: (1) reviewing proposed projects; (2) considering potential impacts that may adversely affect NOAA's trust resources; and (3) providing consistent and scientifically supported conservation recommendations. This report will also provide insight for the public and the regulated community on the issues of concern to National Marine Fisheries Service along with approaches to design and implementation of projects that avoid and minimize adverse effects to fish habitat.

Organization of the Report

The document is organized by activities that may potentially impact EFH and other fishery habitat occurring in riverine, estuarine/coastal, and marine/offshore areas. Chapter One describes the technical workshop that was conducted and presents the results of those discussions and habitat

impact evaluations. The major activities that were identified as impacting these three habitat areas include:

- coastal development
- energy-related activities
- alteration of freshwater systems
- marine transportation
- offshore dredging and disposal
- physical and chemical effects of water intake and discharge facilities
- agriculture and silviculture
- introduced/nuisance species and aquaculture
- global effects and other impacts

Each subsequent chapter characterizes impacts associated with the major activities listed above. Each chapter describes the adverse effects of various activities on fishery habitat and the species associated with those habitats, provides the scientific references to support those findings, and concludes with best management practices or conservation recommendations that could be implemented to avoid or minimize those particular adverse effects. Although the activities and effects identified in the technical workshop are reflected in the appropriate chapter, the reader may notice some minor variation in the order and content if the chapter author(s) failed to locate information in the literature on a specific topic or believed additional discussion of effects were warranted. The preparers of this report have attempted to summarize the current knowledge of impacts and effects from existing and potential activities in the coastal areas of the northeast region of the United States. However, the reader should not consider the information in the report as comprehensive for all activities and impacts on fishery habitats. For more detailed analyses and understanding, the reader should refer to the cited references and the most current literature regarding specific activities and impacts.

The BMPs and conservation measures provided in this report are designed to minimize or avoid the adverse effects of human activities on fishery habitat and to promote the conservation and enhancement of fishery habitat. The BMPs and conservation measures provided in this report reflect many of the conservation principals recommended in Hanson et al. (2003). These general principles include: (1) nonwater-dependent actions should not be located in fishery habitat if such actions may have adverse impacts on those resources; (2) activities that may result in significant adverse affects on fishery habitat should be avoided where less environmentally harmful alternatives are available; (3) if alternatives do not exist, the impacts of these actions should be minimized; and (4) environmentally sound engineering and management practices should be employed for all actions that may adversely affect fishery habitat.

The conservation measures and BMPs included with each activity present a series of practices or steps that can be undertaken to avoid or minimize impacts to fishery habitats. Not all of these suggested measures are applicable necessarily to any one project or activity that may adversely affect habitat. More specific or different measures based on the best and most current scientific information may be developed as part of the project planning or regulatory processes. The conservation recommendations and BMPs provided represent a generalized menu of the types of measures that can contribute to the conservation and protection of fishery habitat and other coastal aquatic habitats.

The final chapter contains a brief discussion of the purpose and application of compensatory mitigation used to offset adverse effects on fishery habitat. We have chosen to include a discussion on compensatory mitigation in its own chapter because its application is not generally considered a

best management practice or a recommendation to conserve fishery habitat. Instead, compensatory mitigation is a method of offsetting adverse effects after they have occurred. For that reason, compensatory mitigation should be considered only after all measures to avoid and then minimize impacts have been exhausted. Compensatory mitigation should never be used as a first-line conservation measure.

Some of the impact types described in one chapter may also be found in other chapters containing similar impacts or activities. Therefore, the reader may find some redundancy in the various chapters. Because the report's focus was to describe the impacts to living marine resources and habitats associated with specific anthropogenic activities and often have similar adverse affects on living marine resources, some redundancy in the descriptions of impacts between various chapters was unavoidable.

Characterization of Habitat in the Northwest Atlantic Ocean

The general focus of this report pertains to effects on marine, estuarine, and diadromous fishes and their habitats. However, the preparers of the report have attempted to provide a broad perspective of coastal aquatic habitat and the organisms that depend upon those habitats in an ecosystem context. Although the report often refers to "fishery habitat" or "fish," the definitions of these resources should not necessarily be limited to any particular regulatory or management mandate, such as EFH. The authors have attempted to include information on known or potential impacts that may affect the ecological functions and values for habitats for all species of fish and invertebrates. Because the focus of this report is on impacts to fish and fishery habitats, we have included only limited discussions on impacts specific to marine mammals and sea turtles.

Habitats provide living things with the basic life requirements of nourishment and shelter (Stevenson et al. 2004). According to Deegan and Buchsbaum (2005), a habitat includes the physical environment, the chemical environment, and the many organisms that compose a food web. This report employs a similarly broad definition to discuss the multitude of adverse effects on habitats in the coastal northeastern United States. For example, the quality of the water in which aquatic organisms live, feed, and reproduce is a facet of their habitat, and the presence of contaminants or alterations to the water has important implications on the health of those organisms. Habitats may also provide a broader range of benefits to the ecosystem, such as the way seagrasses physically stabilize the substrate and help recirculate oxygen and nutrients (Stevenson et al. 2004). These habitats do not exist in isolation but are linked through ecological and oceanographic processes that are a part of the larger ecosystem. For example, the movement of the water plays a major role in the interconnection of habitats by transporting nutrients, food, larvae, sediments, and pollutants among them (Tyrrell 2005).

The northwest Atlantic Ocean includes a broad range of habitats with varying physical and biological properties extending from the cold waters of the Gulf of Maine south to the more temperate climate of the Mid-Atlantic Bight. In this region, the oceanographic and physical processes interact to form a network of expansively to narrowly distributed habitat types (Stevenson et al. 2004). The offshore component of this region, also known as the Northeast US Continental Shelf Ecosystem (Sherman et al. 1996), is composed of four distinct subregions: the Gulf of Maine, Georges Bank, the Mid-Atlantic Bight, and the continental slope (Stevenson et al. 2004). In addition, the region contains freshwater rivers and streams that flow towards the sea into numerous bays and estuaries that serve as important refuge and nursery areas for marine species. This report focuses on the three major systems composing this ecosystem: riverine, estuarine/nearshore, and marine/offshore environments.

The habitat classifications described by Jury et al. (1994) and adopted by NOAA as a national standard for organizing its Estuarine Living Marine Resources (ELMR) program's database are useful because they facilitate consideration of physico-chemical interactions in water quality and habitat impacts and implications for aquatic organisms. Conveniently, this approach also aligns with ambient suspended sediment and particulate loads because maximum turbidity zones of temperate, well-mixed estuaries typically coincide with low salinity regions (Herman and Heip 1999). Accordingly, this report has used the three ELMR salinity ranges developed for coastal aquatic habitats to describe "riverine" (<0.5 ppt), "estuarine/nearshore" (0.5-25.0 ppt), and "marine/offshore" (>25.0 ppt) conditions.

Riverine

Riverine habitats, located along the coast of New England and the Mid-Atlantic, provide essential habitat to anadromous and catadromous ("diadromous") fishes. These habitats include freshwater streams, rivers, streamside wetlands, and the banks and associated vegetation that may be bordered by other freshwater habitats (NEFMC 1998). Depending upon the local water velocity and other physical characteristics, riverine systems may include a variety of benthic substrates ranging from exposed bedrock, cobble, and other hard bottom types to extremely unconsolidated, soft bottom material. These features have a great bearing on the fish and invertebrate species that may be present.

Riverine habitats serve multiple purposes including migration, feeding, spawning, nursery, and rearing functions. An important component of a river system also includes the riparian corridor. The term "riparian" refers to the land directly adjacent to a stream, lake, or estuary. A healthy riparian area has vegetation supporting prey items (e.g., insects); contributes necessary nutrients; provides large woody debris that creates channel structure and cover for fish; and provides shade, which controls stream temperatures (NEFMC 1998).

Estuarine/nearshore

Estuaries are the bays and inlets influenced by both the ocean and rivers that serve as the transition zone between fresh and salt water. In the northeastern United States, they also may include the substantial inland reaches of large river systems where salinities exceed 0.5 ppt. For instance, ocean tides influence the lower 153 miles of the Hudson River, and oligohaline salinities (0.5 pp – 5 ppt) can extend well inland under low flow conditions. Typically, the northernmost intrusion of brackish water does not extend past the city of Poughkeepsie, nearly 75 miles north of The Battery at the southern tip of Manhattan, NY.

Estuaries support a community of plants and animals that are adapted to the zone where fresh and salt waters mix. Estuarine habitats fulfill fish and wildlife needs for reproduction, feeding, refuge, and other physiological necessities (NEFMC 1998). Coastal and estuarine features such as salt marshes, mud flats, rocky intertidal zones, sand beaches, and submerged aquatic vegetation are critical to inshore and offshore habitats and fishery resources of the northeastern United States (Stevenson et al. 2004). For example, healthy estuaries include eelgrass beds that protect young fish from predators, provide habitat for fish and wildlife, improve water quality, and can help stabilize sediments. In addition, mud flats, high salt marshes, and saltmarsh creeks also provide productive shallow water habitat for epibenthic fishes and decapods. Inshore habitats are dynamic and heterogeneous environments that support the majority of marine and anadromous fishes at some stage of development (NEFMC 1998).

Marine/offshore

The Gulf of Maine is an enclosed coastal sea, characterized by relatively cold waters and deep basins with a patchwork of various sediment types. Georges Bank is a relatively shallow coastal plateau that slopes gently from north to south and has steep submarine canyons on its eastern and southeastern edge. It is characterized by highly productive, well-mixed waters and strong currents. The Mid-Atlantic Bight is composed of the sandy, relatively flat, gently sloping continental shelf from southern New England to Cape Hatteras, NC. The continental slope begins at the continental shelf break and continues eastward with increasing depth until it becomes the continental rise. It is fairly homogenous, with exceptions at the shelf break, some of the canyons, the Hudson Shelf Valley (offshore New York), and areas of glacially rafted hard bottom (Stevenson et al. 2004).

The offshore benthic habitat features include sand waves, shell aggregates, gravel beds, boulder reefs, and submerged canyons which provide nursery areas for many fish species (NEFMC 1998). Many marine organisms inhabit the stable offshore environment for multiple stages of their life history.

Essential Fish Habitat

In 1996, the US Congress declared that "one of the greatest long-term threats to the viability of the commercial and recreational fisheries is the continuing loss of marine, estuarine, and other aquatic habitats. Habitat considerations should receive increased attention for the conservation and management of fishery resources of the United States" (Magnuson-Stevens 1996, sec. 2.a.9.). Along with this declaration, Congress added new habitat conservation provisions to the Magnuson-Stevens Fishery Conservation and Management Act (MSA), the federal law that governs US marine fisheries management. The MSA requires that fishery management plans describe and identify essential fish habitat, minimize adverse effects on habitat caused by fishing, and identify other actions to encourage the conservation and enhancement of such habitat. Essential fish habitat has been defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (Magnuson-Stevens 1996, sec. 3.10.).

The MSA also requires federal agencies to consult with the Secretary of Commerce, acting through the NOAA's National Marine Fisheries Service, on all actions authorized, funded or undertaken, or proposed to be authorized or undertaken by the agency, that may adversely affect EFH. The process developed for conducting these EFH consultations is described in the EFH regulations (50 CFR §600.905 – 920). In summary, federal agencies initiate consultation by preparing and submitting an EFH assessment to the National Marine Fisheries Service that describes the action, analyzes the potential adverse effects of the action on EFH, and provides the agency's conclusions regarding the effects of the action on EFH. In response, the National Marine Fisheries Service provides the agencies with conservation recommendations to conserve EFH by avoiding, minimizing, mitigating, or otherwise offsetting the adverse effects to EFH. Adverse effect is defined as any impact which reduces the 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. Adverse effects may be site-specific or habitat-wide, including individual, cumulative, or synergistic consequences of actions [50 CFR §600.910(a)]. This broad definition of adverse effects has been employed in this report to describe the various activities and sources of nonfishing impacts that can degrade fisheries habitat.

Once the National Marine Fisheries Service provides conservation recommendations, the federal action agencies must provide a detailed response in writing to the Nationial Marine Fisheries Service. The response must include measures proposed for avoiding, mitigating, or offsetting the impact of a proposed activity on EFH. If the federal action agency chooses not to adopt National Marine Fisheries Service's conservation recommendations, it must explain its reasons for not following the recommendations.

Impacts to Habitat

Habitat alteration and disturbance occur from natural processes and human activities. Deegan and Buchsbaum (2005) placed human impacts to marine habitats into three categories: (1) permanent loss; (2) degradation; and (3) periodic disturbance. Permanent loss of habitat can result from activities such as wetland filling, coastal development, harbor dredging, and offshore mining operations (Robinson and Pederson 2005). Habitat degradation may be caused by physical changes, such as increased suspended sediment loading, overshadowing from new piers and wharves, as well as introduction of chemical contamination from land-based human activities (Robinson and Pederson 2005). Periodic disturbances are created by activities such as trawling and dredging for fish and shellfish and maintenance dredging of navigation channels.

The primary differences between these three categories are that permanent loss is irreversible, habitat degradation may or may not be reversible, and periodic disturbance is generally reversible once the source of disturbance is removed (Deegan and Buchsbaum 2005). These authors indicate that recovery times for degraded habitat depend on the nature of the agent causing the degradation and the physical characteristics of the habitat. Recovery times for periodic disturbances will vary depending on the intensity and periodicity of the disturbance and the nature of the habitat itself. Natural fluctuations in habitats, such as storms and long-term climatic changes, occur independently of anthropogenic impacts.

Deegan and Buchsbaum (2005) state that "habitat quantity is a measure of the total area available, while habitat quality is a measure of the carrying capacity of an existing habitat." Generally, activities that lead to a permanent loss of habitat reduce the quantity of habitat, whereas habitat degradation and periodic disturbances result in a loss of habitat quality. The reduced quality of habitat (e.g., siltation, eutrophication, and alteration of salinity and food webs) may be equally damaging to the biological community as a loss in habitat quantity. As Deegan and Buchsbaum (2005) have noted, "the physical structure of the habitat does not need to be directly altered for negative consequences to occur." For example, reductions in water quality can impair and limit the ability of aquatic organisms to grow, feed, and reproduce.

The end point of gradual declines in the quality of habitat can be the complete loss of habitat structure and function (Deegan and Buchsbaum 2005). Losses of habitat quantity and quality may reduce the ability of a region to support healthy and productive fish populations. From the population perspective, the loss of habitat quantity and quality creates stresses on a population. Populations that are stressed by one or more factors can be more susceptible to stresses caused by other factors (Robinson and Pederson 2005), resulting in cumulative effects. These authors call for a holistic approach to fishery management: one that considers the interactions among exploitation, contaminants, and habitat degradation on various fish stocks.

Lotze et al. (2006) show that severe depletion of marine resources (i.e., 50% reduction in abundance level) first began with the onset of European colonization. This study found that 45% of species depletions and 42% of extinctions involved multiple human impacts, mostly exploitation and habitat loss. Seventy eight percent of resource recoveries are attributed to both habitat

protection and restricted exploitation, while only 22% of recoveries are attributed to reduced exploitation alone (Lotze et al. 2006). These authors also conclude that reduced exploitation, increased habitat protection, and improved water quality need to be considered together and that the cumulative effects of multiple human interventions must be included in both management and conservation strategies.

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