APPENDIX I

NATURAL RESOURCES

APPENDIX I.1

NATURAL RESOURCES REFERENCES

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APPENDIX I.2

ESSENTIAL FISH HABITAT ASSESSMENT

Appendix 1.2.: ESSENTIAL FISH HABITAT ASSESSMENT

A. INTRODUCTION

Essential fish habitat (EFH) is defined under the Magnuson-Stevens Fishery Conservation Management Act (16 USC §§ 1801 to 1883), as amended by the Sustainable Fisheries Act (SFA) of 1996, as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." "Waters" include aquatic areas and their physical, chemical and biological properties that are used by fish. "Substrate" includes sediment, hard bottom, structures, and associated biological communities that are under the water column. Waters and substrates necessary for fish spawning, breeding, feeding or growth to maturity—covering all stages within the life cycle of a particular species—refers to those habitats required to support a sustainable fishery and a particular species' contribution to a healthy ecosystem (50 Code of Federal Regulations (CFR) 600.10).

Section 303(a)(7) of the Magnuson-Stevens Act requires that the eight Regional Fishery Management Councils (RFMC) describe and identify EFH for each Federally managed species, and minimize adverse impacts from fishing activities on EFH. Section 305(b)(2)-(4) of the Magnuson-Stevens Act outlines the process for providing the National Marine Fisheries Service (NMFS) within the National Oceanic and Atmospheric Administration (NOAA), and the RFMC with the opportunity to comment on activities proposed by Federal agencies that have the potential to adversely impact EFH areas. Federal agencies are required to consult with NMFS (using existing consultation processes for NEPA, the Endangered Species Act, or the Fish and Wildlife Coordination Act) on any action that they authorize, fund or undertake that may adversely impact EFH.

Adverse effects to EFH, as defined in 50 CFR 600.910(A) include any impact that reduces the quality and/or quantity of EFH. Adverse effects may include:

- Direct impacts such as physical disruption or the release of contaminants;
- Indirect impacts such as the loss of prey, reduction in the fecundity (number of offspring produced) of a managed species; and
- Site-specific or habitat-wide impacts that may include individual, cumulative or synergetic consequences of a Federal action.

An EFH assessment of a Federal action that may adversely affect EFH must contain:

- A description of the proposed action;
- An analysis of the effects, including cumulative, on EFH, the managed species and associated species such as major prey species, and the life history stages that may be affected;
- The agency's conclusions regarding the effects of the action on EFH; and
- Proposed mitigation if applicable (50 CFR 600.920(g)).

B. PROJECT DESCRIPTION

Prior to September 11, 2001, the World Trade Center (WTC) complex (Towers 1 through 6, the WTC PATH Terminal and concourse), relied on water withdrawn from the Hudson River for cooling. The withdrawal of river water resulted in the loss of fish and invertebrates through impingement (individuals trapped against intake screens or other barriers at the entrance of cooling water intake structures) or entrainment (individuals drawn into a cooling water intake structure). After passing through the cooling system, the heated river water was discharged back into the Hudson River through one of two discharge outlets. The discharge of the cooling water was authorized by the New York State Department of Environmental Conservation (NYSDEC) through a State Pollutant Discharge Elimination System Permit (SPDES Number NY-0006033) that was most recently renewed in 1999. Although the structures remained largely intact, use of the intake and outfalls, and the associated impingement and entrainment of aquatic organisms ceased after September 11, 2001.

The WTC Memorial and Redevelopment Project (Proposed Action) contemplates using the existing WTC intake structure and outfalls, as part of the cooling system for its office towers, retail users, hotel, museum, and cultural facilities at the Memorial. The intake would also be used to supply cooling water for the Port Authority's permanent WTC PATH Terminal and concourse. While the development of the permanent PATH Terminal is independent of the Proposed Action and is undergoing a separate environmental review with the FTA as the federal lead agency, the volume of river water that would be used to cool that project (approximately 5 to 6 percent of the volume withdrawn at the intake) is included in the Proposed Action. The reuse of the existing cooling water intake and outfalls is the most economical and efficient method for cooling the components of the Proposed Action. It is also consistent with the overall goal of integrating sustainable development techniques into the design of the Proposed Action. The proposed withdrawal has the potential to result in the loss of some aquatic organisms through impingement and entrainment at the intake, however. The Proposed Action would also result in the discharge of heated effluent to the Hudson River through the existing WTC outfalls.

SITE DESCRIPTION

The WTC cooling water intake and outfalls proposed for reuse as part of the Proposed Action, are located within the portion of the Lower Hudson River Estuary that is adjacent to Battery Park City and west of the WTC complex. The pair of intakes are located at the landward end of an inlet channel located under the Battery Park City esplanade. The two outfalls are located within the North Cove, across from the WTC Site.

WATER QUALITY OVERVIEW

The WTC intake and outfalls are located within the Lower Hudson River Estuary. Saltwater from Upper New York Bay enters the Lower Hudson River Estuary during the flood phase of the tidal cycle and lower salinity water is discharged from the Estuary to the Bay during the ebb phase. Tidal flows (200,000 to 500,000 cubic feet per second (cfs)) are considerably larger than fresh water flows (19,000 to 20,000 cfs). Currents are shore parallel and tidally influenced, with primary flows to the north during flood tide and to the south during ebb tide (Ocean Surveys, Inc. 1987).

The salinity of the Lower Hudson River Estuary varies daily with the tidal cycle and seasonally with the volume of freshwater entering from upriver. Freshwater and higher salinity waters are well mixed during low flow conditions but are stratified under high flow conditions when the freshwater overrides the saltwater layer (Moran and Limburg 1986). Ristich et al. (1977) classified the Lower Hudson River

Estuary as polyhaline (18 to 30 parts per thousand (ppt)) in late summer and autumn, and mesohaline (5 to 18 ppt) in spring and early summer.

The NYSDEC classifies the Lower Hudson River as Use Class I saline surface water. The best usages for Class I saline surface waters are as secondary contact recreation and fishing and suitable for fish propagation and survival. The water quality of the Lower Hudson River Estuary is strongly affected by human activity upstream and the densely populated and industrialized land uses that surround it. Historically, water quality problems included low dissolved oxygen (DO) content, high nutrient concentrations, algal blooms, excessive numbers of coliform bacteria, and the presence of floatables. However, the construction and upgrading of wastewater treatment facilities (WWTF), and implementation of water pollution control programs throughout New York Harbor over the past 25 years has greatly reduced nutrient inputs and improved water quality (Brosnan and O'Shea 1995). This improvement in water quality has continued through 2002, with DO concentrations generally above the 4.0 milligram per liter (mg/L) standard (NYCDEP 2003a).

The New York City Department of Environmental Protection (NYCDEP) monitors coliform bacteria as an indicator of sewage-related pollution. Primary sources of coliform bacteria include combined sewer overflows (CSOs) during and immediately after rain events, illegal sewage connections to CSOs, occasional unplanned bypasses in the sewer system due to equipment malfunction, permitted dry weather bypasses due to construction and upgrading WWTF effluent, stormwater, and boat discharges. Disinfected WWTF effluent contributes less than 1 percent of the total coliform load to the New York Harbor. Fecal coliform concentrations for the Inner Harbor Area, which includes the area in the vicinity of the WTC intake and outfalls, showed a dramatic decline from the early 1970s, dropping from more than 2,000 cells per 100 milliliters (cells/100 mL) to below 200 cells/100 mL, below the standard for Use Class I. This decline is attributed to the abatement of raw sewage discharges through construction and upgrading of WWTF, and the city's water pollution control programs (NYCDEP 2002).

DO has increased in the Inner Harbor Area over the past 30 years from an average of below 3 mg/L in 1970 to about 5 mg/L in 2001, which is above the 4.0 mg/L standard for Use Class I waters (NYCDEP 2002). DO concentrations in the Hudson River follow a seasonal pattern—lowest during the summer and highest in the late winter/early spring when the river water is coolest and least saline (Moran and Limburg 1986). Areas with DO concentrations less than 4.0 mg/L are often avoided by finfish, although most estuarine organisms can tolerate much lower concentrations for short periods.

Other indicators of water quality recorded for the Inner Harbor Area include chlorophyll *a*, water transparency, suspended sediment, and pH. The concentration of chlorophyll *a* (used to estimate phytoplankton biomass) has increased slightly since measurements of this parameter were begun in 1986. Water transparency, measured with a Secchi disk, has varied only a few percent each year since measurements were begun in 1986 (NYCDEP 2002). Suspended sediments vary with season and weather—near bottom concentrations range between 100 and 200 mg/L in summer, 100 to 400 mg/L during high discharge periods, and greater than 800 mg/L at times of maximum flow. Within the lower Hudson River Estuary, surface and bottom water pH ranges from 7.0 to 8.0 throughout the year (Brosnan and O'Shea 1995).

Water quality data collected at the Harbor Survey station closest to the WTC intake and outfalls (mid-river near Pier A just south of Battery Place) (Table I.2-1), from 1998 through 2002, indicate that the water quality in this part of the lower Hudson River is generally good. All pH levels in the New York Harbor Area are in attainment.

Table I.2-1
NYCDEP Water Quality Data for the Pier A Sampling Station in the Hudson River (1998 – 2002)

Parameter	Top Waters			Bottom Waters		
	Low	High	Avg	Low	High	Avg
Total Fecal Coliforms (per 100 mL)	1	1,720	138.6	2	280	43.4
Dissolved Oxygen (mg/L)	4.2	12.3	7.1	3.5	10.9	6.5
Secchi Transparency (feet)	1.5	8	4.3	NA	NA	NA
Chlorophyll *a* (µg/L)	0.5	39.1	4.8	NM	NM	NM
Salinity (parts per thousand, ppt)	2.1	28.6	19.5	2.9	31.6	25.0
Temperature (EC)	3.1	25.5	17.7	3.4	25.0	17.3

Notes: NM = not measured, NA = not applicable
Source: NYCDEP 2003b.

SEDIMENTS OVERVIEW

Complex flow patterns lead to widely variable sediment characteristics throughout the area, varying from coarse sands and gravels in high-energy areas to fine-grained silts and clays in low-energy areas (USACOE 1999). The primary constituents of Hudson River sediments are silt and clay (USACOE 1996, EEA 1988). As is typical of urban watersheds, New York Harbor Estuary sediments are contaminated due to a history of industrial uses in the area. Contaminants found throughout the New York Harbor Estuary include pesticides such as chlordane and DDT, metals such as mercury, cadmium, lead, and copper, PCBs and various polycyclic aromatic hydrocarbons (Rohmann and Lilienthal 1987). Adams et al. (1998) found the mean sediment contaminant concentration for 50 of 59 chemicals measured in sediment samples from the New York/New Jersey Harbor Estuary to be statistically higher than other coastal areas on the East Coast. Within the New York/New Jersey Harbor Estuary, Adams et al. (1998) ranked Newark Bay as the most degraded area on the basis of sediment chemistry, toxicity, and benthic community, followed by the Upper Harbor, Jamaica Bay, Lower Harbor, Western Long Island Sound and the New York Bight Apex. Biological effects, identified based upon the benthic invertebrate community, were found to be associated with the chemical contamination. While the sediments of the New York Harbor Estuary are contaminated, the levels of most sediment contaminants (e.g., dioxin, DDT, and mercury) have decreased on average by an order of magnitude over the past 30 years (Steinberg et al. 2002).

C. EFH DESIGNATIONS

The NMFS designates EFH within 10' by 10' squares identified by latitude and longitude coordinates. The location of the WTC intake and outfalls on the lower Hudson River is within a portion of the Hudson River estuary EFH that is situated in the NMFS 10' x 10' square with coordinates (North) 40°50.0' N, (East) 74°00.0' W, (South) 40°40.0' N, (West) 74°00.0' W. This square includes the following waters: the Hudson River and Bay from Guttenberg, NJ south to Jersey City, NJ, including the Global Marine Terminal and the Military Ocean Terminal, Bayonne, NJ, Hoboken, NJ, Weehawken, NJ, Union City, NJ, Ellis Island, Liberty Island, Governors Island, the tip of Red Hook Point on the west tip of Brooklyn, NY, and Newark Bay. This area has been identified as EFH for 15 species of fish. Table I.2-2 lists these species and life stages for which EFH has been designated.

Table I.2-2
Essential Fish Habitat Designated Species for the Lower Hudson River

Species	Eggs	Larvae	Juveniles	Adults	Spawning
Red hake (*Urophycis chuss*)		X	X	X	
Winter flounder (*Pseudopleuronectes americanus*)	X	X	X	X	X
Windowpane (*Scophthalmus aquosus*)	X	X	X	X	X
Atlantic herring (*Clupea harengus*)		X	X	X	
Bluefish (*Pomatomus saltatrix*)			X	X	
Atlantic butterfish (*Peprilus triacanthus*)		X	X	X	
Atlantic mackerel (*Scomber scombrus*)			X	X	
Summer flounder (*Paralichthys dentatus*)		X	X	X	
Scup (*Stenotomus chrysops*)	X	X	X		
Black sea bass (*Centropristis striata*)	N/A		X	X	
King mackerel (*Scomberomorus cavalla*)	X	X	X	X	
Spanish mackerel (*Scomberomorus maculatus*)	X	X	X	X	
Cobia (*Rachycentron canadum*)	X	X	X	X	
Sand tiger shark (*Odontaspis taurus*)		X			
Sandbar shark (*Carcharinus plumbeus*)		X		X	

Source: National Marine Fisheries Service. "Summary of Essential Fish Habitat (EFH) Designation" posted on the internet at www.nero.nmfs.gov/ro/STATES4/conn_li_ny/40407350.html.

D. POTENTIAL IMPACTS TO EFH

GENERAL DISCUSSION OF AQUATIC IMPACTS

OPERATION OF THE WTC COOLING WATER INTAKE

Potential loss of EFH is not expected to occur as a result of the operation of the WTC cooling water intake. Because the intake structure is in place and operational, no in-water construction activities would be required as part of the Proposed Action. Therefore, no physical alteration would occur to EFH in the vicinity of the WTC intake. Furthermore, there would be no need for dredging or any extensive bottom disturbing actions that could negatively affect fish habitat. The operation of the intake would result in an increase in flow velocities from current conditions, but such velocities would be expected to be no greater than those that existed at the intake channel prior to September 11, 2001. Studies comparing the fish communities of underpier habitats to those found in interpier, pile field and channel habitats within the lower Hudson River have found that the number and variety of fish to be significantly lower under piers (EEA 1988, EEA 1990, Able et al. 1995, Able et al. 1998, Able et al. 1999, and Duffy-Anderson and Able 1999). Able et al. (1998) concluded that habitat quality under platforms greater than 20,000 square meters (5 acres) appears to be poor for juvenile fish, compared to pile fields and open water habitats. These studies suggest that the habitat quality in the WTC intake channel under the Batter Park City esplanade would generally be less desirable habitat for most fish species than open water or pile field habitats available within the vicinity of the intakes. Any modification in flow regime that would occur from the operation of the WTC would not be expected to significantly adversely affect EFH.

During sampling conducted at the WTC intake from March 1991 through February 1993, only three EFH species were entrained at the intake: winter flounder (8.4 million eggs and 1.7 million larvae), summer flounder (22,983 larvae), and windowpane (68,609 eggs and 46,771 larvae). Of these three species, winter flounder had the largest estimated annual number of eggs and post-yolk sac larvae entrained during the 1991 to 1993 period. While the estimated annual number of winter flounder eggs and post-yolk sac larvae appears high, the results of the analyses presented in Chapter 18 of the WTC Memorial and Redevelopment Project GEIS show that these losses, combined with the estimated annual average number of juveniles impinged on the intake (116), would equate to an annual loss of about 782 1-year old fish that would have been added to the New York, New Jersey, and Connecticut fishery, or an average loss of about 185 pounds that would have been added to this fishery. The analysis performed in Chapter 18 concluded that this was an extremely small loss to the fishery and would not result in a significant adverse impact to the regional winter flounder population. Numbers of early life stages entrained for summer flounder and windowpane flounder were low (over 100 times lower than the winter flounder numbers) and as such, significant adverse impacts to summer flounder and windowpane flounder populations would not be expected to occur from the operation of the WTC intake.

EFH species impinged included: red hake, winter flounder, windowpane, Atlantic herring, bluefish, Atlantic butterfish, summer flounder, scup, and black sea bass. Estimates of annual impingement for these species ranged from 3 (red hake) to 116 (winter flounder, juveniles only), with most averaging 20 or fewer individuals impinged annually. The GEIS for the Proposed Action evaluated the potential adverse impacts to fish resources resulting from the use of the WTC cooling water intake for partial build-out in 2009 and full build-out in 2015. The results of the evaluation of selected fish species, including the EFH species winter flounder, bluefish, black sea bass, and red hake, show that while there would be losses of aquatic organisms due to impingement or entrainment at the intake, the estimated number of fish and invertebrates lost through operation of the intake in 2015, including prey species for EFH such as bay anchovy and Atlantic menhaden, would be expected to be an average of 65 to 82 percent lower (depending on the season) than what would be expected to occur from the operation of the intake at the design flow. The estimated low annual loss of some individuals through impingement, and higher estimated annual loss of individuals through entrainment would equate to a much smaller number of older fish that would not be added to the population, or small number of pounds that would be lost to a particular fishery because of the extremely high natural mortality of these lifestages. These losses may, however, result in significant adverse impacts to populations of these species in the Lower Hudson River under the Proposed Action in 2015 if withdrawal volumes increase and approach design flows.

As part of the SPDES permitting process for operation of the WTC intake, measures to reduce impingement losses (e.g., further flow reduction, modified screens with fish return, reduction of flow velocities, closed-cycle cooling, and fish avoidance systems such as barrier nets, light and sound) and entrainment losses (e.g., flow reduction, closed-cycle cooling, fine mesh barriers to exclude eggs and larvae such as Gunderbooms and fine mesh wedge wire screens) would be explored with respect to feasibility, effectiveness, potential effects to EFH, cost, and constraints imposed by surrounding property owners and land uses such as deed restrictions or easements.

Because the area to be cooled in 2009 is as much as 60 percent less than 2015 and the pre-September 11 baseline, the volume of water withdrawn for the Proposed Action in 2009, would be similarly reduced. This lower volume of cooling water withdrawn at the WTC intake for the Proposed Action in 2009 would significantly reduce losses of fish and invertebrates through impingement and entrainment. Therefore, the operation of the WTC intake for the Proposed Action in 2009 would not be expected to result in significant adverse impacts to aquatic biota and EFH.

EFFLUENT DISCHARGE

The heated effluent that would be discharged through the existing WTC outfalls from cooling the various components of the Proposed Action, would meet the thermal limitations specified in the 1999 SPDES permit. Because NYSDEC developed the thermal limitations included with the SPDES permit to be protective of aquatic life, the proposed discharge of heated river water through the WTC outfalls would not be expected to have a significant adverse impact to aquatic habitats in the Lower Hudson River Estuary, and the fish community using these areas. Additionally, because the effluent plume is at the surface, it would not affect bottom dwelling species.

STORMWATER

Stormwater generated within the Project Site during construction of the project components and during operation of the Proposed Action would not be discharged directly to surface waters, but would be directed to the municipal combined sewer system. (During wet weather conditions, overflow discharge from the combined sewer system is discharged into either the Hudson River or East River.) Implementation of erosion and sediment control measures, and stormwater management measures during construction, including the approved stormwater pollution prevention plan (SWPPP), and the proposed reclamation of stormwater for other uses such as irrigation of open space areas, would minimize potential impacts to the municipal stormwater system from the introduction of stormwater due to the Proposed Action. Therefore, no significant adverse impacts to water quality, aquatic habitat, or aquatic organisms would be expected to occur from construction or operation of the Proposed Action.

ASSESSMENT OF EFH SPECIES

Table I.2-2 lists the 15 managed fish species that have been identified by the NMFS as having EFH in the lower Hudson River estuary. King mackerel (*Scomberomorus cavalla*) and Spanish mackerel (*Scomberomorus maculatus*), for which EFH has been identified for the egg, larval, juvenile, and adult life stages, are considered southern species. These species are rarely found as far north as the mid-Atlantic or New York Bight, and are often associated with marine, offshore habitats. The sandbar shark (*Carcharinus plumbeus*) (EFH for larvae and adults) and sand tiger shark (*Odontaspis taurus*) (EFH for larvae) are highly migratory shark species that rarely appear in the upper waters of the New York and New Jersey Harbor Estuary.

The following sections present an analysis of EFH for each fish species and life stage for listed in Table I.2-2—including the likelihood that the species would occur within the vicinity of the WTC intake and outfalls.

RED HAKE (Urophycis chuss)

Red Hake is a bottom-dwelling fish that lives on sand and mud bottoms along the continental shelf from southern Nova Scotia to North Carolina (concentrated from the southwestern part of the Georges Banks to New Jersey). Spawning adults and eggs are common in marine portions of most coastal bays between Rhode Island and Massachusetts. Spawning occurs from May to June in the New York Bight (Steimle et al. 1999a). The lower Hudson River is within an area designated as EFH for larval, juvenile, and adult red hake.

Larval red hake are free floating and occur in the middle and outer continental shelf. They are most common in water temperatures from 11 to 19°C (52-66°F) and depths from 10 to 200 m (33-660 feet). Recently metamorphosed juveniles remain pelagic (occupy open water areas) for about two months where they then begin growth up to 25-30 mm (1.0-1.2 inches) in total length. Shelter is a critical habitat requirement for red hake. In the autumn, young juveniles descend from the water column to the bottom and seek sheltering habitat in depressions in the sea floor. Settling peaks usually occur in October and November. Older juveniles use scallop shells, mussel beds, surf clam collars, etc., residing near these shelters until their second autumn when they move inshore to within 55 m (180 feet) depths. They will remain inshore until the temperature reaches 4°C (39°F), at which point they head offshore to overwinter (USACOE 2000; Steimle et al. 1999a).

Woodhead (1990) describes red hake as a common resident of the New York Harbor system. In the Hudson-Raritan Estuary, the distribution of red hake is influenced by salinity, water temperature, and dissolved oxygen. Juvenile red hake were collected when salinity was greater than 22 ppt and at depths from 5 to 50 m (16-164 feet) deep. Collections tapered off when salinity reached greater than 28 ppt. Adult red hake prefers temperatures from 2 to 22°C (36-72°F), salinity ranging from 20 to 33 ppt and depths greater than 25 m (82 feet) deep. In Middle Atlantic Bight, red hake occur most often in coastal waters in the spring and autumn, moving offshore to avoid the warm summer temperatures. Additionally, red hake have been reported to be sensitive to low DO levels, preferring concentrations of 6 mg/L or more within the Hudson-Raritan Estuary (Steimle et al. 1999a).

The water quality measurements from the nearby Pier A monitoring station suggest that juvenile red hake presence may be occasionally limited by low DO in the vicinity of the WTC intake and outfalls, adults may be limited by the lower salinity levels, and both may be limited by the relatively shallow waters. The portion of the Lower Hudson River Estuary in the vicinity of the WTC intake and outfalls makes up a small portion of the EFH for this species and most of the adults and juveniles appear to occur south of the Narrows within the Hudson-Raritan Estuary (Steimle et al. 1999a). Additionally, the southern stock of red hake (the stock that occurs within the New York/New Jersey Harbor) is not currently considered overfished (NMFS 2003). The estimated annual average number of red hake impinged at the WTC intake during the 1991 to 1993 study is 3. Therefore, the operation of the WTC cooling water intake and outfalls would not be expected to result in adverse effects to the red hake fishery or its designated essential fish habitat.

WINTER FLOUNDER (Pseudopleuronectes americanus)

Winter flounder can be found from Labrador to North Carolina but most commonly in estuaries from the Gulf of St. Lawrence to the Chesapeake Bay including the Lower Hudson (Heimbuch et al. 1994; USACOE 2000). It is a fairly small, thick flatfish that is abundant in the Lower Hudson River Estuary, where it is a resident, but may travel upriver into fresh water (Heimbuch et al. 1994). It spawns during the winter and early spring, typically at night in shallow, inshore estuarine waters with sandy bottoms. Woodhead (1990) reports spawning to occur mostly in the Lower New York Bay and the New York Bight. The lower Hudson River is within an area designated as EFH for eggs, larval, juvenile, and adult winter flounder.

Eggs float in the top 25 cm (10 inches) of the intertidal zone and clump together post-fertilization at which point they sink (Heimbuch et al. 1994; USACOE 2000). Optimal egg hatching occurs at 3°C (37°F) and in salinity ranging from 15 to 25 ppt. Winter flounder larvae develop to juveniles within the estuarine system. In March, April and May, winter flounder larvae can be found in the Upper New York Bay near the bottom (Heimbuch et al. 1994).

For the first summer, young-of-year winter flounder remain in the shallow waters (0.1-10 m [0.2-33 feet] in depth) of bays and estuaries where they were spawned, where temperatures are less than 28°C (82°F) and salinities range from 5-33 ppt. Juveniles often occupy areas with sand and/or mud substrates. Some juveniles beyond their first year may overwinter in estuaries at temperatures less than 25°C (77°F), salinities from 10-30 ppt, and depths from 1-5 m (3-16 feet). However, in winter, juvenile catches generally increased outside of the estuary while at the same time decreasing within the estuary, suggesting that some juveniles also migrate out of the estuary in the winter (Pereira et al. 1999).

Adult winter flounder prefer depths of 20 to 48 m (66-158 feet) and are commonly associated with mud, sand, pebble, or gravel bottoms (USACOE 2000). Adults generally leave the New York Harbor estuary in the summer as water temperatures increase, returning to the Harbor in the autumn (Woodhead 1990). Winter flounder will live close to shore, swimming into shallow water to feed. Adults tend to move to deeper water when water temperatures increase in the summer or decrease in the autumn and winter (Heimbuch et al. 1994). NMFS Northeast Fisheries Science Center (NEFSC) trawls within the Hudson-Raritan estuary found adult winter flounder at temperatures between 4-12°C (39-54°F) and salinities as low as 15 ppt, although most were found at salinities greater than 22 ppt. The bulk of the adult catch occurred in water depths of 25 m (82 feet) or less in the spring (during and just after spawning) and 25 m or deeper in the autumn (prior to spawning) (Pereira et al. 1999).

Winter flounder are bottom fish and all stages of this species have the potential to occur within the vicinity of the WTC intake and outfalls. Juveniles feed on a variety of worms and small crustaceans, switching to mostly mollusks as they grow. Adults eat small invertebrates and fish fry. Because they are sight feeders increased turbidity can interfere with feeding success (USACOE 2000).

Within the vicinity of the WTC intake and outfalls, winter flounder eggs and larvae may occur in late winter and spring (LMS 1994). Young-of-the-year may occur from early April through December. Yearling winter flounder may occur in the portion of the estuary near the WTC intake and outfalls from late May to December. Catches of winter flounder in the Lower Hudson Estuary off Manhattan were highest from May through June (Woodhead 1990). Older winter flounder have been found in the portion of the estuary in the vicinity of the WTC intake and outfalls late May to September (Heimbuch et al. 1994). While winter flounder are found throughout the New York/New Jersey Harbor Estuary, this species is currently experiencing high fishing rates that are in excess of natural production (annual exploitation rates from 55 to 70 percent). The Southern New England/Mid-Atlantic stock unit (which includes the New York population), is considered to be overfished. The 2001 exploitation rate was 37 percent (ASMFC 2002). The results of the impact analysis presented in the GEIS for the Proposed Action concluded that losses of winter flounder through impingement and entrainment at the intake would not be expected to result in significant adverse impacts to the winter flounder population.

WINDOWPANE (Scophthalmus aquosus)

Windowpane, also called sand flounder, is found from the Gulf of St. Lawrence to South Carolina and has its maximum abundance in the New York Bight. Windowpane are generally found offshore on sandy bottoms in water between 50 and 80 m deep (164-262 feet), and close inshore in estuaries just below the mean low water mark. They migrate onshore in the shallow shoal water in the summer and early autumn as water temperatures increase, and migrate offshore during the winter and early spring months when temperatures decrease. Windowpane spawn within the mid-Atlantic Bight from April to December in the bottom waters with temperatures ranging from 8.5 to 13.5°C (47-56°F). Spawning peaks occur in May and then again in the autumn in the southern portion of the Bight (USACOE 2000). The Lower Hudson River Estuary is within an area designated as EFH for eggs, larval, juvenile, and adult windowpane.

The buoyant eggs and larvae that settle to the bottom are found predominately in the estuaries and coastal shelf water for the spring spawned eggs, and in the coastal shelf waters alone for those eggs spawned in the autumn. Windowpane eggs are found floating in the water column at temperatures of 5-20°C (41-68°F), specifically at 4-16°C (39-61°F) in spring (March through May), 10-16°C (50-61°F) in summer

(June through August), and 14-20°C (57-68ºF) in autumn (September through November), and within depths less than 70 m (230 feet) (Chang et al. 1999). Larvae are typically found in the area of the estuary where salinity ranges from 18 to 30 ppt in the spring and on the shelf in the autumn. Juvenile windowpane were found year-round in both the shelf waters and in the Hudson-Raritan Estuary. Larvae are found at similar temperature and depth as the egg stage of this species, particularly at 3-14°C (37-57°F) in the spring, 10-17°C (50-63°F) in the summer, and 13-19°C (55-66°F) in the autumn (Chang et al. 1999).

Within the estuary, juvenile fish were fairly evenly distributed but seemed to prefer the deeper channels in the winter and summer. They were most abundant where bottom water temperatures ranged from 5 to 23°C (41-73°F), depths ranged from 7 to 17 m (23-56 feet), salinities ranged from 22 to 30 ppt, and dissolved oxygen concentrations ranged from 7 to 11 mg/L. Similarly, adults were fairly evenly distributed year-round, preferring deeper channels in the summer months. Adults were collected in bottom waters where temperatures ranged from 0 to 23°C (32-73°F), depths were less then 25 m (82 feet), salinity ranged from 15 to 33 ppt, and dissolved oxygen ranged from 2 to 13 mg/L (USACOE 2000).

All stages of windowpane have the potential to occur within the vicinity of the WTC intake and outfalls; however, juveniles and adults are less likely to occur in these relatively shallow areas during the winter and summer. Able et al. (1998) did not collect any windowpanes during sampling of shallow water habitats near piers and in open water areas in the Lower Hudson River conducted May through October in 1993 and 1994. The southern New England/Middle Atlantic stock is currently considered to be overfished although overfishing is not currently occurring (NMFS 2003). As with winter flounder, this species is widely distributed and the operation of the WTC intake and outfalls would not be expected to result in significant adverse impacts to this fishery.

ATLANTIC HERRING (Clupea harengus)

Atlantic herring is a planktivorous marine species that occurs throughout the Northwestern Atlantic waters from Greenland to North Carolina. They are most abundant north of Cape Cod and relatively scarce in waters south of New Jersey (USACOE 2000). Atlantic herring rarely move into fresh water (Smith 1985). The Lower Hudson River Estuary is within an area designated as EFH for larval, juvenile, and adult Atlantic herring.

Juvenile and adult herring undergo complex north-south migrations and inshore-offshore migration for feeding, spawning, and overwintering. They spawn once a year in late August to November, in the coastal ocean waters of Gulf of Maine and Georges Banks. This species never spawns in brackish water. Post-spawn, the adults migrate to the New York Bight to overwinter from December to April. The autumn migration to overwintering areas is done in tight schools while the spring migration to spawning areas is much more dispersed. Fish that pass through the mid-Atlantic Bight are typically four years of age or older (USACOE 2000).

Larval herring are free-floating and for Autumn-spawned fish this stage can last 4 to 8 months. Portions of those hatched remain at the spawning site while others drift in ocean currents reaching eastern Long Island Sound. In the Gulf of Maine, larvae occur at temperatures ranging from 9 to 16°C (48-61°F), and a salinity of 32 ppt. During post-metamorphosis, which occurs through April and May, juveniles form large schools and move into shallow waters. Large schools of juveniles have been found in Connecticut and southern Massachusetts in May and June. In the summer and autumn, juveniles move out of the nearshore waters to overwinter in deep bays or near the bottom in offshore areas. Within Long Island Sound, springtime abundances have been reported as being highest at temperatures ranging from 9 to 10°C (48-50°F), depths ranging from 10 to 30 m (33-98 feet), and salinity ranging from 25 to 28 ppt. Within the

Hudson-Raritan Estuary, catches of herring were highest at temperatures ranging from 3 to 6°C (37-43°F) and in the deeper portions of the estuary (USACOE 2000). Juveniles collected in the Hudson-Raritan Estuary NEFSC bottom trawl surveys were found to prefer temperatures at 2-16°C (36-61°F) and 12-22°C (54-72°F), being most abundant at 4-6°C (40-43°F) and 15-18°C (59-64°F). Juveniles are commonly found at depths ranging from 30-135 m (98-443 feet), preferring deeper waters in the summer (Reid et al. 1999).

On average, males and females mature at about 25-27 cm (10-11 inches). In the Hudson-Raritan estuary NEFSC bottom trawl surveys, adults were most abundant at 3-6°C (37-43°F) at depths ranging from 4.5-13.5 m (14-44 feet). Atlantic herring prefer salinities 28 ppt or greater (Reid et al. 1999).

Juveniles and adults perform diel and semi-diel vertical migrations in response to daily photoperiods and increased turbidity. Being sensitive to light intensity, activity is highest after sunrise and just before sunset where the herring will avoid the surface during daylight to avoid predators (Reid et al. 1999).

No spawning would occur within the vicinity of the WTC intake and outfalls and larvae would not likely be found due to their salinity and temperature preferences. Juvenile and adult Atlantic herring would most likely occur within the portion of the estuary in the vicinity of the WTC intake and outfalls in low numbers because of salinity and depth preferences. Able et al. (1998) did not collect any Atlantic herring during sampling of shallow water habitats near piers and in open water areas in the Lower Hudson River Estuary conducted May through October in 1993 and 1994. In addition, EEA (1988) collected them in extremely low numbers at Pier 76. The Atlantic herring stock complex in the northeastern United States is considered under-utilized with the exception of the portion in the Gulf of Maine (Reid et al. 1999) and is not overfished (NMFS 2003). Further, because this species' stock is coastwide, the fraction of the population that may occur within the vicinity of the WTC intake and outfalls would be extremely small. The estimated annual number of Atlantic herring impinged at the WTC intake during the 1991 to 1993 study is 8. Therefore, operation of the WTC intake and outfalls would not be expected to adversely impact this fishery.

BLUEFISH (Pomatomus saltatrix)

Bluefish is a carnivorous marine fish that occurs in temperate and tropical waters on the continental shelf and in estuarine habitats around the world. In North America, bluefish live along most of the Atlantic coastal waters from Nova Scotia south, around the tip of Florida, and along the Gulf Coast to Mexico. Bluefish migrate between summering and wintering grounds, generally traveling in groups of fish of similar sizes loosely aggregated with other groups. They generally migrate north in the spring and summer and south in the autumn and winter. Along the North Atlantic, summering ground centers are located in the New York Bight as well as southern New England and northern sections of the North Carolina coastline. Wintering grounds are found in the southeastern parts of the Florida coast. Juvenile and adult bluefish travel far up estuarine waters (where salinity may be less then 10 ppt) while eggs and larvae are largely restricted to marine habitats (USACOE 2000). The Lower Hudson River Estuary is within an area designated as EFH for juvenile and adult bluefish.

There are two spawning stocks along the U.S. Atlantic coast—a south Atlantic spring spawn, and mid-Atlantic summer spawn. The fish active in the spring spawn migrate to the Gulf Stream/coastal shelf interface between northern Florida and Cape Hatteras, in April and May. Post-spring spawn, smaller bluefish drift west while the larger fish slowly migrate north along the shelf and west into mid-Atlantic bays and estuaries including the Lower Hudson Estuary where they stay until autumn. Summer spawning fish migrate to the mid-Atlantic from Cape Cod to Cape Hatteras in June through August. Summer post-spawn fish head towards the mid-Atlantic shores and are particularly abundant in Long Island Sound

(USACOE 2000; Fahay et al. 1999). Juveniles from the spring spawn drift north in the early summer and also enter the important nursery habitats in estuaries and bays along the mid-Atlantic coast in June. Summer spawned fish enter the estuaries in middle to late summer (Buckel et al. 1999). All spent fish and juveniles migrate to the wintering grounds in the autumn (USACOE 2000).

Juveniles in the Mid-Atlantic Bight inhabit inshore estuaries from May to October, preferring temperatures between 15 and 30°C (59-86°F), and salinities between 23 and 33 ppt. Although juvenile and adult bluefish are moderately euryhaline, occasionally they will ascend well into estuaries where salinities may be less than 3 ppt. Juveniles use estuaries as nursery areas, and can be found in sand, mud, silt, or clay substrates as well as *Spartina* or *Fucus* beds. Bluefish juveniles are sensitive to changes in temperature. Thermal edges apparently serve as important cues to juvenile migration off shore in the winter season (Fahay et al. 1999).

Adult bluefish are pelagic and highly migratory with a seasonal occurrence in Mid-Atlantic estuaries from April to October. They prefer temperatures from 14-16°C (57-61°F) but can tolerate temperatures from 11.8-30.4°C (35-87°F) and salinities greater than 25 ppt. Adult bluefish are not uncommon in bays and larger estuaries, as well as coastal waters (Bigelow and Schroeder 1953; Fahay et al. 1999).

Within the vicinity of the WTC intake and outfall, juvenile and adult bluefish may occur in the late spring through autumn. Juveniles and young adults are common in the Lower Hudson River Estuary in the summer (Woodhead 1990), and larger individuals are sometimes found upstream to Haverstraw Bay (Smith 1985). Able et al. (1998) did not collect any bluefish during sampling of shallow water habitats near piers and in open water areas in the Lower Hudson River conducted May through October in 1993 and 1994. No spawning would occur within the vicinity of the WTC intake and outfalls. Bluefish was categorized as overfished—the stock size was below the minimum threshold set for this species—and a rebuilding program has been implemented. However, recent estimates of fishing mortality suggest that the rebuilding program, state-by-state quota system, and recreational harvest limit have been successful and that overfishing is no longer occurring (MAFMC 2002, NMFS 2003). The estimated annual number of bluefish impinged at the WTC intake during the 1991 to 1993 study is 16. Therefore, operation of the WTC intake and outfalls would not be expected to adversely impact the recent success of the rebuilding program or the status of this stock.

ATLANTIC BUTTERFISH (Peprilus triacanthus)

Butterfish occur from Newfoundland to Florida and are most abundant between southern New England and Cape Hatteras. It has been suggested that two populations of Butterfish exist. One population appears largely restricted to shoals (less than 20 m [66 feet]) south of Cape Hatteras, and another mainly north of Hatteras that occurs in shoals and possibly some deeper waters along of the shelf. The lower Hudson River is within an area designated as EFH for larval, juvenile, and adult Atlantic butterfish.

Throughout its range, butterfish are found over the entire shelf, inshore and offshore. Cooling temperatures associated with late autumn trigger a migration offshore to the edges of the shelf where waters are warm. Butterfish require 10°C (50°F) for survival. This species spawns from June to August in inshore waters generally less then 30 m (98 feet) deep. Peak egg production is in late June and early July off Long Island Sound. Studies performed in the Hudson-Raritan Estuary noted that butterfish comprised less than 1 percent of total catches of fish (USACOE 2000).

Newly hatched larvae are between 2 and 16 mm (0.1-0.6 inches) long. Larvae are found at the surface or in the shelter of the tentacles of large jellyfish, and are more nektonic (free swimming) than planktonic (drift with water movements) when between 10 and 15 mm (0.4-0.6 inches) long. Larvae are found at temperatures ranging from 7-26°C (45-79°F), although most abundant at 9-19°C (48-66°F), and at depths less than 120 m (394 feet) (Cross et al. 1999).

At 6 mm (0.24 inches) larval body depth has increased substantially in proportion to length and at 15 mm (0.6 inches), the fins are differentiated and the young fish takes on the general appearance of the adult. Adult butterfish can range from 120 to 305 mm (4.7-12 inches) long. Both juveniles and adults have similar habitat characteristics. They are eurythermal and euryhaline and are common near the surface in sheltered bays and estuaries during the spring to autumn months. In the Hudson-Raritan trawl survey, juveniles and adults were found at depths from 3-23 m (10-75 feet), salinities from 19-32 ppt, and dissolved oxygen from 3-10 mg/L. Juvenile and adult butterfish also often prefer sandy and muddy substrates, and temperatures from 3-28°C (37-82°F) (Cross et al. 1999).

Occasional adult and juvenile butterfish have the potential to occur within the vicinity of the WTC intake and outfalls. Spawning would not occur within the portion of the estuary in the vicinity of the WTC intake and outfalls. Woodhead (1990) reports butterfish to be a common transient in the New York Harbor in the summer. Habitat surveys in the Hudson River found that Atlantic butterfish comprised less than 1 percent of total catch of fishes during the study. Atlantic butterfish prefer sandy bottoms but are not closely associated with the bottom when inshore during the summer. They may stay close to the bottom during the day and move upward at night (Smith 1985). The estimated annual number of butterfish impinged at the WTC intake during the 1991 to 1993 study is 31. Butterfish stock is not overfished or approaching an overfished condition (Cross et al. 1999; NMFS 2003) and it is considered an underexploited fishery (Cross et al. 1999). Therefore, the operation of the WTC intake and outfalls would not be expected to result in significant adverse impacts to this fishery.

ATLANTIC MACKEREL (Scomber scombrus)

Atlantic mackerel is a pelagic marine fish that occurs in the western North Atlantic from Labrador to North Carolina. It sustains fisheries from the Gulf of St. Lawrence and Nova Scotia to the Cape Hatteras area. The Lower Hudson River Estuary is within an area designated as EFH for juvenile and adult Atlantic mackerel. There may be two populations: one occurring in the northern Atlantic and associated with the New England and Maritime Canadian coast, and another more southerly population inhabiting the mid-Atlantic coast. Both populations overwinter in the deep waters at the edge of the continental shelf, generally moving inshore (in a northeastern direction) during the spring, and reversing this migration in autumn.

The southern population begins its spawning migration by moving inshore between the Delaware Bay and Cape Hatteras and in a northeastern direction along the coast. The timing of the migration and spawn is a result of warming water temperatures. The peak spawn for the southern population occurs off New Jersey and Long Island Sound in April and May. Most spawning occurs in the shoreward half of the shelf and in waters from 7 to 14°C (45-57°F) (with the peak being 10 to 12°C (50-54°F) (Studholme et al. 1999). By June there are schools of juveniles off Massachusetts, and they move into the Gulf of Maine by June and July where they remain for the summer. In the Hudson-Raritan Estuary, juveniles are present from April to December, but are most common from April through June and October through November. Adults are present from April through June and from September through December, most commonly from April to May and from October to November (USACOE 2000).

Juvenile transformation includes swimming and schooling behaviors starting at 30-50 mm (1.2-2.0 inches), and closely resemble adults when about 1 year in age. In the Hudson-Raritan Bay estuary, juveniles are present in the spring and summer months preferring depths from 4.9-9.8 m (16-32 feet), salinity ranges from 26-28.9 ppt, dissolved oxygen from 7.3-8.0 mg/L and temperatures from 17.6-21.7°C (64-71°F) (Studholme et al. 1999).

Adult Atlantic mackerel can range from 26 cm (10 inches) in their second year to about 40 cm (15.8 inches) in their sixth year. NEFSC trawl surveys show that adults are found in the spring at temperature ranges from 5-13°C (41-55°F) dispersed from 0-380 m (1,250 feet) (most abundant at 160-170 m [525-558 feet]), and in the summer at temperatures ranging from 4-14°C (39-57°F) at depths of 10-180 m (33-591 feet) (abundant at 50-70 m [164-230 feet]). Adults also prefer salinities of 25 ppt or greater (Studholme et al. 1999).

Atlantic mackerel were rarely collected during trawls in the New York Harbor by USACOE from October 1998 through November 1999 (USACOE 1999). No Atlantic mackerel were impinged during the 1991-1993 study of the WTC intake (LMS 1994). Able et al. (1998) did not collect any Atlantic mackerel during sampling of shallow water habitats near piers and in open water areas in the Lower Hudson River Estuary conducted May through October in 1993 and 1994. Most individuals are found in the Lower Harbor (Raritan Bay and Sandy Hook Bay) (Woodhead and McEnroe 1991 in USACOE 1999). Spawning would not occur in the Lower Hudson River Estuary. Because the habitat found within the vicinity of the WTC intake and outfalls in the Lower Hudson River Estuary does not represent a significant portion of the EFH for this species, as evidenced by the low numbers of individuals that have been collected in this area, significant adverse impacts to EFH for this species, or the fishery, would not be expected to occur as a result of operating the WTC intake and outfalls. The Atlantic mackerel fishery is no longer considered overfished and this stock is now considered underexploited (MAFMC 2002; NMFS 2003).

SUMMER FLOUNDER (Paralichthys dentatus)

Summer flounder prefer the estuarine and shelf waters of the Atlantic Ocean and are found between Nova Scotia and southeastern Florida. They are most abundant from Cape Cod, Massachusetts, to Cape Hatteras, North Carolina. The lower Hudson River is within an area designated as EFH for larval, juvenile, and adult summer flounder. Summer flounder usually appear in the inshore waters of the New York Bight in April, continuing inshore in May and June, and reach their peak abundance in July and August. Spawning takes place in the New York Bight in nearshore waters outside estuarine systems in September to October. Spawning occurs in surface water temperatures of 7-14°C (45-57°F), with a peak around 10-12°C (50-54°F) (Packer et al. 1999).

Larvae occur in water from 0 to 22°C (32-72°F) and are transported to estuarine nurseries by currents. They are distributed throughout the estuary prior to late summer and are more concentrated in sea grass beds as opposed to tidal marshes in the late summer and early autumn (USACOE 2000). Planktonic larvae (2-13 mm [0.08-0.5 inches]) have been found in temperatures ranging from 0-23°C (32-73°F), but are most abundant between 9 and 17°C (48-63°F). Within New Jersey waters, summer flounder larvae have been found to prefer salinities ranging from 20-30 ppt. In the Mid-Atlantic Bight, larvae were found at depths from 10-70 m (33-230 feet). Greater densities of young fish were found in or near inlets (Packer et al. 1999).

Young summer flounder move into shallow (found usually at 0.5-5.0 m [1.6-16 feet] in depth) estuaries using them as nursery habitat in the autumn, summer, and spring months. Juvenile summer flounder are well adapted to the temperature and salinity ranges present in estuarine habitats. They are able to withstand a wide range of temperatures, and salinities ranging from 10-30 ppt. Juveniles can be found on mud and sand substrates in flats, channels, salt marsh creeks, and eelgrass beds (Packer et al. 1999).

Adult summer flounder feed both in the shelf waters and estuaries, and are more active in the daylight hours since they are primarily visual feeders (USACOE 2000). Adults are found to grow to lengths ranging from 25-71 cm (10-28 feet). Adults inhabit sand substrates usually at depths up to 25 m (82 feet), at temperatures ranging from 9-26°C (48-79°F) in the autumn, 4-13°C (39-55°F) in the winter, 2-20°C (36-72°F) in the spring, and 9-27°C (48-81°F) in the summer. Salinity is known to have minimal effect on distribution in comparison to substrate preference (Packer et al. 1999).

Spawning of summer flounder would not occur in the vicinity of the WTC intake and outfalls. Larvae would have the potential to occur in the vicinity of the WTC intake and outfalls, and were collected at relatively low numbers (estimated annual average number entrained of 22,983 post-yolk sac larvae) in the 1991-1993 impingement/entrainment study of the WTC intake. Summer flounder have been collected in areas of the Upper Harbor, primarily in the summer (USACOE 1999). Able et al. (1998) collected two summer flounder during sampling of shallow water habitats near piers and in open water areas in the Lower Hudson River conducted May through October in 1993 and 1994. In 2002 the stock was considered overfished and was in the 8th year of a 10-year rebuilding program (NMFS 2003; MAFMC 2002). However, the latest stock assessment for summer flounder indicates that management measures have been successful. The resource is no longer overfished and overfishing is not occurring. Summer founder biomass is estimated to be above the threshold point for the first time since this species was placed under the joint management of the Atlantic States Marine Fisheries Commission (ASMFC) and the Mid-Atlantic Fishery Management Council (MAFMC). The ASMFC and MAFMC have recommended increasing the total allowable landing limits to 28.2 million pounds in 2004 (compared to 23 million pounds in 2003) (ASMFC 2003). The estimated annual number of summer flounder impinged at the WTC intake during the 1991 to 1993 study is 20. Summer flounder are widely distributed in nearby habitats (USACOE 2000), and the stock would not be expected to be significantly impacted by the operation of the WTC intake and outfalls.

SCUP (Stenotomus chrysops)

Scup is a marine fish that occurs primarily on the continental shelf from Cape Cod, Massachusetts to Cape Hatteras, North Carolina. The Lower Hudson River Estuary is within an area designated as EFH for eggs, larval, and juvenile scup. Scup arrive in the waters off New Jersey and New York by early May. During the summer months, older fish (four years old or older) tend to stay in the inshore waters of the bays while the younger fish are found in the more saline waters of estuaries such as the Hudson-Raritan Estuary. Spawning occurs in May through August with a peak in June and occurs principally in the estuaries of New York and New Jersey. Juveniles grow quickly and migrate with the rest of the population to offshore wintering grounds starting in late October and are absent from inshore waters by the end of November (USACOE 2000).

Scup eggs are buoyant and are rather small (0.8 to 1.0 mm [0.03-0.04 inches]), hatching in about 2-3 days depending on temperature. Most eggs are collected from May-August at depths less than 50 m (164 feet) and at temperatures ranging from 11-23°C (52-73°F) (Steimle et al. 1999c).

Newly hatched larvae are pelagic and approximately 2 mm (0.08 inches) long. In approximately three days, diagnostic characters of the species are evident and shortly afterwards the larvae abandon the pelagic phase and become bottom dwelling. They occur at water temperatures ranging from 14-22°C (57-72°F) and occupy more saline (23-33 ppt) portions of bays. They are often found within the water column at depths less than 50 m (164 feet) (Steimle et al. 1999c).

Juveniles from 15-30 mm (0.6-1.2 inches) (up to 10 cm [4 inches]) are common during November. By the end of their first year they can reach up to 16 cm (6.3 inches). Juveniles inhabit estuarine intertidal areas at depths of 5-12 m (16-39 feet), particularly areas with sand and mud substrates or mussel and eelgrass beds. Juveniles prefer temperatures from about 9-27°C (48-81°F) and salinities greater than 15 ppt (Steimle et al. 1999c).

Scup males and females reach sexual maturity at age two and reach about 15.5 cm (6 inches) in length. From April to December, adults can be found inshore along silt, sand, and mud substrates at depths less than 30 m (98 feet). Adults prefer temperatures ranging from 6-27°C (43-81°F), and salinities ranging from 20-30 ppt (Steimle et al. 1999c).

In the New York Harbor, spawning occurs primarily in the Lower New York Bay and the Eastern Long Island Bay (USACOE 2000) and would not be expected to occur within the vicinity of the WTC intake and outfalls. Juveniles may occur within the portion of the estuary in the vicinity of the WTC intake and outfalls in the summer and autumn. Woodhead (1990) reports that scup is a common summer transient in the New York Harbor. Able et al. (1998) did not collect any scup during sampling of shallow water habitats near piers and in open water areas in the Lower Hudson River conducted May through October in 1993 and 1994. The EFH for this marine species is primarily in the higher salinity areas of the southern portion of the Upper Harbor (USACOE 1999). The rebuilding schedule and management measures implemented in 1996 have resulted in a dramatic increase in scup abundance and recent data suggest the stock is no longer overfished (MAFMC 2002; ASMFC 2003). The estimated annual number of scup impinged at the WTC intake during the 1991 to 1993 study is 18. Therefore, the operation of the WTC intake and outfalls would not be expected to result in significant adverse impacts to the scup stock.

BLACK SEA BASS (Centropristis striata)

Black sea bass is a marine species that occurs from Cape Cod, Massachusetts to Cape Canaveral, Florida. The Lower Hudson River Estuary is within an area designated as EFH for juvenile and adult black sea bass. The fishery is divided into a northern population above Cape Hatteras, North Carolina, and a southern population below Cape Hatteras. The northern population migrates seasonally: inshore and north in the spring, and offshore and south in the autumn. In the autumn, older fish move offshore sooner and overwinter in deeper waters (73 to 163 m [240-535 feet]) than young-of-the-year fish (56 to 110 m [184-361 feet]). Black sea bass can tolerate temperatures as low as 6°C (43°F) but are most abundant in off-shore waters warmer than 9°C (48°F), between 20 to 60 m (66-197 feet) deep (USACOE 2000). During the spring migration, adults move to spawning grounds and juveniles move into estuaries. For the northern population spawning generally takes place in the summer, in water 18 to 45 m deep from the Chesapeake Bay to Montauk.

Larvae develop for the most part in continental shelf waters and are most abundant in the southern portion of the Middle Atlantic Bight. They quickly become bottom dwellers and estuarine. In the mid-Atlantic Bight, young-of-year fish inhabit estuaries from July to September, at depths from 1-38 m (3-125 feet). They prefer rough bottom habitats with shells, amphipod tubes, and deep channel rubble (Steimle et al. 1999b) and have been noted to appear on inshore jetties in late May to early June. In the Hudson River, young-of-the-year have been captured in open water and interpier areas. The young-of-year are migratory during some portions of the first year (USACOE 2000). They migrate out of the estuary and away from inner continental shelf nursery areas during the autumn as water temperatures drop (Steimle et al. 1999b). Young-of-the-year have been collected in the lower Hudson River off Manhattan from mid-July to September (Able et al. 1995), and have the potential to occur within the portion of the estuary in the vicinity of the WTC intake and outfalls.

Juvenile sea bass occur in the saline portions of estuaries from Massachusetts to Florida starting with the initial spring migration until late autumn. During this period they can grow up to 19 cm (7.5 inches).

Juveniles can be found in water temperatures ranging from 6-30°C (43-86°F) and salinities ranging from 8-38 ppt (but most preferring 18-20 ppt) (USACOE 2000). They prefer hard bottom (Bigelow and Schroeder 1953), and are commonly found around jetties, piers, wrecks, and bottom areas with shells (USACOE 2000).

Adult black sea bass prefer similar habitat conditions to juveniles, and perform similar migratory patterns. Adults also find shelter around manmade structures (Steimle et al. 1999b). Black sea bass are bottom feeders, consuming crabs, shrimp, mollusks, small fish, and squid. Woodhead (1990) describes black sea bass as a common summer transient in the New York Harbor, and individuals have been collected in the New York Harbor and the Arthur Kill (Smith 1985).

Juvenile and adult black sea bass have the potential to occur within the vicinity of the WTC intake and outfalls. The USACOE collected low numbers of individuals in trawls conducted within the Port Jersey area from October 1998 through November 1999 (USACOE 1999). In May through October shallow water sampling by Able et al. (1998), black sea bass were the 13th most abundant species in 1993 and the second most abundant species in 1994. While previously considered overfished, management efforts have been successful in rebuilding the stock and it is no longer considered overfished (ASMFC 2003). The ASMFC and MAFMC recently recommended increasing the total allowable landing limit for black sea bass from 6.8 million pounds in 2003 to 8.0 million pounds in 2004 (ASMFC 2003). The estimated annual number of black sea bass impinged at the WTC intake during the 1991 to 1993 study is 55. Therefore, operation of the WTC intake and outfall would not be expected to result in significant adverse impacts to the continued rebuilding of this stock.

KING MACKEREL (Scomberomorus cavalla)

King mackerel is a marine fish that inhabits Atlantic coastal waters from the Gulf of Maine to Rio de Janeiro, Brazil, including the Gulf of Mexico. The Lower Hudson River Estuary is within an area designated as EFH for eggs, larval, juvenile, and adult king mackerel. There may be two distinct populations of king mackerel. One group migrates from waters near Cape Canaveral, Florida south to the Gulf of Mexico, making it there by spring and continuing along the western Florida continental shelf throughout the summer. A second group migrates to waters off the coast of the Carolinas in the summer, after spending the spring in the waters of southern Florida, and continues on in the autumn to the northern extent of the range. Overall, temperature appears to be the major factor governing the distribution of the species. The northern extent of its range is near Block Island, Rhode Island, near the 20°C (68°F) isotherm and the 18-meter (59 feet) contour. King mackerel spawn in the northern Gulf of Mexico and southern Atlantic coast. Larvae have been collected from May to October, with a peak in September. In the south Atlantic, larvae have been collected at the surface with salinities ranging from 30 to 37 ppt and temperatures from 22 to 28°C (70-81°F). Adults are normally found in water with salinity ranging from 32 to 36 ppt (USACOE 2000).

Able et al. (1998) did not collect any king mackerel during sampling of shallow water habitats near piers and in open water areas in the Lower Hudson River conducted May through October in 1993 and 1994. No king mackerel were impinged or entrained during the 1991-1993 WTC intake study. King mackerel would occur only as occasional transient individuals within the New York/New Jersey Harbor Estuary system, and would only be likely to occur in the Lower Harbor area where the salinities are higher. Therefore, EFH for this species would not be affected by the operation of the WTC intake and outfalls.

SPANISH MACKEREL (Scomberomorus maculatus)

Spanish mackerel is a marine species that can occur in the Atlantic Ocean from the Gulf of Maine to the Yucatan Peninsula. The Lower Hudson River Estuary is within an area designated as EFH for eggs, larval, juvenile, and adult Spanish mackerel. Spanish mackerel is most common between the Chesapeake Bay and the northern Gulf of Mexico from spring through autumn, then moves south to overwinter in the waters of south Florida. These populations spawn in the northern extent of their ranges (along the northern Gulf Coast and along the Atlantic Coast). Spawning begins in mid-June in the Chesapeake Bay and in late September off Long Island, New York. Temperature is an important factor in the timing of spawning and few spawn in temperatures below 26°C (79°F). Spanish mackerel apparently spawn at night. Studies indicate that Spanish mackerel spawn over the Inner Continental Shelf in water 12-34 m (39-112 feet) deep.

Spanish mackerel eggs are pelagic and about 1 mm in diameter. Hatching takes place after about 25 hours at a temperature of 26°C. Most larvae have been collected in coastal waters of the Gulf of Mexico and the east coast of the United States. Juvenile Spanish mackerel can use low salinity estuaries (about 13 to 20 ppt) as nurseries and also stay close inshore in open beach waters (USACOE 2000).

Overall, temperature and salinity is indicated as the major factor governing the distribution of this species. The northern extent of their range is near Block Island, Rhode Island, near the 20°C (68°F) isotherm and the 18 meter contour. During warm years, they can be found as far north as Massachusetts. They prefer water from 21 to 27°C (70-81°F) and are rarely found in waters cooler than 18°C (64°F). Adult Spanish mackerel generally avoid freshwater or low salinity (less than 32 ppt) areas such as the mouths of rivers (USACOE 2000).

Able et al. (1998) did not collect any Spanish mackerel during sampling of shallow water habitats near piers and in open water areas in the Lower Hudson River conducted May through October in 1993 and 1994. No Spanish mackerel were impinged or entrained during the 1991-1993 WTC intake study. Because this is a marine species that prefers higher salinity waters, only occasional individuals are likely to occur within the vicinity of the WTC intake and outfalls. Therefore, EFH for this species would not be affected by the operation of the WTC intake and outfalls.

COBIA (Rachycentron canadum)

Cobia are large, migratory, coastal pelagic fish of the monotypic family Rachycentridae. In the western Atlantic Ocean, cobia occur from Massachusetts to Argentina, but are most common along the south Atlantic coast of the United States and in the northern Gulf of Mexico. In the eastern Gulf, cobia typically migrate from wintering grounds off south Florida into northeastern Gulf waters during early spring. They occur off northwest Florida, Alabama, Mississippi, and southeast Louisiana wintering grounds in the fall. Some cobia overwinter in the northern Gulf at depths of 100 to 125 m (328 to 410 feet). The Lower Hudson River Estuary is within an area designated as EFH for eggs, larval, juvenile and adult cobia.

Information on the life history of cobia from the Gulf and the Atlantic Coast of the United States is limited. Essential fish habitat for coastal migratory pelagic species such as cobia includes sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters, from the surf to the shelf break zone, but from the Gulf Stream shoreward, including *Sargassum.* For cobia, essential fish habitat also includes high salinity bays, estuaries, and seagrass habitat. The Gulf Stream is an essential fish habitat because it provides a mechanism to disperse coastal migratory pelagic larvae. Preferred temperatures are greater than 20°C and salinities are greater than 25 ppt.

Cobia are likely to occur only as occasional transient individuals within the vicinity of the WTC intake and outfall due to its coastal migrations, pelagic nature, and salinity requirements. No effects to EFH for this species are anticipated.

SAND TIGER SHARK (Odontaspis taurus)

The sand tiger shark is a large, coastal marine species found in tropical and warm temperate waters throughout the world and is often found in shallow water (less than 4 m [13 feet]). The Lower Hudson River Estuary is within an area designated as EFH for larval sand tiger sharks. Males mature between 190-195 cm (75-77 inches) total length, or four to five years, and females at more than 220 cm (87 inches) or six years. The sand shark has extremely limited reproductive potential, producing only two young per litter measuring approximately 100 cm (39 inches). Embryos, being cannibalistic, consume other embryos until only one from each oviduct survives where each pup grows to be quite large (up to 40 inches) before birth. Neonates, after birth, migrate northward in the summer to estuarine nursery areas (UD 2001). In North America, the species gives birth in March and April and during the winter in the southern portion of its range. Young sand sharks migrate northward to nursery areas of the Mid-Atlantic Bight coastal sounds and estuaries, including: Chesapeake, Delaware, Sandy Hook, and Narragansett Bay.

Overfishing of the large aggregations associated with mating has led to a declining population. The essential fish habitat for young and juvenile sand tiger sharks are the shallow coastal waters from Barneget Inlet, New Jersey to Cape Canaveral, Florida to the 25 m (82 feet) isobath (USACOE 2000). This species is not expected to occur within the New York/New Jersey Harbor Estuary except as occasional transient individuals. Therefore, EFH for this species would not be affected by this project.

SANDBAR SHARK (Carcharhinus plumbeus)

The sandbar shark is found throughout the world in subtropical and warm temperate waters, and is common to many coastal habitats. It is bottom-dwelling and most commonly found in 20 to 55 m (66-180 feet) waters. The Lower Hudson River Estuary is within an area designated as EFH for larval and adult sandbar sharks.

The sandbar shark is a slow growing species. Both sexes reach maturity at about 180 cm (71 inches) total length. Estimates of age of maturity range from 15-16 years to 29-30 years, although 15-16 years is the commonly accepted age of maturity. Sandbar sharks produce two litters per year, with each litter consisting of 1 to 14 pups (9 being the average). The gestation period lasts about a year and reproduction is biennial. Young are born at about 60 cm (24 inches) (smaller in the northern parts of the North American range) from March to July. In the United States, the sandbar shark uses estuarine nurseries in shallow coastal waters from Cape Canaveral, Florida, to the northern extent of the range at Great Bay, New Jersey (Merson and Pratt 1997). Bays from Delaware to North Carolina are important nursery areas (Knickle 2001).

Juveniles return to Delaware Bay after the winter. Neonates have been captured in Delaware Bay in late June. Young-of-the-year are present in Delaware Bay until early October when the temperature falls below 21°C (70°F). Juveniles have been found as far north as Martha's Vineyard, Massachusetts in the summer. Young and juvenile sandbar sharks strongly prefer salinities of greater than 22 ppt and temperatures greater than 21°C (70°F). Essential fish habitat for young and early juvenile sandbar sharks are shallow coastal areas to the 25 m (82 feet) isobath from Montauk, Long Island, New York, south to Cape Canaveral, Florida; nursery areas in shallow coastal waters from Great Bay, New Jersey to Cape Canaveral, Florida; also shallow coastal waters up to a depth of 50 m (164 feet) on the west coast of Florida and the Florida Keys. This species is not expected to occur within the New York/New Jersey

Harbor Estuary except as occasional transient individuals. Therefore, EFH for this species would not be affected by this project.

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