Final Draft

BIOLOGICAL ASSESSMENT FOR THE SHORTNOSE STURGEON (Acipenser brevirostrum) IN THE HUDSON RIVER AND FOUNDRY COVE AREAS OF THE MARATHON BATTERY CO. SITE

PREPARED BY:

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION II
NEW YORK, NEW YORK

WITH ASSISTANCE FROM:

GANNETT FLEMING, INC.
HARRISBURG, PENNSYLVANIA

IN ASSOCIATION WITH:

ECOLSCIENCES, INC.
ROCKAWAY, NEW JERSEY

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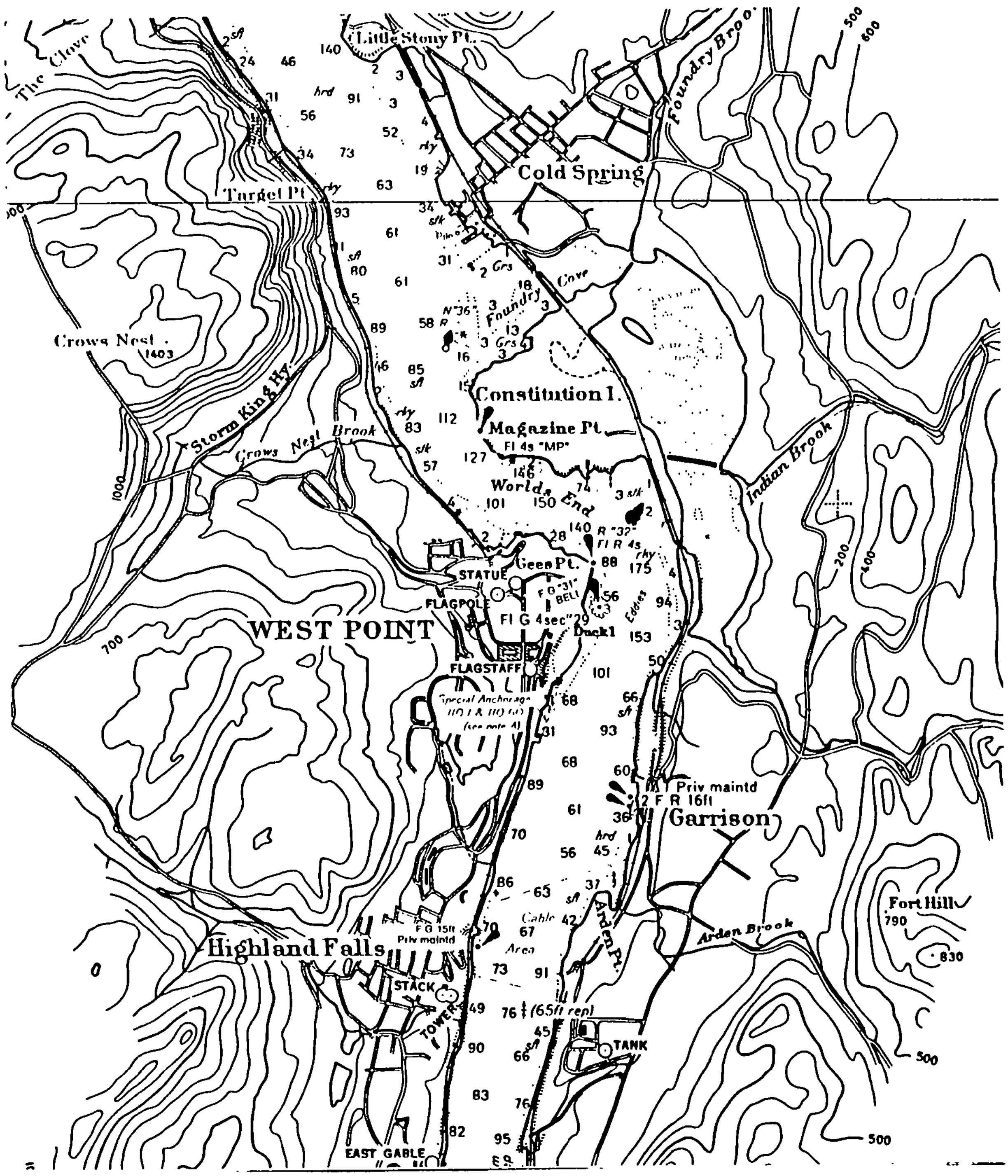
I. INTRODUCTION

The Environmental Protection Agency (EPA) is proposing to implement remedial actions at the Marathon Battery Co. Site (MBCS) in Cold Spring, New York, pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act, as amended by the Superfund Amendments and Reauthorization Act (CERCLA/SARA). The shortnose sturgeon (Acipenser brevirostrum), a federally-listed endangered species, is known to occur in the Hudson River in the vicinity of the site. Portions of the proposed remedial actions will take place in aquatic habitats of, and associated with, the Hudson River. Accordingly, as part of its efforts to comply with the requirements of the Endangered Species Act (ESA), EPA has prepared a Biological Assessment (BA) of the potential impacts of the proposed remedial actions on the shortnose sturgeon.

A. Background

The MBCS, located in the Village of Cold Spring, New York, includes a former nickel-cadmium battery manufacturing facility and surrounding plant grounds, Constitution Marsh, East Foundry Cove Marsh, East and West Foundry Coves, and the Hudson River in the vicinity of the Cold Spring Pier (Figures 1 and 2). Contamination at the site is due to the presence of three heavy metals - cadmium, nickel, and cobalt. Portions of the project site, particularly East Foundry Cove and the vicinity of Cold Spring pier, contain contaminated sediments that are proposed to be dredged, chemically fixed, and transported off the site. The contours of the dredged areas will be restored, as necessary.

As an initial step in ensuring that the remedial actions for the subject site comply with the ESA, EPA conducted informal consultation with both the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS). The USFWS's reply to EPA stated that, except for occasional or transient individuals, no federally-listed or proposed endangered or threatened species under its jurisdiction is known to exist in the project impact area. However, NMFS stated in its reply that the habitat, or habitat types, of Foundry Cove may be used by the endangered shortnose sturgeon, and that the potential impacts of the proposed remedy on the species and its habitat should be evaluated prior to undertaking any remedial work.

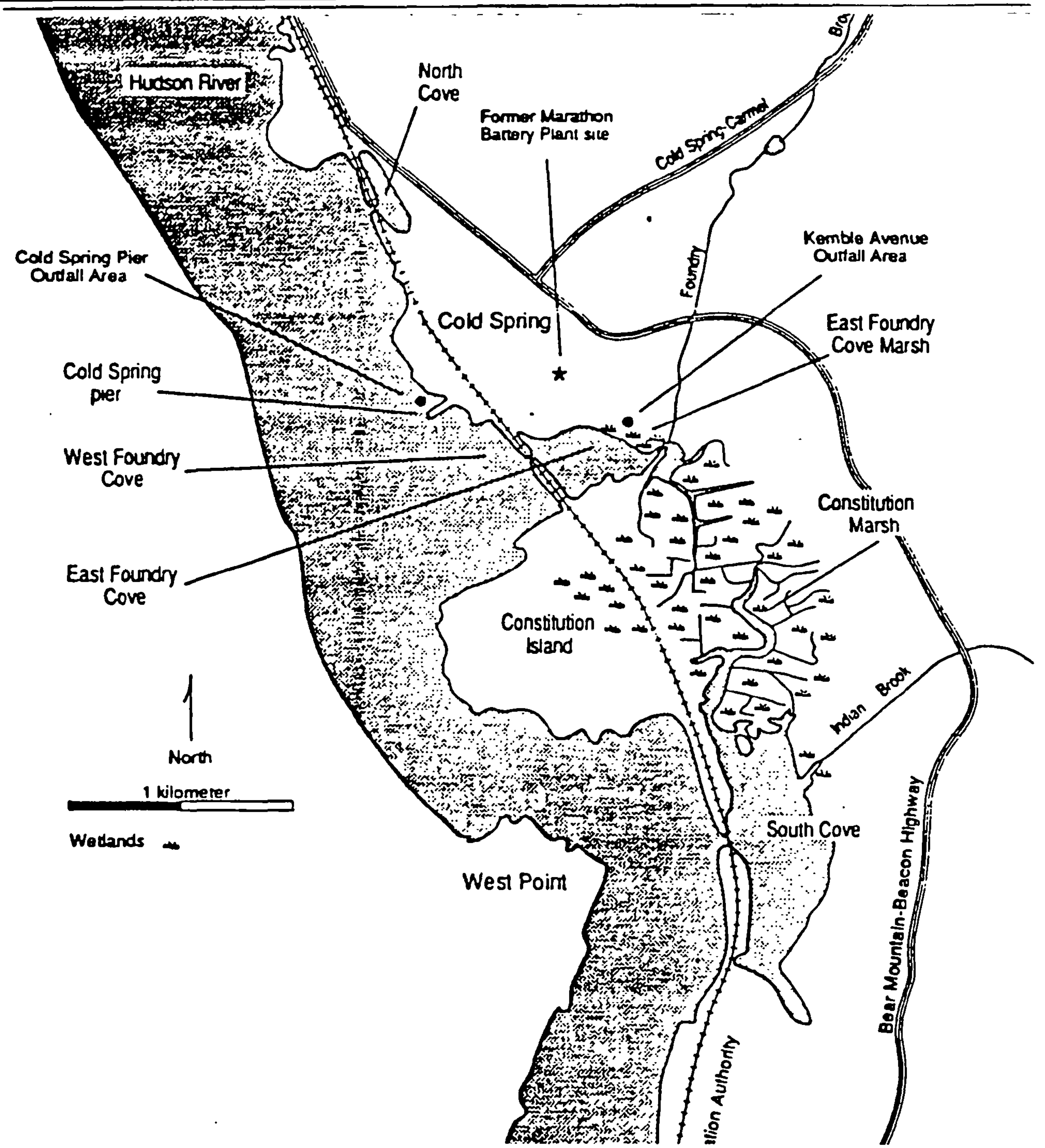


Biological Assessment for Shortnose Sturgeon at the MBCS

FIGURE 1
VICINITY MAP

Scale: 1" = 3333'

Source: NOS Chart No. 12343



Source: Ebasco, 1989

Biological Assessment for Shortnose Sturgeon at the MBCS
FIGURE 2 SITE MAP
Scale: 1" = 1200'

EPA has prepared this BA in accordance with procedures cited in Section 7(c) of the ESA. One element of this procedure is the review of technical literature and other scientific data to determine the species distribution, habitat needs, and other biological requirements (EPA, 1988). These biological requirements, together with site-specific habitat information, provide the basis for an assessment of the potential adverse impacts of the proposed actions to the shortnose sturgeon.

This BA addresses general information about the taxonomy, ecology and life history of the shortnose sturgeon (Chapter II), and findings pertinent to the species' habitat requirements, preferences, and physiological tolerances (Chapter III). Chapter IV introduces site-specific habitat information and discusses a Habitat Evaluation Procedure (HEP) analysis based on those site-specific data, and Chapter V presents an evaluation of potential impacts to shortnose sturgeon from the proposed remedial activities. Chapter VI summarizes the information and conclusions presented in the body of the BA.

II. GENERAL INFORMATION

Taxonomy: Shortnose Sturgeon (Acipenser brevirostrum), LeSueur 1818. Pisces; Osteichthyes; Acipenseriformes; Acipenseridae

Common Names: Shortnose sturgeon, little sturgeon (St. John River), roundnoser (Hudson River), bottlenose or mammose (Delaware River), salmon sturgeon (Carolinas), shortshell or lake sturgeon (Altamaha River, GA), pinkster (small individuals in New York waters), esturgeon a museau court (French)

Prior Taxonomy: Acipenser brevirostris

A. Description

The shortnose sturgeon is a bottom-dwelling anadromous fish species found in several tidal river systems from New Brunswick to Florida (Lee et al., 1980). It is listed as an endangered species in the United States, and as a rare and possibly endangered species in Canada (McAllister, 1970). The fish is dark dorsally, light ventrally, growing to a length of about three feet and a weight of about nine pounds. The snout is pointed with an inferior mouth; the tail is heterocercal. The body is somewhat cylindrical with ventral flattening, with five lateral rows of conspicuous horny scutes. A single or paired row of shields occurs anterior to the dorsal fin. In adults, the snout is shorter than the postorbital distance, but in young, is longer than this distance (Bond, 1979). The placement of fins reflects the primitive condition in Pisces, with pectoral and pelvic fins well separated and situated on the same ventrolateral axis. The caudal peduncle is short and stout.

B. Taxonomy

The sturgeons are classified with the paddlefishes in the Order Acipenseriformes. The characteristics of this order include a cartilaginous endoskeleton, a lack of vertebral centra, a strongly heterocercal caudal fin, and radials supporting the rays of the pelvic fins. The anus and urogenital opening is located at the base of the pelvic fins. Ganoid scales are present on the upper portion of the caudal fin, and some members of the order retain a spiracle. A cellular air bladder is present. Dermal bone is prominent on the heads of sturgeons (Bond, 1979).

The Order Acipenseriformes includes two families - the Acipenseridae (sturgeons) and the Polyodontidae (paddlefishes). The sturgeons are distinguishable from the paddlefishes by having bony scutes along the sides and back, and four barbels on the underside of the rostrum (Bond, 1979). The family Acipenseridae contains four genera and over 20 species; the family is holartic in distribution, and has marine, freshwater, and anadromous members.

The largest sturgeon is the beluga (Huso huso) of the Caspian and Black seas. It may reach a length of about 27 feet and a weight of 3300 pounds. Large specimens may be over 100 years old. The Russian sturgeon (Acipenser guldenstadti) of the Caspian Sea and the Sea of Azov, which reaches lengths of about eight feet, is one of the most important commercial sturgeon species. The largest North American sturgeon is the white sturgeon (Acipenser transmontanus) of the Pacific Coast; this species reaches lengths of 20 feet, and ranges from southern California to Alaska's Cook Inlet. The white sturgeon is found in fresh and salt water through this range.

Other Acipenseridae include:

Scaphirhynchus platorhynchus - the shovelnose sturgeon of the Mississippi River;

Pseudoscaphirhynchus hermanni - the shovelnose sturgeon of the Amu Darya River in the USSR;

Acipenser sturio - found on both coasts of the Atlantic;

Acipenser fulvescens - found in the Mississippi drainage and north through the Great Lakes, St. Lawrence River, and Hudson Bay; and

Acipenser medirostris - the green sturgeon found in marine waters off the Pacific coast, and westward to Asia.

Two additional species of Acipenser, the Atlantic sturgeon, Acipenser oxyrhynchus and the shortnose sturgeon, Acipenser brevirostrum, occur in the marine, estuarine, and fresh waters of the northeastern United States. The shortnose sturgeon is distinguished from its sympatric congener by its smaller maximum size (three feet versus 10 feet), wider mouth (69-81% of interorbital width versus 55% or less of interorbital distance), preanal shields in a single rather than double row, and blackish viscera (Bond, 1979).

C. Distribution

The shortnose sturgeon inhabits large tidal rivers along the Atlantic coast of North America, from the Saint John River of New Brunswick to the Saint Johns River of Florida. The Hudson River appears to support the most viable populations of this species (Cooper et al., 1977). River systems from which shortnose sturgeon have been recorded include:

Saint John River, New Brunswick
Bay of Fundy, Nova Scotia
Montsweag Bay, Maine
Kennebec-Sheepscot River, Maine
Connecticut River, Connecticut
Hudson River, New York
Raritan Bay, New Jersey
Delaware Bay and River
Altamaha River, Georgia
Saint Johns River, Florida
Indian River, Florida

D. Economic Importance

The shortnose sturgeon has historically been of incidental commercial importance along the Easter seaboard of North America since the 1800's (Dadswell, 1984). The flesh of the shortnose sturgeon is considered tasty and of good quality (Dadswell, 1984); the eggs are suitable for caviar and are considered superior to those of the Atlantic sturgeon (Scott and Scott, 1988). However, the smaller size and lower egg production of the shortnose sturgeon made it a less desireable commercial species than the larger Atlantic sturgeon (Cooper et al., 1977).

E. Regulatory Status

The shortnose sturgeon is listed as an endangered species in the United States (Miller, 1972), having been placed on that list in 1967 (Brundage and Meadows, 1982). Several eastern states also list the species as threatened: those states include New York, New Jersey, North Carolina. The species is on the list of rare and possibly endangered Canadian fishes (McAllister, 1970; Scott and Crossman, 1973). Habitat loss and overfishing are the likely main causes of the species' decline.

F. Age Structure and Growth

The shortnose sturgeon is a slow-growing, late-maturing, long-lived fish species. Dadswell et al. (1984) reported that immature fish began to resemble adults when they reached eight to 12 inches FL (fork length), but remain immature until they reach about 18 inches in length (3 to 10 years in age). Dadswell (1979) used 19.7 inches (50 cm) as a length cutoff for classifying Saint John River estuary shortnose sturgeon as adults in his population estimates. Maturation appears to be a function of the sex of the individual and the latitudinal location of the population.

Dadswell (1979), evaluating meristic characteristics for more than 4000 shortnose sturgeon captured in the Saint John River estuary, calculated the von Bertalanffy growth equation for adults (between 10 and 67 years) of both sexes to be (in centimeter units):

$$L_t = 130(1-e^{-0.042(t+1.96)})$$

For juveniles of one to nine years, the von Bertalanffy growth equation was:

$$L_t = 65.8(1-e^{-0.104(t+1.52)})$$

Length became asymptotic at 47-48 inches after 60-70 years; maximum length was estimated at 51 inches.

The oldest female shortnose sturgeon captured in the Dadswell (1979) study was 67 years old; the oldest male was 32 years old. The sex ratio of adults was 2:1 for females, apparently reflecting the longer life span of females. Age-frequency distributions for gill net collections in 1974 and 1975 showed a mode of younger fish (24-26 inches) and a long descending tail of older-aged fish; from these data, Dadswell concluded that mortality was relatively high among younger fish, with mortality rates declining with age. This is the expected pattern for a long-lived species.

Dovel (1981) tagged almost 2,800 shortnose sturgeon in the Hudson River between the years 1976 and 1980. Application of the Peterson estimation method to recapture data yielded an estimate of the size of the shortnose sturgeon population over the age of five years in the Hudson at between 13,000 and 30,000 individuals. Dovel further concluded that the maximum size and age of shortnose sturgeon in the Hudson is approximately half of that recorded for the Saint John River estuary, and that the time to initial spawning for the Hudson River fish was reduced by half over those of the Saint John River.

G. Reproduction

Shortnose sturgeon spawning occurs during the spring, generally when water temperatures rise to the 9 to 14 °C range (Heidt and Gilbert, 1978; Dadswell, 1979; Taubert, 1980a; Buckley and Kynard, 1981, 1985b). Spawning occurs in freshwater tidal areas - waters that are influenced by tidal oscillations, but above the salt wedge. In the Hudson River, spawning occurs from the Troy Dam south to Coxsackie (Dovel, 1979). Adults either arrive on the spawning grounds in fall, remaining in these areas until spring spawning, or migrate to the spawning sites during spring periods of rising water temperature and increased freshwater flows (Buckley and Kynard, 1985a). Dovel (1981) indicated that shortnose sturgeon congregated for winter in a relatively small area in the vicinity of Esopus Meadows; this is an area just east of the Village of Saugerties that is classified as a Significant Coastal Fish and Wildlife Habitat by the New York State Department of State (NYSDOS). The NYSDOS notes in its designated habitat narrative that this area serves as a post-spawning and wintering habitat for shortnose sturgeon.

The sturgeon spawn adhesive demersal eggs - eggs that sink and adhere to hard bottom substrata (the lithophilous spawning habit). Dadswell (1979) noted that fecundity was 27,000 to 208,000 eggs per female in the Saint John River estuary, while fecundity of specimens from the Altamaha River (GA) ranged from 79,000 to 90,000 eggs per female (Heidt and Gilbert, 1978). The spawning period is compressed, lasting perhaps no more than three to five days, and often occurs during a period of decreasing river discharge (Buckley and Kynard, 1985b). Some authors (Dovel, 1981; Buckley and Kynard, 1985b) have offered qualitative evidence indicating that a single gravid female is attended by several males during spawning.

The eggs, being strongly adhesive after fertilization, are likely to remain within a few hundred yards of the site of spawning. The eggs hatch about 13 days after fertilization; the larvae are about 10 millimeters in length at hatching. The larval shortnose sturgeon tend to remain closely associated with the substratum, although behavioral observations by Buckley and Kynard (1981) indicate that a "swim-up" phase is present; in this phase, the larvae make short swimming excursions into the water column and return to the bottom. In this way, the larvae gradually drift downstream.

The larval shortnose sturgeon grow rapidly, and may reach from 6 to 12 inches during the first growing season (Dadswell, 1984). During this time, they probably confine their movements to riverine areas upstream of the salt wedge (Potter and Dadswell, 1979; Brundage and Meadows, 1982).

Older juveniles and adult shortnose sturgeon are found in midsummer on feeding grounds in midestuary. In fall, they often migrate to overwintering areas in deep, haloclinal areas of the lower estuary (Dadswell, 1979); some adults, however, may overwinter in deep freshwater sites located near or even upstream of the spawning reaches (Dadswell, 1979; Buckley, 1982; Buckley and Kynard, 1985b). Migratory movements to spawning areas in the spring bring fish together from all of these overwintering areas (Buckley and Kynard, 1985b).

G. <u>Populations</u>

Although the shortnose sturgeon is considered to be rare in abundance, the populations of the Saint John and Hudson rivers appear to be substantial. Using Seber-Jolly estimation statistics, Dadswell (1979) estimated the adult (> 19.7 in.) shortnose sturgeon population of the

Saint John River estuary to be between 12,600 and 23,400 individuals. Dovel (1981), using Peterson estimation statistics, estimated the Hudson River population to be between 13,000 and 30,000 individuals.

The young of the shortnose sturgeon are difficult to distinguish from those of the Atlantic sturgeon; thus, precise distribution and abundance information for these life history stages is limited (Cooper et al., 1977).

III. HABITAT REQUIREMENTS AND PHYSIOLOGICAL TOLERANCES

The United States Fish and Wildlife Service (USFWS) has issued a Habitat Suitability Index (HEP) model for the shortnose sturgeon. That model, authored by J.H. Crance in 1986, identifies five habitat variables that appear to affect the movement, distribution, and abundance of shortnose sturgeon. These habitat variables are: water temperature, water velocity, substratum type, water depth, and water salinity. These variables can, in turn, be used to evaluate the suitability of various habitats for shortnose sturgeon use. The various literature reports on the species indicate that the habitat requirements for feeding and spawning are quite different in this species - in fact, are almost diametrically opposite; for that reason, the discussions of habitat requirements that follow discuss feeding and spawning separately.

A. Water Temperature

A.1. **Feeding** - Studies of shortnose sturgeon feeding behaviors have disclosed extremes of feeding activities, but have not yet precisely identified optimum or preferred feeding temperatures. Dadswell (1979) found that feeding by adult shortnose sturgeon in freshwater portions of the Saint John River was generally restricted to periods when water temperatures exceeded 10 °C. Juvenile shortnose sturgeon (2+ inches in length) are often cultured in water that is 24 to 27 °C (Crance, 1986), although unpublished information cited by Dadswell et al. (1984) indicated that "young" shortnose sturgeon experienced distress or rapid mortality at temperatures over 25 °C.

The HEP model for the shortnose sturgeon rates the temperature range between 11 and 22 °C as the optimum mean temperature range for summer foraging (Crance, 1986).

A.2. **Spawning** - The shortnose sturgeon is an anadromous spring spawner. Movement to spawning areas during the spring appears to be stimulated by the rise in water temperatures above 8 °C (Pekovitch, 1979; Taubert, 1980a; Dadswell et al., 1984. Dovel found that spawning occurred in the Hudson River between Coxackie and Troy during the last part of April and through May, when water temperature exceeded 10 °C. Spawning occurred in the Saint Johns River at temperatures between 10 and 12 °C (Dadswell, 1979), and in the Connecticut River when temperatures were between 11.5 and 15 °C (Taubert, 1980; Buckley and Kynard, 1985).

The HEP model for the shortnose sturgeon rates the temperature range between 10 and 16 °C as the optimum mean temperature during the spawning season (Crance, 1986).

B. Water Velocity

B.1 **Feeding** - Shortnose sturgeon use their protrusible mouths to feed on benthic macroinvertebrates. During summer foraging, adult shortnose sturgeon utilize shallow midestuarine feeding grounds (Dadswell, 1979) that have little or no current (McCleave et al., 1977; Dadswell, 1979; Taubert, 1980). Larvae that do not demonstrate strong migrational movements appear to prefer deep channel areas with swift currents (Cromartie, 1982; Dadswell, 1979; Taubert, 1980a). Juveniles are associated with deep channels, in current velocities of 0.3 to 1.3 feet per second (fps) (Pottle and Dadswell, 1979; Dadswell et al., 1984).

The HEP model for shortnose sturgeon rates the velocity range between 0.5 and 1.5 fps as the optimum mean water column velocity for foraging adults during summer (Crance, 1986).

B.2. **Spawning** - Shortnose sturgeon spawn demersal eggs that disperse and adhere to rocks and other bottom surfaces. Proper water velocities appear critical to egg survival and hatching. Eggs released in currents of excessive velocity may not have and opportunity to adhere to bottom surfaces, whereas eggs released in currents of insufficient velocity may clump together, resulting in susceptibility to respiratory stress, fungus growth, increased egg predation, and reduced opportunity for dispersion as newly-hatched larvae (Buckley and Kynard, 1985b). Prespawning shortnose sturgeon in the Connecticut River preferred areas of reduced velocities (1.0-7.0 fps) (Buckley and Kynard, 1985b). Spawning was found to occur in the Connecticut River at water velocities between 1.2 and 3.9 fps (Buckley and Kynard, 1985b), in the Hudson River at water velocities between 2.0 and 4.0 fps (Pekovitch, 1979) and in the Saint James River at water velocities between 3.3 and 9.8 fps (Washburn and Gillis Associates, LTD, undated). Buckley and Kynard (1985b) noted that, if rising water temperatures "would cause the final maturation of oocytes," then "the appropriate water velocity may cue the female to deposit eggs."

The HEP model for the shortnose sturgeon rates the velocity range between 1.0 and 2.5 fps as the optimum mean water column velocity during the spawning season (Crance, 1986).

C. Substratum Type

C.1. **Feeding** - As noted earlier, the protrusible tube mouth of the shortnose sturgeon is an adaptation for feeding on benthic macroinvertebrates (e.g., polychaetes, molluscs, crustaceans, insects) (Dadswell, 1979, 1984; Taubert, 1980b). Dadswell determined that shortnose sturgeon feeding areas were saline areas with gravel-silt bottoms, and freshwater areas with shallow, muddy bottoms. In Maine, shortnose sturgeon were found feeding during summer over mud flats (McCleave et al. 1977). Pottle and Dadswell (1979) found sand-mud or gravel-mud substrata were preferred by juvenile sturgeon. Juvenile shortnose sturgeon often feed extensively on cladocerans and insect larvae; thus, substratum type appears less important to these early life stages than to the older juveniles and adults. Carlson and Simpson (1987) found that the stomach contents of juvenile shortnose sturgeon collected from the freshwater portions of the Hudson River estuary consisted principally of chironomid larvae characteristic of silty-sand substrata.

The HEP model for the shortnose sturgeon lists macrophytes, mud/clay, silt, and sand as the optimum foraging substrata for foraging adults in summer (Crance, 1986).

C.2. **Spawning** - Substrata reportedly utilized by shortnose sturgeon during spawning vary somewhat in composition. Spawning substrata include: cobble and rubble (Dadswell, 1979; Taubert, 1980a); gravel, rubble, and large boulders (Squiers, 1983); and rock/rubble or sand/gravel (Washburn and Gillis Associates, LTD, undated). Studies reported by Buckley and Kynard (1982, 1985b) in the Connecticut River indicated that water velocity and water depth may be more important than substratum type in determining preferred spawning locations for shortnose sturgeon.

The HEP model for the shortnose sturgeon lists gravel and cobble/rubble as the optimum substrata for spawning adults (Crance, 1986). Macrophyte beds, and mud/clay or silt bottoms are the substrata least favorable for spawning.

D. Water Depth

D.1. **Feeding** - Water depths of summer foraging areas used by shortnose sturgeon are generally shallow, a finding consistent with the preferred summer velocity regime and substratum of silt and/or beds of aquatic vegetation. However, McCleave et al. (1977) tracked adults by radiotelemetry during summer periods and found the individuals in depths ranging from 3 to 80 feet. The monitored fish did spend extensive periods in waters about three feet in depth, and did not orient to channels when crossing such features. Shortnose sturgeon tend to forage in deeper water (15-45 ft) when in a saline environment (Dadswell, 1979), while juveniles tend to confine their activity to deeper riverine channels (Pottle and Dadswell, 1979; Brundage and Meadows, 1982). Juveniles and recently-hatched larvae were captured by Dovel (1981) moving with the current along the Hudson River bottom. Townes (1937) described shortnose sturgeon as feeding in coves along the Hudson River over mud bottoms in 12-30 feet of water.

The seven investigators polled in the establishment of Instream Flow Incremental Methodology (IFIM) graphs for shortnose sturgeon disagreed on optimum depths for adults during summer (Crance, 1986). One noted that the fish are commonly found in shallow coves at water depths less than 10 feet, while another noted that the fish may be found during that season at depths greater than 40 feet. The IFIM graph shows depths of 10 to 20 feet as the optimum water depth for adults in the summer season (Crance, 1986).

D.2. **Spawning** - Shortnose sturgeon spawning sites have been found in or near areas of deep water (Hoff, 1965; Heidt and Gilbert, 1978; Taubert, 1980; Dovel, 1981; Buckley and Kynard, 1982, 1985a,b; Squiers et al., 1982). Squiers (1983) reported spawning site at depths between 20 and 24 feet, while other researchers found spawning sites between seven and 13 feet (O'Herron and Able, 1985; Buckley and Kynard, 1985a).

The IFIM graph shows depths of 12 to 40 feet as the optimum range of depths for spawning, incubation, and larval development (Crance, 1986).

E. Water Salinity

E.1. **Feeding** - Shortnose sturgeon move freely from fresh water to waters with salinities in excess of 30 parts per thousand (ppt) (Taubert, 1980a; Taubert and Dadswell, 1980; Holland and Yelverton, 1973; Squiers and Smith, 1979). Foraging generally occurs in mid-estuary areas with salinities of 0.5 to 3.0 ppt (Dadswell, 1979; Dadswell et al.; 1984). However, populations have been found feeding in fresh water (Taubert, 1980a) and in areas with salinities ranging from 18 to 24 ppt (McCleave et al., 1977). Prey species are benthic macroinvertebrates characteristic of the particular salinity regime.

E.2. **Spawning** - All known spawning sites identified for shortnose sturgeon are in freshwater tidal reaches of estuaries (Crance, 1986). Such areas are generally located just upstream of the salt wedge in mesohaline environments with salinities between 1 and 2 ppt (Squiers and Smith, 1978; Dadswell, 1979).

F. Tolerance to Ambient Environmental Gradients

As an anadromous species of temperate estuaries, the shortnose sturgeon are necessarily exposed to a wide range of fluctuating environmental conditions, including temperature, salinity, water velocity, bottom substrata, and prey species. The literature cited in the previous chapter indicates that the species appears eurytopic - broadly adaptive - for these environmental factors. Adults and older juveniles have been recorded as moving relatively freely through substantial gradients in salinity, water velocity, depth, and substratum type; these cumulative observations substantiate the eurytopic nature of the species. eurytopic

The most narrow habitat preferences appear to be operational during spawning; in the several estuarine systems studied, the spawning reaches described for shortnose sturgeon appear to be well defined as deep, high-energy, freshwater tidal areas with rocky substrata. Larval stages and early juvenile development appear to be concentrated in these same general reaches. Adults and older juveniles appear to move much more freely through the several estuarine gradients, although preferred summer feeding areas tend to be mesohaline, low energy, mid-estuarine shallows.

G. Tolerance to Environmental Contaminants

Little work has been reported specifically on the responses of shortnose sturgeon to environmental contaminants; most laboratory studies of fish tolerances to contaminants have used either standard test species or species that can be easily acquired in significant numbers. The general findings with respect to toxicity of cadmium to estuarine fishes were summarized in a report by the Research Planning Institute (1985); pertinent findings include:

- the general mode of cadmium toxicity on metabolism is through competition and displacement of metalloenzymes (e.g., glucose-6-phosphate dehydrogenase, carbonic anhydrase, leucine aminopeptidase, xanthine oxidase).

- cadmium may also depress respiratory rate, reduce immune responses, reduce the fat content of fish livers, reduce growth rates, and inhibit spawning success.

- cadmium is taken up readily by aquatic organisms; bioconcentration factors (BCF's) range from 3 to 12,400, with most BCF's less than 400.

- the primary path for cadmium contamination appears to be through the food chain, from benthic infauna and rooted macrophytes through the various consumer levels.

- the toxicity of cadmium to fishes is a function of the species tested and the hardness of the water. Salmonids are more sensitive than most nonsalmonid taxa. The toxicity of cadmium decreases with increasing salinity.

Dovel (1981) speculated that the presence of xenobiotic contaminants (e.g., PCB's) in the Hudson River could make the fish more susceptible to fin rot or other fungal fish diseases.

IV. EVALUATION OF FOUNDRY COVE AND COLD SPRING PIER HABITATS

As noted in the Introduction of this BA (Chapter I), because the shortnose sturgeon is a federally-endangered species occurring at least transiently in the Hudson River off Foundry Cove, the EPA must evaluate the proposed remedial activities pursuant to CERCLA/SARA at the former MBCS with respect to potential impacts to shortnose sturgeon. In the preceding chapters, the habitat characteristics determining the general suitability of aquatic habitats for shortnose sturgeon use were discussed in detail. In this chapter, the specific habitats within the Foundry Cove and adjacent Hudson River area are examined with respect to the habitat characteristics outlined in earlier discussions.

A. General Ecological Characteristics of the Foundry Cove and Cold Spring Pier Areas

For remedial study purposes, the MBCS has been segregated into three study areas: Area I, which consists of East Foundry Cove Marsh and Constitution Marsh; Area II, which encompasses the former battery plant, the surrounding grounds, and a vault containing cadmium-contaminated sediments dredged from East Foundry Cove in the 1970's; and Area III, which includes East and West Foundry Coves and the Hudson River in the vicinity of the Cold Spring Pier. East Foundry and West Foundry Coves are connected by a narrow water channel spanned by a railroad trestle. Areas I and III are the aquatic habitats to which the following discussions are oriented.

The Foundry Cove area is located in a freshwater tidal area on the eastern side of the Hudson River at approximately HR Mile Marker 53. The Village of Cold Spring is immediately north of the cove, and the U.S. Military Academy at West Point is just to the south on the western side of the Hudson River. Tidal measurements determined by Acres (1975) demonstrate a nearly four-foot tidal range at the East Cove/West Cove railroad trestle. Continuous tidal velocity measurements indicate a clockwise tidal flow pattern in East Foundry Cove, with velocities generally peaking at one fps.

East Foundry Cove is approximately 48 acres in area, part of which (about 14 acres) lies generally above mean high tide and contains a cattail marsh. The remaining 34 acres is covered by about 1.5 feet of water at mean low tide and contains beds of aquatic macrophytes. The substratum of East Foundry Cove is predominantly unconsolidated silts and clays; analyses indicate an average grain size distribution of 4 percent gravel, 39 percent sand, 48 percent silt, and 9 percent clay (MPI, 1990).

West Foundry Cove is approximately 107 acres in area and is covered by 1.5 to 23 feet of water at mean low tide (mean low water). Water chestnut (Trapa natans) grows densely in the shallower areas of this cove. Water velocities through the channel opening between East and West Foundry Coves range from 1 fps on the flood to 2 fps on the ebb. Velocities also showed a declining gradient from surface to bottom. The substratum here again is sedimentary, with grain size measurements showing a mean distribution of 66 percent silt, 25 percent clay, 8 percent sand, and 1 percent gravel (MPI, 1990).

The Cold Spring Pier Area covers approximately 187 acres in area, the water depths in this area range from three to nine to 100 feet of water at mean low tide. Water depths are relatively shallow (2-10 feet) near the pier structures; riverward of the pier influence, the water deepens quickly to over 50 feet in depth as the main channel of the Hudson River is approached. The substratum of this area is again dominated by silts and clays, with grain size distributions indicating an average of 1 percent gravel, 20 percent sand, 65 percent silt, and 14 percent clay (MPI, 1990).

B. Biological Communities of the Foundry Cove and Cold Spring Pier Areas

As noted above, the Foundry Cove/Cold Spring Pier area is a freshwater tidal ecosystem, only rarely experiencing salinities in excess of 3.5 parts per thousand (ppt). Also, the area is a depositional area with generally shallow water depths and low to moderate current velocities. These conditions encourage the growth of rooted aquatic macrophytes; the macrophytes identified by the site studies include arrow arum (Peltandra virginica) , pickerelweed (Pontederia cordata), cattail (Typha augustifolia), water milfoil (Myriophyllum sp.), and water chestnut (Trapa natans) (Ebasco, 1989).

The fine sediments of the cove provide habitat for benthic macroinvertebrates adapted to life in such low oxygen conditions; such infaunal taxa are dominantly chironomid larvae and oligochaete worms. Blue crabs (Callinectes sapidus) are a dominant epifaunal taxon (ibid.).

Site sampling of resident vertebrates also included fish collections, although the object of those studies was directed more at characterizing levels of contamination in fish tissue rather than statistically describing the community structure of the fishes of the area. The species collected in the cove area included banded killifish (Fundulus diaphanous), sunfish (Lepomis sp.), carp (Cyprinus carpio), white perch (Morone americana), and American eel (Anguilla rostrata). The cove habitat also provides an open water area and macrophyte beds for migrating waterfowl (ibid.).

Although no shortnose sturgeon were collected in the Foundry Cove area, this species is known to use areas north of Cold Spring for spawning, and feeds in low-velocity shallows throughout the Hudson River estuary (NYSDOS, 1990).

C. HEP Evaluation of Foundry Cove and Cold Spring Pier Areas for Shortnose Sturgeon

The USFWS has compiled Habitat Evaluation Procedure (HEP) models for evaluation of estuarine and riverine areas as shortnose sturgeon habitats. The model documentation is given in a USFWS publication entitled "Habitat Suitability Index Models and Instream Flow Suitability Curves: Shortnose Sturgeon" (USFWS, 1986). The microcomputer version of the model is included in the USFWS HEP Version 2.2 software package and documentation (USFWS, 1985).

The habitat variables used in the HEP shortnose sturgeon models are:

- o Mean water temperature during summer, foraging, adults
- o Mean water velocity during summer, foraging, adults
- o Predominant substrate type during summer
- o Mean water temperature, spawning
- o Mean water velocity, spawning
- o Predominant substrate type during spawning

Data for these habitat model variables are available from the site-specific studies at Foundry Cove or from Hudson River data bases. Thus, the existing literature provides habitat information necessary and sufficient to perform HEP analyses of the Foundry Cove aquatic habitats for shortnose sturgeon use.

Habitat data and approximate areal extent of the Foundry Cove area were entered into a HEP analysis using the riverine model for shortnose sturgeon (HEP Model #A-84). The results, summarized in Table 1 and contained in their entirety in Appendix A, indicate that the Foundry Cove area is, by overall HEP model analysis, of minimal value for shortnose sturgeon. It should be noted here that the HEP model incorporates all six variables shown above in the overall assessment, and that the overall Habitat Suitability Index (HSI) score resulting from these input data is the minimum of the six subindex values; thus, to achieve a high score in the HSI output, a habitat area must rate high for both spawning and for foraging. Given the disparate habitat requirements of the species for these two life history processes, it is likely that very few habitats would achieve high HSI values in this regard.

Table 1
HSIs by Subarea

Subarea	HSI*
E. Foundry Cove (Emerg. Marsh)	0.00
E. Foundry Cove (Mud Bottom)	0.00
W. Foundry Cove (Aquatic Bed)	0.20
W. Foundry Cove (Mud Bottom)	0.00
Cold Spring Pier (inner area)	0.00
Cold Spring Pier (outer area)	0.00

* Minimum of six subindex values

These results are not wholly consistent with the habitat characteristics described in previous sections. The Foundry Cove area is, for the most part, an assemblage of shallow, low-velocity, muddy-bottom habitats immediately off the main channel of the Hudson River. Such areas are typical of habitats where investigators have found foraging shortnose sturgeon.

As noted earlier, the HEP model for shortnose sturgeon selects as the output HSI value the lowest of the values computed for the six input variables. The intermediate model outputs, also included in Appendix A, can be examined for additional insight regarding the value of the Foundry Cove habitats for shortnose sturgeon spawning or foraging. As shown in Table 2, all the subareas distinguished in the HEP analysis except the Hudson River outside of the Cold Spring Pier areas rated moderate to high as shortnose sturgeon foraging habitats. All these areas had tolerable summer temperatures, low current velocities, and substrate of silt/clay or aquatic beds.

Conversely, only the Hudson River area outside of the Cold Spring Pier achieved favorable rating for shortnose sturgeon spawning; the temperatures, current velocities, and substrata in this area (dropping from the pier to the river channel) are appropriate for the species.

Table 2

Intermediate Functions in HSI Computations

Subarea	HSI for Spawning*	HSI for Foraging*
E. Foundry Cove (Emerg. Marsh)	0.20	0.62
E. Foundry Cove (Mud Bottom)	0.00	1.00**
W. Foundry Cove (Aquatic Bed)	0.20	1.00
W. Foundry Cove (Mud Bottom)	0.00	1.00
Cold Spring Pier (inner area)	0.00	1.00
Cold Spring Pier (outer area)	0.64	0.00

* Minimum of three subindex values
** Attributable to model artifact - zero current velocity (minimum allowable value) yields 0.80 subindex value

The HEP model HSI values also fall short in characterizing the East Foundry Cove Marsh area. In particular, although this area is a cattail marsh that is only occasionally inundated by water, the model assigns it a moderate intermediate function value for foraging. It is highly unlikely that this area is even potentially accessible to shortnose sturgeon on any regular basis. Finally, the intermediate function value for the East Foundry Cove (mud bottom) as foraging habitat appears high mainly because of a model artifact; with the temperature and substratum type appropriate, the intermediate function for current velocity controls the HSI for foraging value. The HEP model assigns an intermediate function value of 1.00 to very low current velocities (and in fact, assigns an HSI value of 0.80 to an input value of zero velocity), thus exaggerating the value of a "mudflat" habitat for shortnose sturgeon.

Having applied both the test of reasonableness and site-specific information to the HEP output, it is reasonable to characterize three portions of the general Foundry Cove area as being potential habitat for shortnose sturgeon. The West Foundry Cove and inner Cold Spring Pier areas offer habitats with high potential for shortnose sturgeon foraging, while the outer Cold Spring Pier area offers a habitat of moderate value for shortnose sturgeon spawning. The East Foundry Cove areas (emergent marsh and mudflat) are not of particular significance for shortnose sturgeon.

V. ASSESSMENT OF POTENTIAL IMPACTS OF PROPOSED REMEDIAL ACTIONS

The remediation plans for the MBCS address three areas: East Foundry Cove Marsh and Constitution Marsh (Area I), the former battery plant site and surrounding grounds (Area II), and East Foundry Cove, West Foundry Cove and the Hudson River in the vicinity of the Cold Spring Pier (Area III). The assessment of potential impacts to Hudson River aquatic habitats and shortnose sturgeon populations applies to Areas I and III; Area II is an upland habitat.

For purposes of assessing potential impacts to the shortnose sturgeon, the aquatic habitats can be logically divided into three specific subareas. These are 1) the East Foundry Cove area (both the marsh and open water areas of the cove), 2) the West Foundry Cove area, and 3) the Cold Spring Pier area. These areas have spatial, environmental differences that warrant discussion of each area separately, and were dealt with as such in the HEP analyses in the preceding chapter.

A. East Foundry Cove

The remedy selected for the East Foundry Cove area entails the following actions that could affect the habitat characteristics of the East Foundry Cove area:

- dredging of the contaminated sediments from East Foundry Cove Marsh with cadmium concentrations greater than 100 mg/kg;
- dredging of cadmium-contaminated sediments from East Foundry Cove to a depth of one foot;
- thickening, chemical fixation, and off-site disposal of dredged sediments;
- post-dredging restoration of East Foundry Cove Marsh by addition of clean fill, clay with a high affinity for cadmium, and revegetation of the disturbed area;
- post-dredging sampling and restoration of East Foundry Cove, as necessary;
- long term monitoring of the Constitution Marsh sediments and biota;
- long-term monitoring of East Foundry Cove.

The dredging necessary to remove sediments with cadmium concentrations greater than 100 mg/kg would entail the removal of approximately two feet of sediment from an area of approximately 12 acres in East Foundry Cove Marsh. In East Foundry Cove proper, dredging to a specific action level would be technically difficult because cadmium concentrations in the sediments vary within a few inches of sediment depth. By dredging the upper one foot of contaminated sediments, 95 percent of the cadmium contamination will be removed. Restoration of the marsh, which includes the use of clayey fill with a high affinity for cadmium ions, will restrict release of the remaining low amount of cadmium.

The marsh portion of East Foundry Cove proposed to be dredged lies generally above mean high tide. Because of its elevation, it is not a habitat that could be utilized by fish, except during very high tides. The HEP model outputs described in Chapter IV attributed HSI values greater than zero to this habitat subarea. However, as discussed in that chapter, those HSI values are more an artifact of the limits of the mathematical functions than they are realistic quantifications of the habitat value of this emergent marsh for shortnose sturgeon. The actual likelihood of shortnose sturgeon foraging in this emergent marsh area that is rarely submerged is extremely low. Moreover, the selected remedy includes the refilling of the dredged area of this marsh with clays and topsoil. Thus, the potential impacts to the shortnose sturgeon populations of the Hudson River resulting from the proposed remedial activities in the marsh portion of East Foundry Cove are negligible.

The open water area of East Foundry Cove is covered by about 1.5 feet of water at mean low tide, and contains beds of aquatic vegetation. Dredging of one foot of sediment from this area would, even if contours were allowed to remain at the post-dredge elevations, would not substantially alter the value of the habitat for potential shortnose sturgeon foraging. Summer feeding areas have been characterized as shallow areas 3 to 15 feet in depth with little or no current (Dadswell, 1979). The East Foundry Cove will persist as a shallow low current area after the proposed remedy is implemented.

B. West Foundry Cove

The remedy selected for the West Foundry Cove area is the "no action" alternative (EPA, 1989). The only proposed activities are long-term monitoring and a hydrological study of Area III to ascertain whether West Foundry Cove is a depositional area. If West Foundry Cove is shown to be a depositional area, it is anticipated that West Foundry Cove will continue to accrue sediments from East Foundry Cove and/or the Cold Spring Pier areas by natural transport processes. After remedial activities are completed at the East Foundry Cove and Cold Spring Pier areas, any surface sediment subsequently transported from these remediated areas to West Foundry Cove by natural hydrological processes should be cadmium-free and of minimal ecological concern. Tidal action would cause the newly-deposited, clean sediments to mix with existing sediments in West Foundry Cove, thereby reducing the mean cadmium concentration in the sediments of that area (ibid.).

Should the hydrological study demonstrate that sediment tends to be transported from West Foundry Cove and that this sediment presents a threat to the environment (i.e, could be a source of recontamination of the areas to be remediated), then further action would be considered in the West Foundry Cove area (ibid.).

West Foundry Cove has, by HEP analysis, characteristics favorable for shortnose sturgeon foraging. These characteristics will persist under the selected remedy of no action in this particular area. Moreover, implementation of the selected remedies in the East Foundry Cove and Cold Spring Pier areas is unlikely to impact the habitat value of West Foundry Cove for shortnose sturgeon; those remedies, principally dredging of contaminated sediments, incorporate silt curtains designed to minimize the downstream transport of sediments from the area of disturbance. Residual contamination from such activities would, therefore, be low enough to be of minimal concern.

C. Cold Spring Pier

The remedy selected for the Cold Spring Pier area involves dredging of the top 36 inches of sediment in the immediate vicinity of Cold Spring Pier, and the dredging of the top 12 inches of sediment in the area just south of the pier (EPA, 1989). Dredged sediments will be thickened and fixed on the site and transported to an off-site disposal facility.

The aquatic habitat in the immediate vicinity of the Cold Spring Pier is transitional in nature; water depths near the pier structures are shallow, but deepen quickly to 50 feet riverward of the pier influence. The pier acts to slow water velocities and promote sedimentation of suspended solids. The area immediately proximal to the pier (designated as the "inner area" in the Chapter IV HEP analyses) is a habitat of value for foraging; deepening this area by three feet would not substantially alter this habitat's value for shortnose sturgeon foraging. The area more distal to the pier, where water depths grade more sharply toward the river channel, is not a habitat with value for foraging, but, being deeper and more turbulent, has moderate value for spawning. Removal of one foot of contaminated sediment from this outer area would not substantially alter its moderate value as a potential shortnose sturgeon spawning habitat.

D. Other Impact Considerations

1. **HSI Sensitivity Analyses** - The HSI values for the Foundry Cove areas will change only if one or more of the six input variables are altered. If none of these are altered so as to change the subindex value, the HSIs will remain unchanged. Those six input are, again:

- Mean water temperature during summer, foraging, adults
- Mean water velocity during summer, foraging, adults
- Predominant substrate type during summer
- Mean water temperature, spawning
- Mean water velocity, spawning
- Predominant substrate type during spawning

The proposed remedial activities in East Foundry Cove and the Cold Spring Pier areas will not alter the thermal regime of these aquatic habitats; the normal seasonal progression of temperature changes will persist. The substrate types will not be significantly altered; the substrata in the areas to be remediated will remain as soft unconsolidated sediments. The water velocities should be substantially unchanged by the minor changes in bathymetry caused by the dredging of surficial sediments. Thus, the evaluation of the East Foundry Cove by HEP criteria will remain unchanged.

Appendix A contains printouts of sensitivity analyses for the six subareas; these sensitivity analyses automatically add or subtract 10 percent to the input values for the six HEP variables, and compute the HSIs resulting from such changes in input values. The sensitivity analyses in Appendix A show that changes of +/- 10 percent will not change the values of the intermediate functions contributing to the HSIs.

2. **Effects of Proposed Remedies on Hydraulic Regime of Habitats** - The proposed remedial actions - dredging of surficial sediments - will not change the basic nature of the habitats of the Foundry Cove or Cold Spring Harbor Pier areas. The removal of one foot of sediment in the East Foundry Cove area and one to three feet of sediment in the vicinity of the Cold Spring Pier will not substantially alter the hydraulic regime of these areas, or alter

properties resulting from the hydraulic regime. These cove/pier areas will remain areas of deposition off the main channel of the Hudson River; subsequent to dredging, new sediments will be deposited and the bottom contours will likely converge on the pre-dredging contours.

3. **Broad Ranges of Shortnose Sturgeon Habitat Preferences** - Even in the case where the post-dredging contours did not converge on the pre-dredging contours, the post-dredging water depths would be appropriate for shortnose sturgeon foraging. The literature reviewed in earlier chapters indicated that, although shortnose sturgeon forage in "generally shallow" waters (USFWS, 1986), this observations encompasses a wide range of water depths (i.e., 3 - 81 feet). A change of one to three feet in depth, whether transient or permanent, would not eliminate the Foundry Cove areas to be dredged as potential foraging areas for shortnose sturgeon.

4. **Reduction in Contaminant Levels in Substratum** - The most significant impact of the proposed remedial activities on the shortnose sturgeon populations of the Hudson River will be positive; removal of the cadmium-contaminated surficial sediments from areas of East Foundry Cove and Cold Spring Pier will reduce the potential risk of cadmium toxicity to shortnose sturgeon that might make use of those areas in summer foraging. The most likely route of cadmium intake in fishes is dietary; by reducing the cadmium concentrations in surficial sediments (and thus, indirectly, in benthic macroinvertebrates in those sediments), the route for cadmium transfer to bottom-feeding fish is diminished.

VI. CONCLUSIONS

This BA of the potential impacts of EPA's proposed remedial actions for the MBCS on the shortnose sturgeon, a federally-listed endangered species, has been conducted under guidelines implementing the ESA. The aquatic habitats of the Hudson River in the vicinity of MBCS have been characterized by NMFS as being potentially suitable for shortnose sturgeon. In order to assure that the proposed CERCLA/SARA remedial actions do not impact this endangered species, a BA of the potential impacts of the selected remedial actions for the MBCS has been conducted. The BA includes a literature review of the species' habitat requirements, a review of pertinent site-specific data, computation of HEP Habitat Suitability Index values (HSI's) for subareas delineated by cover types, and an assessment of the potential impacts of the proposed remedial actions on shortnose sturgeon.

The Hudson River populations of shortnose sturgeon constitute a significant proportion of this fishery resource along the eastern seaboard of the United States. The shortnose sturgeon is an anadromous species, moving in the spring from saline areas of the estuary to freshwater tidal areas to spawn. Early development continues in these fresh and brackish water reaches of the estuary. Adults and older juveniles range more widely through the estuary, moving into areas of higher salinity for summer foraging and overwintering.

The habitat preferences of the shortnose sturgeon have been treated at length in the technical literature and are summarized in a HEP model for the species (Crance, 1986). According to the HEP formulations, the optimum summer foraging habitat for adult shortnose sturgeon are warm (11-22 °C), shallow (10-20 feet), low current (0.5-1.5 fps) habitats with fine-grained substrata (macrophyte beds; mud, clay, silt, or sand). The optimum spring spawning habitats are cool (10-16 °C), deep (50-130), high current (1.0-2.5), mid-channel habitats with coarse-grained substrata (gravel, cobble, rubble).

Adult and older juvenile shortnose sturgeon are likely to be tolerant of environmental gradients (e.g., salinity, temperature) in part because of their general anadromous habit and in part because of their observed use of a wide variety of habitats. The early life stages (larvae, young juveniles) are likely to be more restricted in their tolerances, and utilize only selected areas of the general shortnose sturgeon range in any given estuary. Specific toxic effects of environmental contaminants on shortnose sturgeon have not been directly demonstrated; inferences can be drawn from findings from other estuarine fish species.

The Foundry Cove and Cold Spring Pier areas are tidal freshwater environments characterized by shallow depths, unconsolidated bottoms of fine sediments, tidal currents of low velocity, and the presence of extensive macrophyte beds.

The Foundry Cove and Cold Spring Pier areas are, by overall HEP analysis, poor shortnose sturgeon habitats. However, examination of intermediate HEP model output indicates that the subindices for foraging are high for most shallow, open water habitat subareas, while the subindices for spawning are low for most shallow subareas. The deep area of the Hudson River riverward of the Cold Spring Pier scores high in the spawning subindices.

The remedial activities proposed for East Foundry Cove Marsh, East Foundry Cove, and the Cold Spring Pier area will remove surficial sediments contaminated with cadmium from prior battery plant operations. The removal of those contaminated surficial sediments will not alter the habitat characteristics of the areas in any way that will significantly diminish their existing value as potential shortnose sturgeon foraging or spawning areas. Moreover, removal of cadmium-contaminated surficial sediments will reduce the potential for dietary transfer of cadmium from benthic invertebrates to the bottom-feeding shortnose sturgeon.

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APPENDIX A

Shortnose Sturgeon HEP Analyses

General Methodology

Habitat Evaluation Procedure (HEP) analyses are quantitative models developed by the United States Fish and Wildlife Service (USFWS) to provide a standardized framework for assessing the value of various environments and cover types for wildlife. The wildlife species used in a HEP study (the 'evaluation species') serve as indicators of habitat value not only for their own species, but also for taxa with similar ecological requirements and preferences.

Computations for HEP studies can be performed on worksheets supplied with the documentation for each evaluation species or, alternatively, can be performed interactively on a microcomputer through a HEP software package distributed by USFWS (Hays, 1985). This latter computational method offers a faster analysis of multiple 'scenarios', a capability for sensitivity analysis, and full printout capabilities for intermediate and final model outputs. The evaluations of shortnose sturgeon in this report were performed using the microcomputer software, running HEP (Version 2) on a Dell System 200 microcomputer.

Specific Methodologies

Habitat value of specific riverine areas for shortnose sturgeon can be evaluated using HEP Model #A-84. A printout of the model structure and annotations is shown below. Note that the HEP variables that are used in the evaluation of riverine habitats for value to shortnose sturgeon are:

X129V1 - Mean water temperature during summer; foraging site; adults (C). Range = 0 - 40 C.

X129V2 - Mean water column velocity during summer; foraging site; adults (cm/sec). Range of variable = 0 - 160 cm/sec.

X129V3 - Predominant substrate type during summer; foraging site; adults (class). Classes = eight categories of substrate ranging from aquatic bed to bedrock.

X129V4 - Mean water temperature during spawning season (C). Range of variable = 0 - 40 C.

X129V5 - Mean water column velocity during spawning season (cm/sec). Range of variable = 0 - 160 cm/sec.

X129V6 - Predominant substrate type during spawning season (class). Classes = eight categories of substrate ranging from aquatic bed to bedrock.

Habitat areas to be evaluated must be categorized as one of three 'cover types' or habitat types: riverine aquatic bed (R5AB), riverine emergent wetland (R5EM), or riverine shore and bottom classes (R5UB/). Using references to Foundry Cove areal estimates and habitat descriptions, the various East Foundry Cove, West Foundry Cove, and Cold Spring Pier areas were characterized as one of these habitat types. One area of aquatic bed is distinguished in West Foundry Cove (WFCAB), one emergent wetland is distinguished in East Foundry Cove (EFCEM), and four unconsolidated bottom areas are distinguished: East Foundry Cove (EFCUB), West Foundry Cove (WFCUB), the area adjacent to Cold Spring Pier (CSPIN), and the Hudson River area peripheral to Cold Spring Pier (CSPOUT). The habitat types used in the study are shown below.

Data applicable to the six habitat variables is available in the Ebasco (1989) and from prior Hudson River data bases (LMS, 1984). The input data matrix is shown below.

Library: C:SNSTURG.HLB
7-2-1991

Model # 2 — Single covertype model.

Model name: SHORTNOSE STURGEON (riverine)

Verification level: Expert Review

Creation/modification date: 4-20-1987

CRANCE, J. H. 1986. HABITAT SUITABILITY INDEX MODELS: SHORTNOSE STURGEON. U.S. FISH WILDL. SERV. BIOL. REP. 82(10.129). 31 pp.
Applies to spawning, incubation, and summer foraging habitat.
Range: throughout the Atlantic Coast of the U.S. May also apply to the St. John River, Canada.

Covertypes:
R5AB : Riverine aquatic bed
R5EM : Riverine emergent wetland
R5UB/ : Riverine shore & bottom classes (UB/RB/SB/US/RS)

```
Lev 3     Lev 2     Lev 1
 X129V1---grf------min--HSI
 X129V2---grf-------|
 X129V3---mnu-------|
 X129V4---grf-------|
 X129V5---grf-------|
 X129V6---mnu-------^
```

Habitat variables:
X129V1 : Mean water temp. during summer. Foraging site, adults. (C)
X129V2 : Mean water column vel. during summer. Foraging site, adults (cm/sec)
X129V3 :Predominant substrate type during summ. Foraging site, adults (class)
X129V4 : Mean water temp. during spawn. season (C)
X129V5 : Mean water column vel. during spawn. season (cm/s)
X129V6 : Predominant substrate type during spawn. season (class)

GRAPH FUNCTION at level 2, position 1
Title: MEAN SUMMER TEMPERATURE (FORAGING) (C)

X: 0.000,	Y: 0.000
X: 8.000,	Y: 0.000
X: 11.000,	Y: 1.000
X: 22.000,	Y: 1.000
X: 35.000,	Y: 0.000
X: 40.000,	Y: 0.000

GRAPH FUNCTION at level 2, position 2
Title: MEAN WATER VELOCITY (FORAGING) (CM/S)

X: 0.000,	Y: 0.800
X: 15.000,	Y: 1.000
X: 45.000,	Y: 1.000
X: 152.000,	Y: 0.000

```
     X:      160.000,    Y:   0.000


MENU FUNCTION at level 2, position 3
     Menu choice:        1      Output value:   1.000
     Menu choice:        2      Output value:   1.000
     Menu choice:        3      Output value:   1.000
     Menu choice:        4      Output value:   1.000
     Menu choice:        5      Output value:   0.700
     Menu choice:        6      Output value:   0.300
     Menu choice:        7      Output value:   0.100
     Menu choice:        8      Output value:   0.000


GRAPH FUNCTION at level 2, position 4
  Title:  MEAN TEMPERATURE (SPAWNING) (C)
     X:        0.000,    Y:   0.000
     X:        7.200,    Y:   0.000
     X:       10.000,    Y:   1.000
     X:       16.000,    Y:   1.000
     X:       18.000,    Y:   0.000
     X:       40.000,    Y:   0.000


GRAPH FUNCTION at level 2, position 5
  Title:  MEAN WATER VELOCITY (SPAWNING) (CM/S)
     X:        0.000,    Y:   0.000
     X:       30.000,    Y:   1.000
     X:       76.000,    Y:   1.000
     X:      152.000,    Y:   0.000
     X:      160.000,    Y:   0.000


MENU FUNCTION at level 2, position 6
     Menu choice:        1      Output value:   0.200
     Menu choice:        2      Output value:   0.000
     Menu choice:        3      Output value:   0.100
     Menu choice:        4      Output value:   0.500
     Menu choice:        5      Output value:   1.000
     Menu choice:        6      Output value:   1.000
     Menu choice:        7      Output value:   0.800
     Menu choice:        8      Output value:   0.700
```

Comments:
The estuarine model for the shortnose sturgeon includes only the summer foraging life requisite because reproduction occures only in fresh-water habitats.

DATA ENTRY FORM: 7-2-1991

Library: SNSTURG.HLB
Model list:
#2 SHORTNOSE STURGEON (riverine)

R5AB: Riverine aquatic bed

X129V1

X129V2

X129V3

X129V4

X129V5

X129V6

R5EM: Riverine emergent wetland

X129V1

X129V2

X129V3

X129V4

X129V5

X129V6

R5UB/: Riverine shore & bottom classes (UB/RB/SB/US/RS)

X129V1

X129V2

X129V3

X129V4

X129V5

X129V6

Study Name: SNSTURGR 7-02-1991

Covertype	Sub-area	Area
R5AB	WCFAB	50.00
R5EM	EFCEM	14.00
R5UB/	CSPIN	4.00
R5UB/	CSPOUT	183.00
R5UB/	EFCUB	34.00
R5UB/	WFCUB	57.00

SNSTURGR HABITAT DATA 7-02-1991

Biological Assessment for Shortnose Sturgeon
Marathon Battery Company Site, Cold Spring, NY
Foundry Cove and Cold Spring Pier Subareas

	COVER TYPE / SUB-AREA:					
	R5AB	R5EM	R5UB/	R5UB/	R5UB/	R5UB/
VARIABLE:	WCFAB	EFCEM	CSPIN	CSPOUT	EFCUB	WFCUB
X129V1	22.000	27.000	22.000	22.000	22.000	22.000
X129V2	30.000	0.000	45.000	60.000	30.000	30.000
X129V3	1.000	1.000	2.000	8.000	2.000	2.000
X129V4	9.000	11.000	9.000	9.000	9.000	9.000
X129V5	30.000	0.000	45.000	60.000	30.000	30.000
X129V6	1.000	1.000	2.000	8.000	2.000	2.000

HEP Output

The HEP model for shortnose sturgeon (riverine) computes Habitat Suitability Indices (HSI's) for the study area as a whole and for each subarea included in the data entry matrix. The HSI for the whole study area is a weighted mean value - the subarea HSI's are weighted (multiplied) by their respective areal coverages and a weighted mean computed from these products. The overall HSI for the Foundry Cove study area, and the individual HSI's for each subarea, are shown below.

Study: SNSTURGR   Model: SHORTNOSE STURGEON (riverine)   7-02-1991

CoverType	SubArea	Area	HSI
R5AB	WCFAB	50.0	0.200
R5EM	EFCEM	14.0	0.000
R5UB/	CSPIN	4.0	0.000
R5UB/	CSPOUT	183.0	0.000
R5UB/	EFCUB	34.0	0.000
R5UB/	WFCUB	57.0	0.000
Overall:		342.0	0.029

Evaluation of Intermediate Functions

The interactive version of HEP permits the evaluator to examine intermediate stages in the computation of the HSI's for the study area and subarea. Examination of these intermediate functions can identify one or more variables that are most influential in determining final HSI values. Below are the intermediate functions for each of the six habitat variables used in the analysis. As noted in the main body of the report, the HEP model for shortnose sturgeon has HSI's based on the minimum output value in the six habitat variable categories. Other habitat variables may indicate the suitability of the habitat for discrete life stage functions (e.g., foraging, spawning) even though the overall habitat value of the area may be low.

Study: SNSTURGR 7-02-1991

Model: SHORTNOSE STURGEON (riverine)

CoverType: R5AB SubArea: WCFAB

```
LEV 3      LEV 2      LEV 1
  X129V1----grf-------min--HSI
      22.00      1.00 |   0.200
                      |
  X129V2----grf-------|
      30.00      1.00 |
                      |
  X129V3----mnu-------|
       1.00      1.00 |
                      |
  X129V4----grf-------|
       9.00      0.64 |
                      |
  X129V5----grf-------|
      30.00      1.00 |
                      |
  X129V6----mnu-------^
       1.00      0.20
```

Study: SNSTURGR 7-02-1991

Model: SHORTNOSE STURGEON (riverine)

CoverType: R5EM SubArea: EFCEM

```
LEV 3      LEV 2      LEV 1
  X129V1----grf-------min--HSI
      27.00      0.62 |   0.000
                      |
  X129V2----grf-------|
       0.00      0.80 |
                      |
  X129V3----mnu-------|
       1.00      1.00 |
                      |
  X129V4----grf-------|
      11.00      1.00 |
                      |
  X129V5----grf-------|
       0.00      0.00 |
                      |
  X129V6----mnu-------^
       1.00      0.20
```

```
Study: SNSTURGR                                                    7-02-1991

    Model:  SHORTNOSE STURGEON (riverine)

    CoverType: R5UB/    SubArea: CSPIN

                          LEV 3      LEV 2      LEV 1
                            X129V1----grf-------min--HSI
                                22.00      1.00 |  0.000
                                                |
                            X129V2----grf-------|
                                45.00      1.00 |
                                                |
                            X129V3----mnu-------|
                                 2.00      1.00 |
                                                |
                            X129V4----grf-------|
                                 9.00      0.64 |
                                                |
                            X129V5----grf-------|
                                45.00      1.00 |
                                                |
                            X129V6----mnu-------^
                                 2.00      0.00
```

```
Study: SNSTURGR                                                    7-02-1991

    Model:  SHORTNOSE STURGEON (riverine)

    CoverType: R5UB/    SubArea: CSPOUT

                          LEV 3      LEV 2      LEV 1
                            X129V1----grf-------min--HSI
                                22.00      1.00 |  0.000
                                                |
                            X129V2----grf-------|
                                60.00      0.86 |
                                                |
                            X129V3----mnu-------|
                                 8.00      0.00 |
                                                |
                            X129V4----grf-------|
                                 9.00      0.64 |
                                                |
                            X129V5----grf-------|
                                60.00      1.00 |
                                                |
                            X129V6----mnu-------^
                                 8.00      0.70
```

Study: SNSTURGR 7-02-1991

Model: SHORTNOSE STURGEON (riverine)

CoverType: R5UB/ SubArea: EFCUB

```
LEV 3      LEV 2      LEV 1
  X129V1----grf-------min--HSI
      22.00       1.00 |  0.000
                       |
  X129V2----grf-------|
      30.00       1.00 |
                       |
  X129V3----mnu-------|
       2.00       1.00 |
                       |
  X129V4----grf-------|
       9.00       0.64 |
                       |
  X129V5----grf-------|
      30.00       1.00 |
                       |
  X129V6----mnu-------^
       2.00       0.00
```

Study: SNSTURGR 7-02-1991

Model: SHORTNOSE STURGEON (riverine)

CoverType: R5UB/ SubArea: WFCUB

```
LEV 3      LEV 2      LEV 1
  X129V1----grf-------min--HSI
      22.00       1.00 |  0.000
                       |
  X129V2----grf-------|
      30.00       1.00 |
                       |
  X129V3----mnu-------|
       2.00       1.00 |
                       |
  X129V4----grf-------|
       9.00       0.64 |
                       |
  X129V5----grf-------|
      30.00       1.00 |
                       |
  X129V6----mnu-------^
       2.00       0.00
```

Sensitivity Analysis

The HEP model permits the evaluator to compute the changes in intermediate HSIs that would result from changing input values by +/- 10 percent. The response of the HSIs to such changes indicates the relative sensitivity of the intermediate functions to small changes in the habitat data.. Where a 10 percent change in input values results in a significant change in the resultant HSI value, the model is sensitive to small changes in that habitat characteristic. Where the intermediate HSIs do not change with small changes in input values, those habitat characteristics retain particular values despite small variations.

Sensitivity analysis:

Study name: SNSTURGR

Current model: SHORTNOSE STURGEON (riverine)

CoverType: R5AB SubArea: WCFAB

Base HSI: 0.200

Variable Name	Variable Value	10% change	HSI Value	% change in HSI	HSI sensitivity to unit change in variable
X129V1	22.000	+2.200	0.200	+0.0	+0.00
		-2.200	0.200	+0.0	+0.00
X129V2	30.000	+3.000	0.200	+0.0	+0.00
		-3.000	0.200	+0.0	+0.00
X129V3	1	integer			
X129V4	9.000	+0.900	0.200	+0.0	+0.00
		-0.900	0.200	+0.0	+0.00
X129V5	30.000	+3.000	0.200	+0.0	+0.00
		-3.000	0.200	+0.0	+0.00
X129V6	1	integer			

Sensitivity analysis:
Study name: SNSTURGR
Current model: SHORTNOSE STURGEON (riverine)
CoverType: R5EM SubArea: EFCEM

Base HSI: 0.000

Variable Name	Variable Value	Variable 10% change	HSI Value	% change in HSI	HSI sensitivity to unit change in variable
X129V1	27.000	+2.700	0.000	+0.0	+0.00
		-2.700	0.000	+0.0	+0.00
X129V2	0.000	+0.000	0.000	+0.0	+0.00
		+0.000	0.000	+0.0	+0.00
X129V3	1	integer			
X129V4	11.000	+1.100	0.000	+0.0	+0.00
		-1.100	0.000	+0.0	+0.00
X129V5	0.000	+0.000	0.000	+0.0	+0.00
		+0.000	0.000	+0.0	+0.00
X129V6	1	integer			

Sensitivity analysis:
Study name: SNSTURGR
Current model: SHORTNOSE STURGEON (riverine)
CoverType: R5UB/ SubArea: CSPIN

Base HSI: 0.000

Variable Name	Variable Value	10% change	HSI Value	% change in HSI	HSI sensitivity to unit change in variable
X129V1	22.000	+2.200	0.000	+0.0	+0.00
		-2.200	0.000	+0.0	+0.00
X129V2	45.000	+4.500	0.000	+0.0	+0.00
		-4.500	0.000	+0.0	+0.00
X129V3	2	integer			
X129V4	9.000	+0.900	0.000	+0.0	+0.00
		-0.900	0.000	+0.0	+0.00
X129V5	45.000	+4.500	0.000	+0.0	+0.00
		-4.500	0.000	+0.0	+0.00
X129V6	2	integer			

Sensitivity analysis:
Study name: SNSTURGR
Current model: SHORTNOSE STURGEON (riverine)
CoverType: R5UB/ SubArea: CSPOUT

Base HSI: 0.000

Variable Name	Variable Value	Variable 10% change	HSI Value	% change in HSI	HSI sensitivity to unit change in variable
X129V1	22.000	+2.200	0.000	+0.0	+0.00
		-2.200	0.000	+0.0	+0.00
X129V2	60.000	+6.000	0.000	+0.0	+0.00
		-6.000	0.000	+0.0	+0.00
X129V3	8	integer			
X129V4	9.000	+0.900	0.000	+0.0	+0.00
		-0.900	0.000	+0.0	+0.00
X129V5	60.000	+6.000	0.000	+0.0	+0.00
		-6.000	0.000	+0.0	+0.00
X129V6	8	integer			

Sensitivity analysis:
Study name: SNSTURGR
Current model: SHORTNOSE STURGEON (riverine)
CoverType: R5UB/ SubArea: EFCUB

Base HSI: 0.000

Variable Name	Variable Value	Variable 10% change	HSI Value	% change in HSI	HSI sensitivity to unit change in variable
X129V1	22.000	+2.200	0.000	+0.0	+0.00
		-2.200	0.000	+0.0	+0.00
X129V2	30.000	+3.000	0.000	+0.0	+0.00
		-3.000	0.000	+0.0	+0.00
X129V3	2	integer			
X129V4	9.000	+0.900	0.000	+0.0	+0.00
		-0.900	0.000	+0.0	+0.00
X129V5	30.000	+3.000	0.000	+0.0	+0.00
		-3.000	0.000	+0.0	+0.00
X129V6	2	integer			

Sensitivity analysis:
Study name: SNSTURGR
Current model: SHORTNOSE STURGEON (riverine)
CoverType: R5UB/ SubArea: WFCUB

Base HSI: 0.000

Variable Name	Variable Value	Variable 10% change	HSI Value	% change in HSI	HSI sensitivity to unit change in variable
X129V1	22.000	+2.200	0.000	+0.0	+0.00
		-2.200	0.000	+0.0	+0.00
X129V2	30.000	+3.000	0.000	+0.0	+0.00
		-3.000	0.000	+0.0	+0.00
X129V3	2	integer			
X129V4	9.000	+0.900	0.000	+0.0	+0.00
		-0.900	0.000	+0.0	+0.00
X129V5	30.000	+3.000	0.000	+0.0	+0.00
		-3.000	0.000	+0.0	+0.00
X129V6	2	integer			

Study: SNSTURGP Model: SHORTNOSE STURGEON (riverine) 7-02-1991

CoverType	SubArea	Area	HSI
R5UB/	CSPIN	4.0	0.000
R5UB/	CSPOUT	183.0	0.000
Overall:		187.0	0.000

```
Study: SNSTURGP                                                    7-02-1991

    Model:  SHORTNOSE STURGEON (riverine)

    CoverType: R5UB/    SubArea: CSPIN

                         LEV 3      LEV 2      LEV 1
                           X129V1----grf-------min--HSI
                               22.00       1.00 |  0.000
                                                |
                           X129V2----grf-------|
                               45.00       1.00 |
                                                |
                           X129V3----mnu-------|
                                2.00       1.00 |
                                                |
                           X129V4----grf-------|
                                9.00       0.64 |
                                                |
                           X129V5----grf-------|
                               45.00       1.00 |
                                                |
                           X129V6----mnu-------^
                                2.00       0.00


Study: SNSTURGP                                                    7-02-1991

    Model:  SHORTNOSE STURGEON (riverine)

    CoverType: R5UB/    SubArea: CSPOUT

                         LEV 3      LEV 2      LEV 1
                           X129V1----grf-------min--HSI
                               22.00       1.00 |  0.000
                                                |
                           X129V2----grf-------|
                               60.00       0.86 |
                                                |
                           X129V3----mnu-------|
                                8.00       0.00 |
                                                |
                           X129V4----grf-------|
                                9.00       0.64 |
                                                |
                           X129V5----grf-------|
                               60.00       1.00 |
                                                |
                           X129V6----mnu-------^
                                8.00       0.70
```

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