NOAA Technical Report NMFS 14

Synopsis of Biological Data on Shortnose Sturgeon, *Acipenser brevirostrum* LeSueur 1818

October 1984

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Michael J. Dadswell, Bruce D. Taubert, Thomas S. Squiers, Donald Marchette, and Jack Buckley

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Malcolm Baldrige, Secretary
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National Marine Fisheries Service
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CONTENTS

*No information available.

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MICHAEL J. DADSWELL,[1] BRUCE D. TAUBERT,[2] THOMAS S. SQUIERS,[3]
DONALD MARCHETTE,[4] and JACK BUCKLEY[5]

ABSTRACT

Information on the biology and populations of the shortnose sturgeon, *Acipenser brevirostrum*, is compiled, reviewed, and analyzed in the FAO species synopsis style. New information indicates this species exhibits biological and life-cycle differences over its north-south latitudinal range and that it is more abundant than previously thought.

1 IDENTITY

1.1 Nomenclature

1.11 Valid name

Acipenser brevirostrum LeSueur 1818 Ref: Trans. Am. Philos. Soc. 2:383. Type locality: Delaware River. Type specimen lodged at Academy of Natural Sciences of Philadelphia, ANSP 16953.

1.12 Objective synonymy

Acipenser brevirostris Richardson 1836:278. Type locality: Eastern North America. Type specimen: None.
Acipenser lesueurii Valenciennes—Duméril 1870:166. Type locality: New York. Type specimen: Paris Muséum National d'Histoire Naturelle.
Acipenser microrhynchus Duméril 1870:164. Type locality: Hudson River. Type specimen: None.
Acipenser dekayii Duméril 1870:168. Type locality: Hudson River. Type specimen: None.
Acipenser rostellum Duméril 1870:173. Type locality: Hudson River. Type specimen: Paris Muséum National d'Histoire Naturelle.
Acipenser sinus Valenciennes Duméril 1870:175. Type locality: New York. Type specimen: Paris Muséum National d'Histoire Naturelle.
Acipenser brevirostris Jordan et al. 1930:34
Acipenser brevirostris Vladykov and Greeley 1963:36
Acipenser brevirostris Magnin 1963:87

LeSueur originally described the species from the Delaware River as *Acipenser brevirostrum*. *Acipenser* (masculine noun) is an old word for sturgeon and *brevirostrum*, short snout, (neuter, 2nd declension, noun in apposition). This was correct. Article 30 of the Rules of Zoological Nomenclature states only a species-group name which is an adjective has to agree. Others, starting with Richardson (1836) and followed by Jordan et al. (1930) and Vladykov and Greeley (1963), changed the species designation to *brevirostris* (ablative, masculine noun) to obtain agreement. This was unnecessary.

1.2 Taxonomy

1.21 Affinities

Suprageneric

Kingdom Animalia
Phylum Chordata
Subphylum Vertebrata
Superclass Gnathostomata
Class Osteichthyes
Subclass Actinopterygii
Infraclass Chondrostei
Order Acipenseriformes
Family Acipenseridae
Subfamily Acipenserinae

Generic

Genus: *Acipenser* Linnaeus 1758
Ref: Systema naturae, ed. X, p. 237
Diagnostic characteristics:
Ref: Vladykov and Greeley 1963: Order Acipenseroidei. Mem. Sears Found. Mar. Res.

Body elongate and fusiform. Scutes in five rows: One dorsal, two lateral, two ventral; and scutes very sharp and strongly developed in young individuals, but becoming progressively blunter with age. Snout protruding, subconical. Mouth inferior, protractile. Teeth absent in adults. Barbels 4, in cross row anterior to mouth. Gills 4, and an accessory opercular gill. Gill rakers < 50, lanceolate. Gill membranes joined to isthmus, spiracles present,

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one branchiostegal (McAllister[6]). Opercle present, suboperculum present or absent. Head covered by bony plates separated by sutures, dermal skeleton without ganoine. Tail depressed, completely mailed, caudal fin with fulcra; tail heterocercal. Dorsal and anal fins behind ventrals. Air bladder large, simple, opening into oesophagus through a short, wide duct. Rectum with spiral valve. Anadromous and freshwater fishes of northern hemisphere; Upper Cretaceous to Recent, 16 species.

Specific

Key to North American, Atlantic coastal species of *Acipenser* (after Vladykov and Greeley 1963; Scott and Crossman 1973)

1a. Mouth width inside lips usually < 55% (range 43-66%) of interorbital width; interorbital width < 29% (range 22-36%) of head length (Fig. 1); average TL:FL = 1.14; gill rakers 17-27 ($\bar{X}$ = 21.6); postdorsal and preanal shields usually in pairs, usually 2-6 plates between anal base and lateral row of scutes (Fig. 2); dorsal plates generally touch or overlap; viscera pale; has fontanelle ....*Acipenser oxyrhynchus* Mitchill 1814

1b. Mouth width exceeds 62% (range 63-81%) of interorbital width; interorbital width usually exceeds 29% (range 29-40%) of head length (Fig. 1); average TL:FL = 1.12, gill rakers 22-40, postdorsal and preanal shields usually in single row, usually no plates between anal base and lateral scute row (Fig. 2); viscera blackish; no fontanelle 2

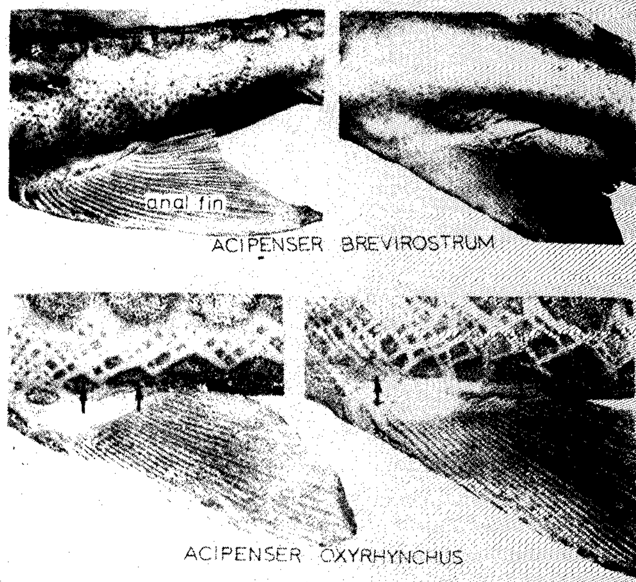

Figure 2.—Lateral view of shortnose sturgeon (above) and Atlantic sturgeon (below); note small bony plates (arrows) above the anal fin of the Atlantic sturgeon (from Gorham and McAllister 1974).

2a. Anal fin rays 25-30; insertion of anal fin behind insertion of dorsal fin; gill rakers 25-40 ($\bar{X}$ = 33.1); caudal peduncle long, tip of anal fin not reaching origin of caudal fin, lateral plates 29-42 ($\bar{X}$ = 35.4); interorbital width 29-35% of head length (adults); dorsal and lateral shields same color as background ....*Acipenser fulvescens* Rafinesque 1817

2b. Anal fin rays 19-22; insertion of anal fin opposite insertion of dorsal, gill rakers 22-29 ($\bar{X}$ = 25.4); caudal peduncle short, tip of anal fin reaching origin of caudal fin; lateral plates 22-33 ($\bar{X}$ = 28.3); interorbital width 34-40% ($\bar{X}$ = 37%) of head length; dorsal and lateral shields pale, contrasting with dark background....................*Acipenser brevirostrum* LeSueur 1818 (Fig.3)

Remarks on Identification. Among these three species, various characters change considerably with growth. Young have longer snouts than adults and their scutes (shields) are sharper and closer together. Mouth width is the best character for separating all sizes of shortnose sturgeon and Atlantic sturgeon including all larvae (Fig. 4) except prolarvae (Taubert and Dadswell 1980; Bath et al. 1981). The absence of plates between the lateral scutes and the anal fin is the best character for distinguishing dressed (headless) shortnose sturgeon, but occasionally Atlantic sturgeon also lack these plates (Squiers and Smith 1978[7]). Morphologically, shortnose sturgeon are quite variable. A complete gradation of morphs from sharp-plated, rough-skinned individuals to flat-plated, smooth-skinned shortnose sturgeon exist in the Saint John estuary (Dadswell, pers. obs.).

[6]D. E. McAllister, Curator of fishes, National Museum of Canada, Ottawa, Canada K1A 0M8, pers. commun. September 1979.

[7]Squiers, T. S., and M. Smith. 1978. Distribution and abundance of shortnose sturgeon and Atlantic sturgeon in the Kennebec River estuary. Prog. Rep. Project #AFC-19-1, Dep. Mar. Resour., Maine, 31 p.

Figure 1.—Ventral view of Atlantic sturgeon (left) and shortnose sturgeon (right); note short snout and wide mouth of the shortnose sturgeon.

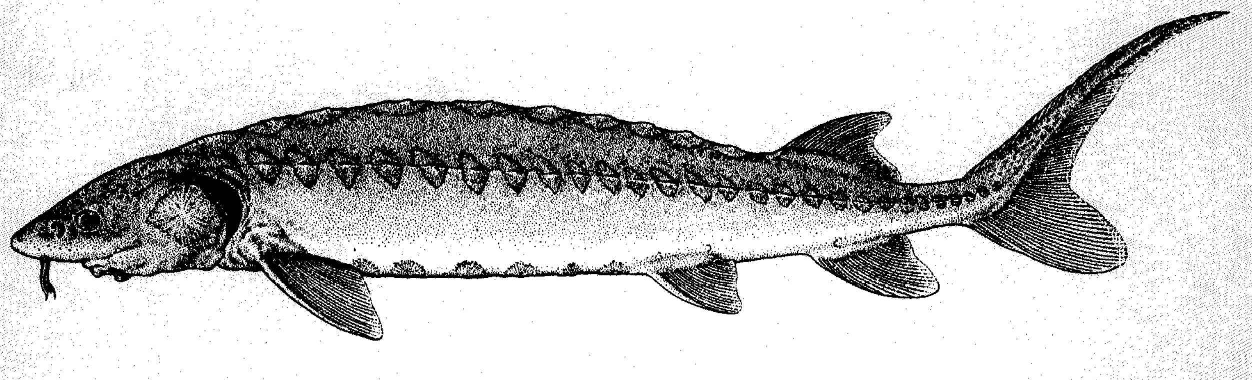

Figure 3.—*Acipenser brevirostrum*. Lateral view of spawning female (580 mm TL) from the Hudson River, N.Y. (after Vladykov and Greeley 1963).

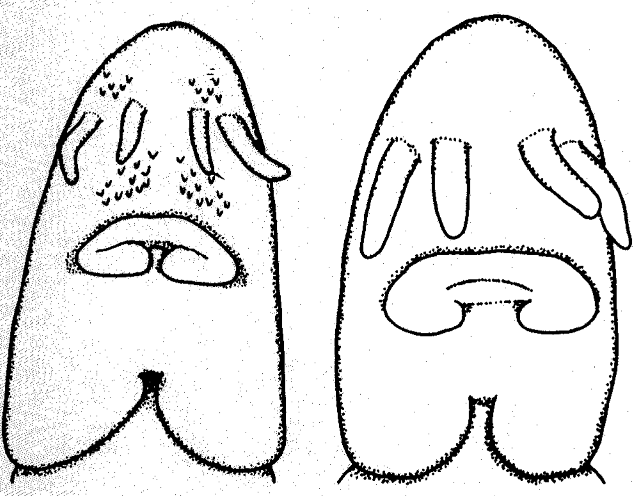

Figure 4.—Ventral view of heads of 17.0 mm larval *Acipenser oxyrhynchus* (left) and *A. brevirostrum* (right) from the Hudson River, N.Y., illustrating difference in mouth size and structure (after W. L. Dovel. 1979. The biology and management of shortnose and Atlantic sturgeon of the Hudson River. N.Y. Dep. Environ. Conserv. Rep. AFS9-R, 54 p.).

1.22 Taxonomic status

A morpho-species, not established by breeding data.

1.23 Subspecies

No subspecies described.

1.24 Standard common names, vernacular names

The standard common name is shortnose sturgeon (Robins et al. 1980). Vernacular names include shortnosed sturgeon, little sturgeon (Saint John River, N.B.), pinkster and roundnoser (Hudson River, N.Y.), bottlenose or mammose (Delaware River), salmon sturgeon (Carolinas), soft-shell or lake sturgeon (Altamaha River, Ga.).

1.3 Morphology

1.31 External morphology

Acipenser brevirostrum is distinguished by wide mouth, absence of a fontanelle, almost complete absence of the postdorsal shields, and by preanal shields usually arranged in a single row (paired preanals, Kennebec R., Squiers and Smith footnote 7).

Scutes in all five main rows not closely set, weakly developed in adults, sharp and close together in juveniles.

Dorsal scutes 7-13, lateral scutes 21-35, ventral scutes 6-11; scutes behind dorsal fin either in single row (75%) or paired (25%), enlarged supra-anal plates absent, double preanal scutes present (25%) or absent (75%); elongated fulcrum at base of lower caudal lobe shorter than base of anal fin (Table 1).

Head short, 22-28% of FL, snout short, blunt rounded (Fig. 3), 70% of postorbital length in adults, convex in side view but longer than postorbital length in young, sharp, triangular concave in side view; fontanelle absent; postorbital length in adults 51-61% (avg. 55%) of head length, but 33% in young; interorbital width 24-43% (avg. 37%) of head length, mouth width (excluding lips) 69-81% (avg. 74%) of interorbital width, no teeth; 4 barbels in front of mouth; gill rakers long, triangular, 23-32 (avg. 26) on first arch.

Fins: Single dorsal far back, above anal, trailing edge crescentic, 38-42 rays; caudal heterocercal, lower lobe long for sturgeon, no notch at tip of upper lobe, difference between TL and FL 11-12%; caudal peduncle short, tip of depressed anal reaching base of caudal fin; anal fin base about 60% of dorsal fin base, trailing edge emarginate, 18-24 rays; paired fins with heavy ossified first ray, pelvics abdominal, far back, pectoral large, pectoral girdle wider than head width; no lateral line.

Color: Body yellowish brown with green or purple cast in saltwater, to nearly black on head, back, and sides level to lateral plates, whitish to yellowish below. Young particularly yellowish in the Saint John River, Canada. Ventral surface and barbels white; all fins pigmented but paired fins outlined in white, scutes pale and obvious against dark background (Fig. 5). Young have melanistic (black) blotches (Fig. 6).

The skin of preserved specimens often acquires a greenish cast (Vladykov and Greeley 1963).

1.32 Cytomorphology

No data available.

Table 1.—Comparative morphometric and meristic data for adult *Acipenser brevirostrum*. TL = total length, MW = mouth width (inside lips), SL = snout length, IOW = interorbital width, POL = postorbital length, HL = head length, FL = fork length. In parentheses, juvenile data.

	Mean for river system					
	Saint John, Canada	Kennebec-Sheepscot	Connecticut	Hudson		Delaware
Character	Gorham and McAllister (1974)	Squiers and Smith (see text footnote 7) Fried and McCleave (1973)	Taubert (1980b)	Vladykov and Greeley (1963)	Hoff and Klauda (1979)[1]	Brundage and Meadows (1982)
MW/LS	0.60±0.08	0.71±0.09	71.6	—	0.58	0.71±0.10
MW/IOW	0.76±0.06	0.81±0.06	0.73	0.74 (same)	0.68	0.68±0.05
SL/HL	0.44±0.03	0.38±0.03		0.35	0.45	0.38±0.05
SL/POL	—	0.73±0.09		0.70 (1.83)	0.76	0.68±0.05
POL/HL	—	0.56±0.03		0.55 (0.33)	0.60	0.58±0.04
IOW/HL	—	0.34±0.03		0.37	0.39	0.39±0.01
HL/FL	—	0.20±0.01		0.22 (0.28)	0.19	0.21±0.02
TL/FL	1.2	1.11±0.02		1.1	1.1	
Gill rakers	27.6±2.5	26.2±0.03		25.5	25	
Anal rays	20.8±1.6	—		—	—	
Dorsal scutes	10.2±1.3	9.7±1.3	11.0	10	—	10.2±2.0
Ventral scutes	8.5±0.9	8.0±0.9	7.9	8	—	7.6±1.0
Lateral scutes	—	26.5±2.6	27.7	28	—	27.3±2.5

[1]Hoff, T. B., and R. J. Klauda. 1979. Data on shortnose sturgeon (*Acipenser brevirostrum*) collected incidentally from 1969 through June 1979 in sampling programs conducted for the Hudson River ecological study. Texas Instruments Inc., Buchanan, N.Y., MS Rep., 25 p.

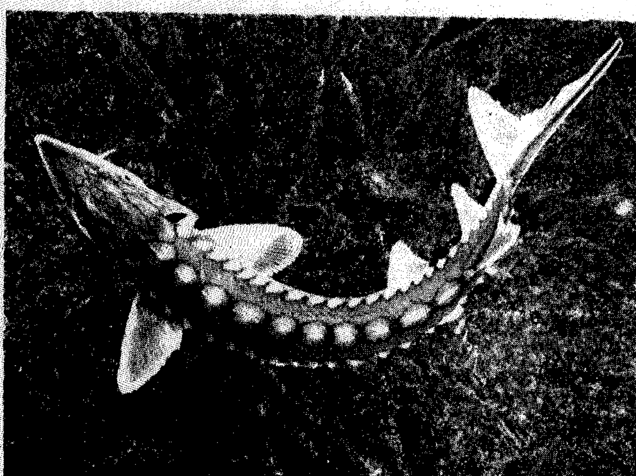

Figure 5.—*Acipenser brevirostrum*. Dorsal view of 430 mm FL juvenile from the Saint John River, Canada.

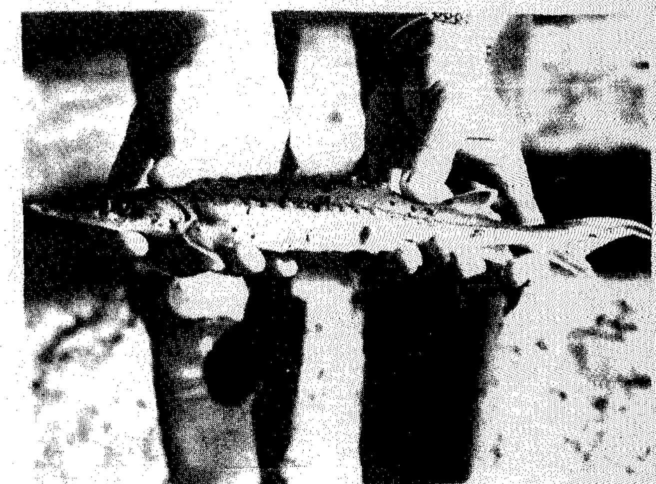

Figure 6.—*Acipenser brevirostrum*. Lateral view of juvenile from the Holyoke Pool, Connecticut River, showing sharp, closely set scutes and melanistic blotches.

1.33 Protein specificity

No data available.

1.34 Internal morphology

A considerable number of publications on the internal structure of sturgeon exist (Parker 1882; Jollie 1980), but little directly concerns shortnose sturgeon. Ryder (1890) illustrated the spiral valve, pyloric end of the stomach, and cartilaginous elements of the ventral fins of *A. brevirostrum*. Vladykov and Greeley (1963) described, but did not illustrate, other internal structures. Viscera is black and peritoneum pigmented.

2 DISTRIBUTION

2.1 Total area

Shortnose sturgeon are restricted to the east coast of North America (Vladykov and Greeley 1963). They have been recorded from the Saint John River, New Brunswick, Canada (Leim and Day 1959), to the Indian River, Fla. (Evermann and Bean 1898) (Fig. 7a, b). Since the species is considered endangered, a summary of occurrence records and catches is given in Table 2.

Throughout its range, shortnose sturgeon occur in rivers, estuaries, and the sea. The majority of populations have their greatest abundance in the estuary of their respective river. All captures at sea have occurred within a few miles of land (Schaefer 1967; Holland and Yelverton 1973; Wilk and Silverman 1976; Marchette and Smiley 1982 see Table 2, footnote 24). Partially landlocked populations are known from the Holyoke Pool section of the Connecticut River (Taubert 1980a) and the Lake Marion-Moultrie system South Carolina (Marchette and Smiley 1982 see Table 2, footnote 24).

This species has no known fossil record.

2.2 Differential distribution

2.21 Spawn, larvae and juveniles

The species is anadromous (Dadswell 1979) but can be landlocked (Taubert 1980a; Marchette and Smiley 1982 see Table 2, footnote 24). The young are hatched in freshwater usually above tidal influence. Ripe adults have been captured as far upstream as rkm (river kilometer) 186 in the Altamaha River, Ga. (Heidt and Gilbert 1978 see Table 2, footnote 27), rkm 198 on the Pee Dee River, S.C. (Marchette and Smiley 1982 see Table 2, footnote 24), rkm 222 in the Delaware River (Hoff 1965), rkm 246 in the Hudson River (Dovel 1981 see Table 2, footnote 15), and adults, eggs, and larvae have been taken at rkm 190 in the Connecticut River (Taubert 1980a).

Eggs are demersal and adhesive (Meehan 1910). Juveniles may remain inland of saline water until 45 cm FL. That length is attained between 2 and 8 yr of age depending on the geographical location of the population. Larvae and juveniles are benthic and occupy the deep channel areas of rivers where currents are strong (Dadswell 1979; Taubert 1980a).

2.22 Adults

Once shortnose sturgeon attain adult size (45-50 cm), they commence migratory behavior, travelling downstream in fall and upstream in spring (Dadswell 1979; Dovel 1981; Marchette and Smiley 1982 see Table 2, footnote 24; Buckley 1982). An unknown portion of most populations appear to move short distances to sea (Bigelow and Schroeder 1953; Schaefer 1967; Holland and Yelverton 1973; Wilk and Silverman 1976; Dadswell 1979). Each fall, in some of the large rivers (Hudson, Connecticut, Saint John), a portion of the adults which will spawn the following spring migrate upstream to deep, overwintering sites adjacent to the spawning grounds (Greeley 1935; Dadswell 1979; Dovel 1981 see Table 2, footnote 15; Buckley 1982). Males apparently lead the upstream migration (Pekovitch 1979 see Table 2, footnote 14; Dovel 1981 see Table 2, footnote 15; Dadswell, unpubl. data). Some ripening and most nonripening adults spend the winter in deep, saline sites (Fig. 8) (Dovel 1978 see Table 2, footnote 13; Dadswell 1979; Marchette and Smiley 1982 see Table 2, footnote 24). On the other hand, mass migrations were not noted in the Holyoke Pool population (Taubert 1980b), and some nonripening adults in most rivers remain in freshwater, do not concentrate, and may be active all winter (Dadswell 1979; Buckley 1982).

2.3 Determinants of distribution changes

2.31 Temperature

The preferred temperature range and upper and lower lethal temperatures for shortnose sturgeon are unknown.

Spring spawning migrations from overwintering sites or arrival on the spawning grounds occurs at temperatures of 8°-9°C (Dovel 1978 see Table 2, footnote 13; Squiers 1982 see Table 2, footnote 4). In the northern part of its range, shortnose sturgeon are seldom found in shallow water once temperature exceeds 22°C (Dadswell 1975;[8] Dovel 1978 see Table 2, footnote 13). In the Saint John River, Canada, surface temperatures over 21°C appeared to stimulate movement to deeper water. Heidt and Gilbert (1978 see Table 2, footnote 27), however, found shortnose sturgeon in the lower Altamaha River in June at water temperatures of 34°C and in the lower Connecticut River they were frequently captured in < 1 m of water at 27°-30°C (Buckley[9]).

Dadswell (1979) and Marchette and Smiley (1982 see Table 2, footnote 24) found a 2°-3°C decline in temperature during fall stimulated downstream migration. In the Saint John River, Canada, they overwinter in regions with temperatures between 0° and 13°C. In Winyah Bay, S.C., overwintering sites have temperatures of 5°-10°C (Marchette and Smiley 1982 see Table 2, footnote 24).

2.32 Current

Juveniles appear to prefer living in deep channel regions (Table 3) with strong currents (15-40 cm/s) (Pottle and Dadswell 1979 see Table 2, footnote 1). During summer, adults are generally found in regions of little or no current (McCleave et al. 1977; Dadswell 1979; Taubert 1980b).

2.33 Waves

No data.

2.34 Depth

See 2.22 and 2.31. Pottle and Dadswell (1979 see Table 2, footnote 1) found juveniles occupied depths in excess of 9 m in river channels. Trawling surveys in the Hudson River indicate a similar situation there (Dovel 1978 see Table 2, footnote 13; Hoff et al. 1977 see Table 2, footnote 12). Adults are found in shallow water in summer (2-10 m) (Dadswell 1979; Dovel 1981 see Table 2, footnote 15; Marchette and Smiley 1982 see Table 2, footnote 24) and in deep water in winter (10-30 m) (Dadswell 1979; Dovel 1981 see Table 2, footnote 15; Marchette and Smiley 1982 see Table 2, footnote 24).

2.35 Light

Light appears to be important in the biology of shortnose sturgeon but is still largely unassessed. Gilbert and Heidt (1979) found, although nets were fished during daylight and darkness, all shortnose sturgeon were caught during darkness. During radio tracking studies, they found tagged sturgeon remained more or less stationary in deep water during daylight but at night they moved into shallow water or extensively up- or down-stream.

[8]Dadswell, M. J. 1975. Biology of the shortnose sturgeon (*Acipenser brevirostrum*) in the Saint John estuary, New Brunswick, Canada. *In* Baseline survey and living resource potential study of the Saint John estuary, Vol. III Fish and fisheries, 75 p. Huntsman Marine Laboratory, St. Andrews, N.B.

[9]J. Buckley, Graduate Student, Massachusetts Cooperative Fishery Research Unit, Department of Forestry and Wildlife, University of Massachusetts, Amherst, MA 01002, pers. commun. February 1982.

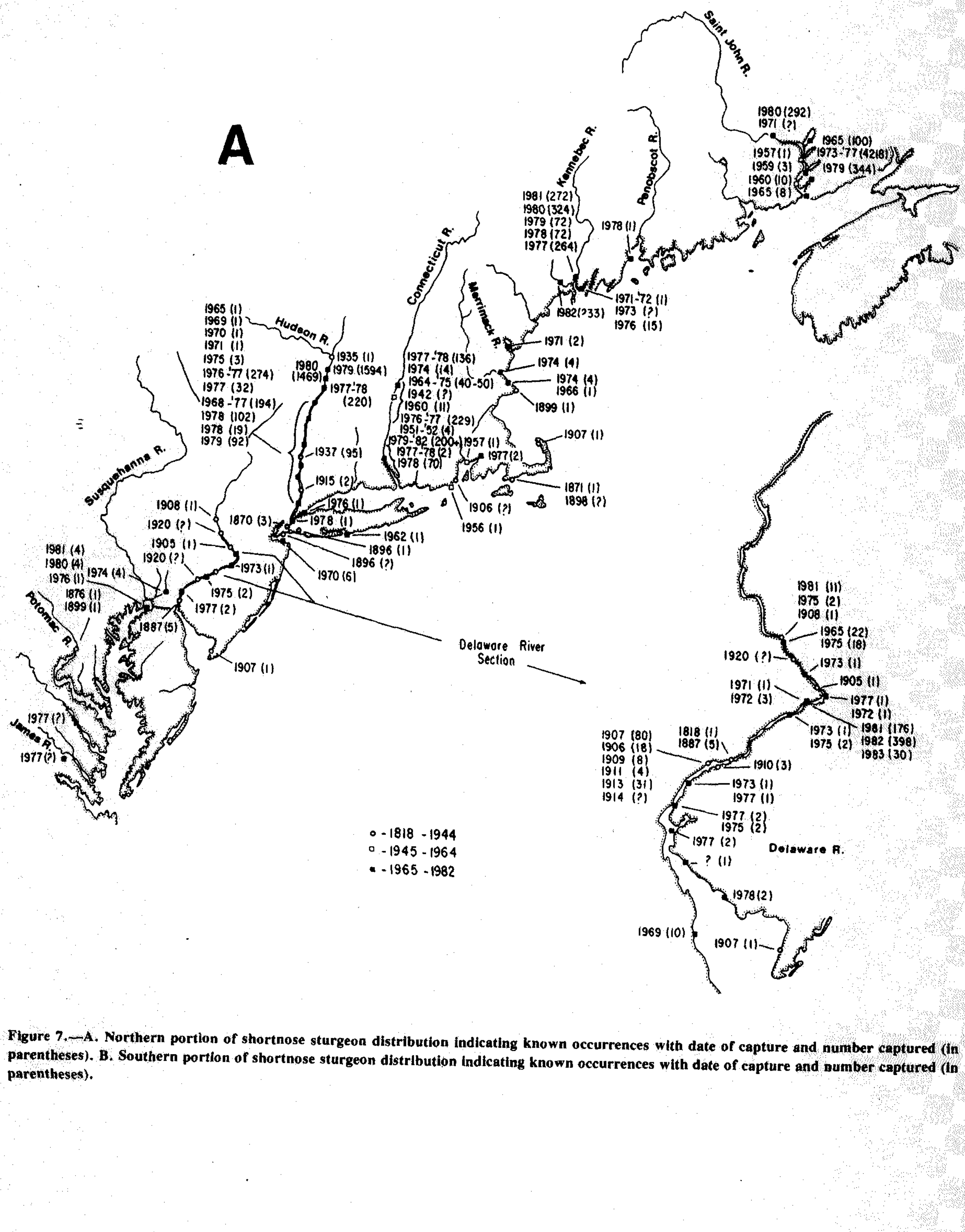

Figure 7.—A. Northern portion of shortnose sturgeon distribution indicating known occurrences with date of capture and number captured (in parentheses). B. Southern portion of shortnose sturgeon distribution indicating known occurrences with date of capture and number captured (in parentheses).

2.36 Turbidity

No data. Dadswell (pers. obs.) observed that catches of shortnose sturgeon in both invisible monofilament and heavy duty, multifilament gill nets increase appreciably on windy days when the water is more turbid than usual. This suggests shortnose sturgeon are more active under lowered light conditions, or such conditions as have been documented by Gilbert and Heidt (1979).

2.37 Substratum

Dadswell (1979) noted that foraging grounds of shortnose sturgeon in freshwater are over shallow, muddy bottoms with abundant macrophytes and foraging grounds in saline waters were over gravel-silt bottoms 5-15 m deep. Marchette and Smiley (1982 see Table 2, footnote 24) found shortnose sturgeon among macrophytes over sandy bottom in summer and over mud bottom in

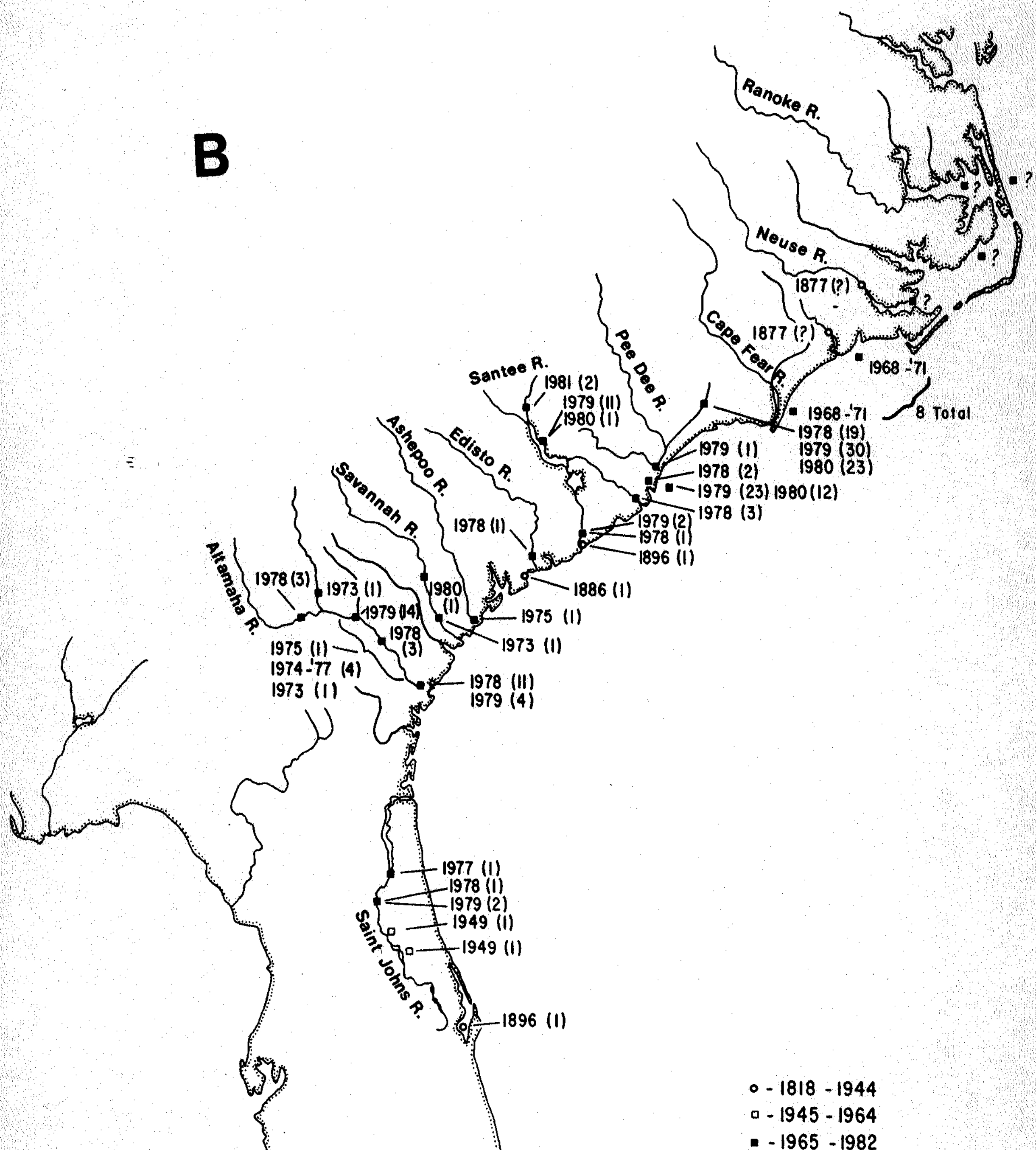

Figure 7.—*Continued.*

Table 2.—Occurrence and number captured of shortnose sturgeon collected on the east coast of North America since 1818.

Locality	Date	Number caught	Source
NEW BRUNSWICK, CANADA			
Saint John River	1957	1	Leim and Day (1959)
	1959	3	Vladykov and Greeley (1963)
	1960	10	Magnin (1963)
	1965	8	Gorham (1965)
	1971	99	Meth (1973)
	1971	45	Gorham (1971)
	1974	32	Gorham and McAllister (1974)
	1973-77	4,218	Dadswell (1979)
	1976	11	Appy and Dadswell (1978)
	1979	2 larvae, 300 juveniles, 42 adults	Pottle and Dadswell (1979)[1]
	1980	292	Anonymous (1980)[2]
MAINE			
Sheepscot Estuary	1971-73	31	Fried and McCleave (1973)
Montsweag Bay	1973	3	Fried and McCleave (1974)
	1976	15	McCleave et al. (1977)
Kennebec River-Montsweag Bay	1977	264	Squiers and Smith (see text footnote 7)
	1978	72	
	1979	72	Squiers et al. (1981)[3]
Montsweag Bay and Androscoggin River	1980	324	
	1981	272	Squiers (1982)[4]
	1982	233	
Penobscot River	1978	1	Squiers[5]
NEW HAMPSHIRE			
Piscataqua River	1971	1	Spurr[6]
Gulf of Maine	1971	1	
MASSACHUSETTS			
Provincetown	1907	1	Bigelow and Schroeder (1953)
Waquoit	?	1	
Rockport	?	1	Goode and Bean (1879) (unconfirmed)
Woods Hole	1871	1	Baird (1873)
	1898	?	Bumpus (1898)
Merrimack River	1949	1	McLaughlin[7]
	1974	4	
Parker River	1972	1	Rideout[8]
Holyoke Pool	1942	100+	McCabe (1942) (in fish markets)
Connecticut River	1964-75	40-50 +8 juveniles	Student collections, U. Mass., Amherst, Mass.
	1974	14	Texas Instruments (1975)[9]
	1976-77	229	Taubert (1980b)
	1977-78	13 larvae	
RHODE ISLAND			
Point Judith	1956	1	Gordon (1960)
Narragansett Bay	1957	1	Gordon (1960) (unconfirmed)
CONNECTICUT			
Lower Connecticut River	1951-52	4	Vladykov and Greeley (1963)
	1977-78	5	Taubert[10]
	1978	70	Reed and Buckley (1978)[11]
	1979	1	Impinged, Haddam Neck
	1979	71	Buckley (1982)
	1980	32	
	1981	22	
	1982	166	
NEW YORK			
Fire Island	1962	1	Schaefer (1967)
Hudson River	1870	3	Duméril (1870) (in Paris museum)
Hudson River (Gravesend Bay)	1896	1	Bean (1897)
Hudson River	1915	2	MacCallum (1921)
Hudson River (Albany)	1935	1	Greeley (1935)
Hudson River	1936	95	Greeley (1937); Curran and Ries (1937)
	1965	1	Boyle (1960)
	1969	1	

Table 2.—*Continued.*

Locality	Date	Number caught	Source
Hudson River	1969	1	Atz and Smith (1976)
	1970	1	Koski et al. (1971)
	1971	1	Raytheon Inc.
	1969-77	194	Hoff et al. (1977)[12]
	1975	3	Brundage and Meadows (1982)
	1976-77	274 (9 yoy & juveniles)	Dovel (1978)[13]
	1977	32 (4 larvae) (19 yoy)	Nalco Environmental Sciences
	1978	106	Texas Instruments, ESA Permit E20
	1978	174	Dovel, ESA Permit E11
	1979	1,594 (2 larvae) (10 yoy)	Pekovitch (1979)[14]
	1979	92	Texas Instruments, ESA Permit E20
	1980	1,469	Dovel (1981)[15]
NEW JERSEY			
Sandy Hook Bay	1970	6	Wilk and Silverman (1976)
Bay at Green Creek	1907	1	Vladykov and Greeley (1963)
Cape May Co., Delaware River	1817	1	LeSueur (1818) (type specimen)
Delaware River	1887	5	Ryder (1890)
	Apr. 1906	18	Meehan (1910)
Torresdale, Phil Co.		(4 ♀ ripe, 2 ♂)	
	1907	80-90	Meehan (1910) (50% ♂)
	1909	8	Meehan (1910) (2 ♀, 6 ♂)
	1911	4	Vladykov and Greeley (1963)
	1913	3	
Trenton	1905	1	Fowler (1905)
Delaware River	?	3	Fowler (1910)
Bristol, Bucks Co.	1908	1	Fowler (1912)
Delaware River	?	?	Fowler (1920)
Burlington Co., Mercer Co., Gloucester Co.	1914	?	Smith (1915) (commercial catch)
Scudders Falls	1954	2(20 seen)	Hoff (1965)
	1983 (Apr./May)	15	Brundage (unpubl. data)
Little Ck., Del.	1969	10	Carl Baren[16]
Rm 28	1969	1	
Lambertville	1972	2	
Rm 102-124	1973	1	
Rm 52-69	1975	2	
Rm 149	1977	1	
Rm 61	1977	1	
Trenton	1977	2	
Delaware Memorial Bridge			
Delaware River	1973	1	Miller et al. (1973)
Burlington Co.	1975	2	Martin Marietta Corp. (1976)[17]
Salem Nuclear Generating Station	1978	2	Masnik and Wilson (1980)
	1981	1	Brundage (unpubl. data)
Artificial Island	1979	2	Brundage and Meadows (1982)
Edgewater Park			
Rm 115	1982	1	Brundage (unpubl. data)
Lambertville	1981	11	Lupine[18]
Trenton, Delaware	1981	176	Hastings (1983)[19]
	1982	398	
	1983	30	
Newbold Island	1971	3	Anselmini (1976)
Mercer Zone	1972	3	Anselmini (1974)
MARYLAND			
Still Pond Neck	1976	1	Miller[20]
Upper Chesapeake			
Elk River	1978	4	S. Bristo
Upper Chesapeake Bay			
Susquahanna Flats	1980	4	Saul[21]
	1981	4	Hogan[22]

Table 2.—*Continued.*

Locality	Date	Number caught	Source
Potomac River	1876	1	Uhler and Lugger (1876)
	1899	?	Smith and Bean (1899)
ATLANTIC OCEAN			
Cape Henry, Va.			
to Cape Fear, N.C.	1968-71	8	Holland and Yelverton (1973)
NORTH CAROLINA			
Salmon Creek	?	1	Vladykov and Greeley (1963) (NSNM 64330)
Beaufort	1886	?	Jordan (1886)
North, New, and Neuse Rivers	1877	abundant?	Yarrow (1877)
Ashepoo River	1970	1	Anderson[23]
SOUTH CAROLINA			
Charleston	1896	1	Jordan and Evermann (1896)
South Santee River	1978	3	Marchette and Smiley (1982)[24]
South Edisto River	1978	1	
	1979	2	
Atlantic Ocean	1980	2	
Pee Dee River	1982	3	
Waccamaw River-			
Winyah Bay	1978	20	
	1979	39	
	1980	37	
	1981	39	
	1982	3	
(running-ripe male 1st wk April)			
Charlestown Harbour	1978	1	
Lake Marion-			
Wateree River	1979	11	
	1980	1	
	1981	1	
GEORGIA			
Lower Savannah River	1975	1	Smith[25]
	1979	3	Recovery Team Shad Fishery Survey 1979
	1980	1	Marchette (unpubl. data)
Lower Ogeechee River	1973	1	Smith (footnote 25)
Altamaha River	1975	?	Dahlberg (1975)
	1974-77	8	Adams[26]
	1978	16	Heidt and Gilbert (1978)[27]
	1979	18	Gilbert and Heidt (1979)
	1979	1	Recovery Team Shad Fishery Survey 1979
Ocumulgee River (16 mi from fork)	1978	3	Heidt and Gilbert (1978)
FLORIDA			
Big Lake George	1949	1	Kilby et al. (1959)
Saint Johns River			
Lake Crescent	1949	1	Moody[28]
Murphy Creek	1977	1	
Saint Johns River			
Welaka	1978	1	
Cedar Ck.	1979	1	
Clay/Putnam Co. Line	1979	1	

[1]Pottle, R., and M. J. Dadswell. 1979. Studies on larval and juvenile shortnose sturgeon. Rep. to N.E. Utilities, Hartford, Conn., 87 p.

[2]Anonymous. 1980. Studies on the early life history of the shortnose sturgeon, (*Acipenser brevirostrum*). Washburn and Gillis Assoc. Ltd., Fredericton, N.B., Canada, 119 p.

[3]Squiers, T. S., M. Smith, and L. Flagg. 1981. American shad enhancement and status of sturgeon stocks in selected Maine waters. Completion Report, Dep. Mar. Resour. Maine Proj. AFC-20, p. 20-64.

[4]Squiers, T. S. 1982. Evaluation of the 1982 spawning run of shortnose sturgeon (*Acipenser brevirostrum*) in the Androscoggin River, Maine. MS Rep., Dep. Mar. Resour., Maine, 14 p.

[5]T. S. Squiers, Fisheries Biologist, Maine Department of Marine Resources, Augusta, ME 04333, pers. commun. June 1979.

[6]E. W. Spurr, New Hampshire Fish and Game, Portsmouth, NH 03891, pers. commun. June 1977.

[7]C. L. McLaughlin, Jr., Assistant Aquatic Biologist, Massachusetts Fish and Game, Westboro, MA 01581, pers. commun.

[8]S. Rideout, Massachusetts Fish and Game, Westboro, MA 01581, pers. commun. June 1977.

[9]Texas Instruments Inc. 1975. Connecticut River ecological survey of the aquatic biology and water quality. Survey of the Montague, Massachusetts, study area. May-December 1974. Prepared for Northeast Utilities Service Co., April.

[10]B. D. Taubert, University of Massachusetts, Amherst, Mass., pers. commun. May 1979.

[11]Reed, R. J., and J. Buckley. 1978. Survey of the Connecticut River for shortnose sturgeon, *Acipenser brevirostrum*, below the Holyoke Dam, Holyoke, Massachusetts. Report to Northeast Utilities, Massachusetts Cooperative Fisheries Unit, 3 p.

[12]Hoff, T. B., R. J. Klauda, and B. S. Belding. 1977. Data on distribution and incidental catch of shortnose sturgeon (*Acipenser brevirostrum*) in the Hudson River estuary 1969 to present. Texas Instruments Inc., Buchanan, N.Y., MS Rep., 21 p.

[13]Dovel, W. L. 1978. Sturgeons of the Hudson River, New York. Final Performance Rep. for N.Y. Dep. Environ. Conserv., 181 p.

[14]Pekovitch, A. W. 1979. Distribution and some life history aspects of the shortnose sturgeon (*Acipenser brevirostrum*) in the upper Hudson River estuary. Hazelton Environ. Sci. Corp., Ill., 23 p.

[15]Dovel, W. L. 1981. The endangered shortnose sturgeon of the Hudson estuary: Its life history and vulnerability to the activities of man. The Oceanic Society. FERC Contract No. DE-AC 39-79 RC-10074.

[16]C. F. Baren, Project Leader, U.S. Fish and Wildlife Service, Delaware River Basin Anadromous Fishery Project, P.O. Box 95, Rosemount, NJ 08556, pers. commun. June 1977.

[17]Martin Marietta Corp. 1976. Monitoring fish migration in the Delaware River. Final Report. March 1976, 86 p.

[18]A. Lupine, Biologist, New Jersey Fish and Game, Rosemount, NJ 08556, pers. commun. April 1982.

[19]Hastings, R. W. 1983. A study of the shortnose sturgeon (*Acipenser brevirostrum*) population in the upper tidal Delaware River; assessment of impacts of maintenance dredging. Draft Rep. U.S. Corp. Engineers, Philadelphia Dist., 132 p.

[20]P. Miller, Chesapeake Bay Institute, The Johns Hopkins University, Baltimore, MD 21218, pers. commun. January 1978.

[21]W. G. Saul, Collection Manager, Department of Ichthyology, The Academy of Natural Sciences, Philadelphia, PA 19103, pers. commun. July 1977.

[22]W. Hogan, Biologist, Maryland Tidewater Commission, Annapolis, Md., pers. commun. April 1981.

[23]W. D. Anderson, Grice Marine Biological Laboratory, 205 Fort Johnson, Charleston, SC 29412, pers. commun. June 1977.

[24]Marchette, D. E., and R. Smiley. 1982. Biology and life history of incidentally captured shortnose sturgeon, *Acipenser brevirostrum* in South Carolina. S.C. Wildl. Mar. Res. unpubl. ms, 57 p.

[25]L. Smith, Department of Natural Resources, Fisheries Management, Box 219, Richmond Hill, GA 31324, pers. commun. July 1977.

[26]J. G. Adams, Senior Biologist, Georgia Power Company, Atlanta, Ga., pers. commun. August 1977.

[27]Heidt, A. R., and R. J. Gilbert. 1978. The shortnose sturgeon in the Altamaha River drainage, Georgia. MS Rep., Contract 03-7-043-35-165, NMFS, 16 p.

[28]H. L. Moody, Project Leader Lower St. John's River Fishery Project, Florida Game and Freshwater Fisheries Commission, P.O. Box 1903, Eustis, FL 32726, pers. commun. May 1977.

winter. Recent experiments (Pottle and Dadswell 1979 see Table 2, footnote 1) indicate juveniles prefer a sand or gravel substratum.

In contrast, shortnose sturgeon were not found in vegetated backwater regions of the Holyoke Pool. The preferred habitat for this population was riverine and nonvegetated (Taubert 1980b). During summer, adults in the lower Connecticut River were encountered most often over sand substrates (Buckley footnote 9).

2.38 Shelter

No data.

2.39 Ice

No data.

2.310 Dissolved gases

No data.

2.311 Dissolved (inorganic) solids

Dadswell (1975, 1979) described shortnose sturgeon in the Saint John estuary, Canada, as concentrated in the 1-3 $^0/_{00}$ salinity zone but occurring throughout the estuary from freshwater of 70 μ ohm conductance to saltwater of 29 $^0/_{00}$ (Fig. 8a). Marchette and Smiley (1982 see Table 2, footnote 24) found the summer concentration zone was in the 0.5-1.0 $^0/_{00}$ zone of the Winyah Bay complex (Fig. 8b). In the Saint John River, Canada, an annual upstream migration of the shortnose sturgeon effectively maintains the population in the 1-3 $^0/_{00}$ salinity range during summer and Marchette and Smiley (1982 see Table 2, footnote 24) observed similar behavior in Winyah Bay, S.C. Shortnose sturgeon have been reported from coastal water of 27 $^0/_{00}$ (Wilk and Silverman 1976), 30 $^0/_{00}$ (Squiers and Smith footnote 7), and 30-31 $^0/_{00}$ (Holland and Yelverton 1973; Marchette and Smiley 1982 see Table 2, footnote 24). Taubert (1980b) described a population in the Holyoke Pool of the Connecticut River of which a majority apparently remains in and completes its entire life cycle in freshwater.

2.312 Pollutants

No data.

2.313 Vegetation

Dadswell (footnote 8, 1979) and Dovel (1978 see Table 2, footnote 13) found shortnose sturgeon adults were abundant among rooted macrophytes in 2-5 m depths during summer. Dadswell (1979) attributed this occurrence to an abundance of preferred prey (small gastropods) on the bottom and on the stems and leaves of the macrophytes. Marchette and Smiley (1982 see Table 2, footnote 24) observed shortnose sturgeon swimming upside down at night feeding off snails on the undersides of lily pads (*Nuphar luteum*).

2.314 Fauna

Appy and Dadswell (1978) and Dadswell (1979) noted that adult shortnose and juvenile Atlantic sturgeon tend to segregate themselves in the Saint John estuary, the Atlantic sturgeon dominating in more saline water. A salinity of 3 $^0/_{00}$ appeared to be the boundary across which the distributions of the two species diffuse. Pottle and Dadswell (1979 see Table 2, footnote 1) observed that young Atlantic sturgeon (0+–3+ yr) were intermixed with juvenile shortnose sturgeon in the upper Saint John River estuary. Marchette and Smiley (1982 see Table 2, footnote

24) found that juvenile Atlantic sturgeon were mixed with adult shortnose sturgeon but outnumbered them 2:1 in Winyah Bay, S.C.

2.4 Hybridization

No natural hybrids of shortnose sturgeon with other acipenserids have been reported to date, although one suspected hybrid with an Atlantic sturgeon was captured from the Saint John River, Canada (McAllister [10]), and four suspected hybrids were captured in Winyah Bay, S.C. (Marchette [11]).

3 BIONOMICS AND LIFE HISTORY

3.1 Reproduction

3.11 Sexuality

The species is normally heterosexual.

Atz and Smith (1976) described a shortnose sturgeon from the Hudson River with a gonad containing intermingled testicular and ovarian tissue. One ovatestis contained small, cystlike structures consisting of disorganized tissues including cartilage, bone, blood vessels, gut epithelium, and connective tissue which was attributed to abnormal development of a parthenogenetic or self-fertilized egg.

Sexual dimorphism

Little sexual dimorphism is exhibited by this species. Adult females are generally larger than adult males of the same age and gravid females are distinct in spring because of their swollen appearance (Dadswell 1979). Males and females can be reliably distinguished externally only during the final stages before spawning; males by abdominal pressure which causes milt to flow (possible only during the final 2-3 d), and females because the black eggs are apparent through the abdomen (during a 3-mo period, March-May in the north, January to March in the south).

3.12 Maturity

Age of first maturation of males varies from south to north, possibly occurring at 2-3 yr in Georgia, at age 3-5 yr from South Carolina to New York, and increasing northward to 10 or 11 yr in the Saint John River, Canada (Table 4). Females exhibit a similar south-north trend, maturing at age 6 or younger in Georgia, age 6-7 from South Carolina to New York, and age 13 in the Saint John River, N.B. Sexual differentiation is possible 1-2 yr younger

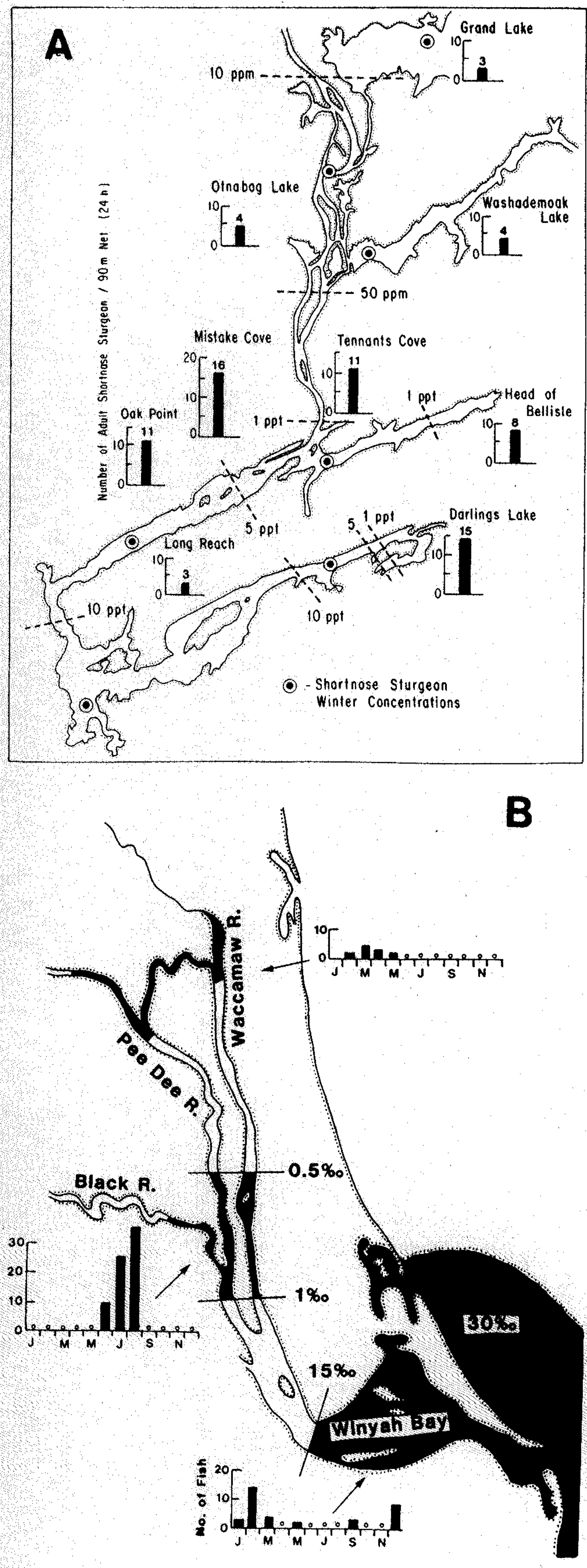

Figure 8.—A. Average June-August abundance of shortnose sturgeon in gill net catches in the Saint John estuary, Canada, as related to surface salinities. Winter concentration sites are those discovered to date. B. Location of known summer concentrations and overwintering sites in the Winyah Bay-Pee Dee River complex, S.C. Isohalines of salinity are approximate summer limits.

[10] D. E. McAllister, Curator of fishes, National Museum of Canada, Ottawa, Canada K1A 0M8, pers. commun. May 1977.

[11] D. E. Marchette, Fisheries Biologist, South Carolina Wildlife and Marine Resources, Charleston, SC 29412, pers. commun. February 1982.

Table 3.—Percent, number, and mean length of shortnose sturgeon <45 cm and >45 cm in gill net catches in relation to capture site in the Saint John estuary, Canada. Mesh size range was 2.5-20.2 cm stretched. Habitat type was riverine (r) or lacustrine (l). Distance upstream is river kilometer from Saint John Harbour on the Bay of Fundy.

Locality	Type	Distance (rkm)	Depth (m)	Samples	Catch n(<45 cm)	Catch %	Mean length (cm) <45	Mean length (cm) >45
Milkish Cove	r	5	4	3	1	1.6	41.0	83.2
Westfield	r	15	5	2	3	16.6	44.0	61.7
Oak Point (June)	r	35	15	1	8	32.0	26.6	66.9
Oak Point (fall)	r	35	15	3	12	8.6	41.5	70.1
Evandale	r	45	18	3	48	91.3	37.1	50.0
Belleisle	l	45	13	2	5	9.7	39.0	82.3
Wickham	r	55	12	1	6	42.8	34.8	50.9
Washademoak	l	60	20	3	15	26.4	40.6	83.9
Gagetown	r	70	12	3	38	82.2	40.5	55.5
Oromocto[1,2]	r	90	10	1	7	58.0	31.4	49.4
Grand Lake[2]	l	90	20	4	3	21.0	24.2	60.2

[1]F. F. Meth, Biologist, Environmental Protection Service, Department of Environment, Halifax, Canada, pers. commun. August 1976.
[2]New Brunswick Fish and Game, Head Office, Fredericton, N.B., pers. commun. August 1976.

Table 4.—Age and size at first maturation and first spawning of shortnose sturgeon in various river systems.

Locality	Males Age	Males FL (cm)	Females Age	Females FL (cm)	Authority
			First maturation		
Saint John, Canada	11	50.0	13.0	58.0	Dadswell (1979)
Hudson	3-4	40.0	—	—	Greeley (1937); Pekovitch (see Table 2, footnote 14)
Delaware		50.0		58.8	Hoff (1965); Hastings (see Table 2, footnote 19)
Pee Dee	—	43.4	—	44.4	Marchette and Smiley (see Table 2, footnote 24)
Altamaha	2-3	58.6	6	72.2	Heidt and Gilbert (see Table 2, footnote 27)
			First spawning		
Saint John, Canada	11	54.0	15	66.0	Dadswell (1979)
Holyoke Poole Connecticut	8	57.0	9	52.0	Taubert (1980b)
Lower Connecticut	10		15		Buckley (1982)
Hudson	3-4	44.5	6-8	51.5	Greeley (1937)
Delaware	—	50.0	7-10	61.2	Hoff (1965); Hastings (see Table 2, footnote 19)
Pee Dee	5	53.0	7	56.5	Marchette and Smiley (see Table 2, footnote 24)
Altamaha	2-3	58.6	6	72.2	Heidt and Gilbert (see Table 2, footnote 27)

than the above. Dadswell (1979) found 50% maturity in the Saint John River occurred at 12.4 yr for males and 17.2 yr for females (Fig. 9).

Length at maturity for this species is similar throughout its range, occurring between 45 and 55 cm FL for both males and females (Table 4).

First spawning

First spawning in males occurs 1-2 yr after maturity, but among females is delayed for up to 5 yr (Dadswell 1979; Fig. 9). Approximate female age at first spawning in the Saint John River, Canada, is 15 yr, the Hudson-Delaware Rivers 7-10 yr, and the Altamaha, 6 yr or less (Table 4). Size of males at first spawning is

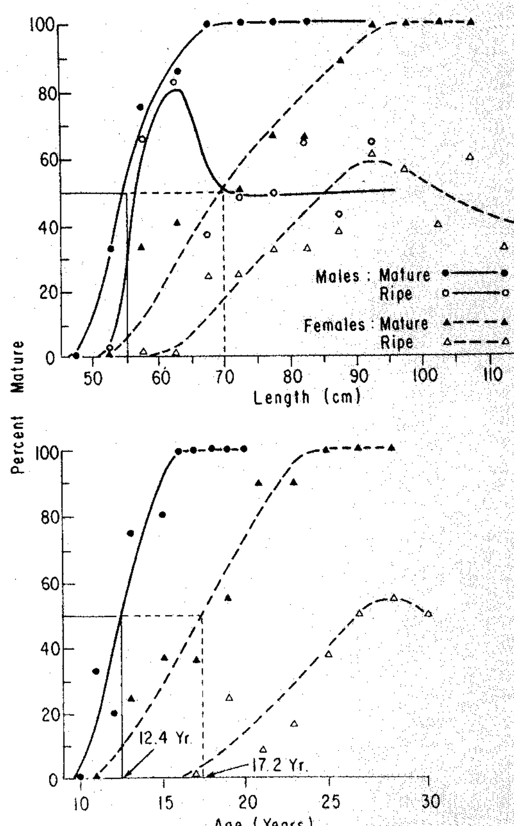

Figure 9.—Maturity ogives indicating length and age at 50% maturity for male and female shortnose sturgeon from the Saint John River, Canada, and incidence of ripening adults (stages III-V) among those mature. Length-maturity data treated in 5 cm increments for both sexes; and age-maturity in 2-yr increments for females and 1-yr increments for males.

44 to 55 cm FL and of females 50 to 70 cm FL. Taubert (1980b) found the first spawning of males in the Holyoke Pool was 8-12 yr old ($\bar{X}$ = 9.8) and of females 9-14 yr or 52 to 67 cm FL. Marchette and Smiley (1982 see Table 2, footnote 24) found mean age of first spawning of males in South Carolina was 5-10 yr ($\bar{X}$ = 7.5)

and of females 7-14 yr ($\bar{X}$ = 10.5).

3.13 Mating

Little is known of spawning behavior. Dovel (1981 see Table 2, footnote 15) found that the entire spawning population in the Hudson River moved upstream "en masse" from the overwintering site to the spawning site during the spring spawning run. Observations in the Saint John River, Canada, Connecticut River, and the Hudson River during each of 1977 through 1982 spawning periods indicated the entire spawning population was confined to a short reach of the river (1-2 km) (Taubert 1980a; Anonymous 1980 see Table 2, footnote 2). In the lower Connecticut River below Holyoke Dam (rkm 139), spawning occurred over a short period of 2-5 d in a very small area 6,000 m long (Buckley 1982). Telemetry and gill net captures indicated spawners were in the deepest available areas (6 m).

Washburn and Gillis Associates (Anonymous 1980 see Table 2, footnote 2) and Buckley and Kynard (1981) found single females captured in gill nets on the spawning grounds were often surrounded by numerous males in the same region of the net. Dadswell (1979) found that sequentially tagged shortnose sturgeon had a tendency to be recaptured together. The probability of this occurrence at random was calculated to be 1.88×10^{-24} and is highly unlikely. There is no proof, however, that this possible "pair bonding" is carried over to the spawning act, nor is it known whether the "pairs" consist of one of each sex.

3.14 Fertilization

Fertilization is probably external as in all other Acipenseridae (Ginsburg and Dettlaf 1969). Fertilization rates in nature are unknown. Meehan (1910) reported hatchery survival from fertilization to hatching on two occasions were 0.3% and 6.6%. Buckley and Kynard (1981) reported a survival of 19.3% from eggs to larvae under hatchery conditions. Whether these low survival values are due to low fertilization rates is unknown.

3.15 Gonads

Female and male shortnose sturgeon have two gonads. In females, one gonad is usually slightly larger than the other. During development the gonads change dramatically in color and size. Dadswell (1979) has described the stages as shown in Table 5.

Dadswell (1976) found female gonad weight during stage II averaged 10% of total body weight (Table 6). Dadswell (1979) described the seasonal pattern of gonad tissue growth and found an abrupt increase in weight during July to October with a subsequent further slow increase during winter. Between July and September, ripening females gained between 15 to 30% of their total body weight (Table 7). When fully ripe (stage V), female gonads averaged 21-28% of total body weight (Table 6) (Dadswell 1979; Marchette and Smiley 1982 see Table 2, footnote 24). Spent (stage IV) female gonads weighed 4-6% of total body weight.

Male shortnose sturgeon gonads are usually of equal size. They are grayish white to white throughout development (see above) and vary between 5% in stage II and 15% in stage V of total body weight.

Fecundity

Fecundity of shortnose sturgeon in the Saint John River, Canada, ranged from 27,000 to 208,000 eggs/fish (Table 6) and was directly related to total body weight. The fecundity relationship was Log F (eggs $\times 10^3$) = 3.92 + 1.14 Log W (total weight in kg) (Dadswell 1979).

Fecundity of Altamaha River shortnose sturgeon was between 79,000 and 90,000 eggs for fish between 75 and 87 cm FL (Heidt and Gilbert 1978 see Table 2, footnote 27). Marchette and Smiley (1982 see Table 2, footnote 24) found a 58 cm FL female from the Pee Dee River contained 30,000 eggs. Saint John River fish had a mean of 11,568 eggs/kg body weight (Dadswell 1979) but Heidt and Gilbert (1978 see Table 2, footnote 27) and Marchette and Smiley (1982 see Table 2, footnote 24) found southern shortnose

Table 5.—Classification and description of maturity stages in shortnose sturgeon.

Stage	Period present	Condition of gonad: Female	Condition of gonad: Male
0	All year	Immature, sex macroscopically indeterminate	
I	All year	Eggs small, 0.5 mm, translucent golden brown	Almost clear ribbon, 1-2 mm in width
II	All year	Eggs 0.5 mm, bright yellow, fat body 70% by weight	Ribbon about 5 mm wide, whitish gray, large fat body 10 mm wide, yellowish gray
III	June-Oct.	Egg 1.0 mm, grayish, yellow fat body	10 mm wide, whitish gray, fat body = gonad size
IV	Sept.-Apr.	Eggs 2.0-2.5 mm, chocolate brown, gray polar globule	Testes occupy most of body cavity, white, no fat body, no milt running
V	May-June	Eggs 3.10 mm, black, gray-brown polar globule	Testes occupy most of body cavity, white, milt running
VI	May-Apr.	Spent, gonad pinkish, flaccid, blood clots, a few aborted eggs	Spent, whitish pink, milt present in body cavity. Males regain condition II quickly, stage VI not present after July.

Table 6.—Gonad development and fecundity of shortnose sturgeon.

FL (cm)	TW (kg)	Stage	Egg diameter (mm)	Gonad wt (g)	% body wt	Number of eggs	Eggs/g gonad	Eggs/kg TW
			Saint John River, N.B., Canada					
100	8.6	6	—	505	5.9	—	—	—
107	8.7	6	—	525	6.0	—	—	—
75	4.8	6	—	210	4.4	—	—	—
89	6.3	2	0.52	530	8.4	—	—	—
101	9.3	2	0.54	918	9.8	—	—	—
95	7.7	2	0.54	910	11.8	—	—	—
94	7.7	2	0.53	943	12.2	—	—	—
85	7.5	3	2.01	1,940	24.0	69,150	36	9,220
95	9.2	3-4	2.40	2,310	23.0	125,670	54	13,660
85	7.9	4	2.50	2,020	25.0	85,400	43	10,810
95	12.0	4	2.50	3,100	26.0	148,590	48	12,380
107	18.3	4	2.70	4,810	27.0	208,000	43	11,370
66	2.5	5	3.10	425	17.0	26,775	63	10,710
76	5.2	5	3.05	1,030	19.8	63,345	61.5	12,181
83	7.3	5	3.00	1,776	24.3	88,800	50.0	12,164
90	5.2	5	3.00	1,318	25.0	49,000	38	9,430
98	7.2	5	3.20	1,650	22.9	96,525	58.5	13,406
109	10.7	5	3.18	2,511	23.5	126,379	50.3	11,811
			Pee Dee River, South Carolina					
58	1.8	5	3.15	518	28.0	30,000	57.9	16,216
			Altamaha River, Georgia					
76	5.3	5	—	—	—	79,383	—	14,865
77	5.5	5	—	—	—	80,049	—	14,475
87	6.6	5	—	—	—	90,361	—	13,608

sturgeon to have about 14,000-16,000 eggs/kg body weight. Egg size in the examined South Carolina fish was the same as the northern population which may indicate southern shortnose sturgeon produce more eggs at a given size. This is consistent with other fish species having a wide north to south range of spawning populations (Jones 1976).

3.16 Spawning

Shortnose sturgeon spawn once a year during spring but among adults in northern populations and perhaps in southern ones also, spawning is not a yearly event for each individual. Dadswell (1979) found the spent/recovering condition persisted up to 10 mo after spawning and stage II females were present all year. Only 30% of adult females examined during the August to March ripening period were found to be developing sexually as were 50% of the males. The evidence suggests females probably spawn at a maximum of once every 3 yr and males every other year in the Saint John River, Canada. In addition, check zones (a series of closely grouped yearly annuli) of the pectoral ray, which can be interpreted as leading up to spawning (Roussow 1957), may indicate a duration of as long as 5-11 yr between spawnings (Dadswell 1979).

Taubert (1980b) described a similar situation in the Holyoke Pool, Connecticut River. Using check zones, he found male shortnose sturgeon spawned for the first time at a mean of 9.8 yr and a second time at a mean of 18.2 yr. Range in years between first and second spawnings was 4-12 ($\bar{X}$ = 8.4 yr). Taubert (1980b) did not identify any females spawning for the second time. Also of 193 sturgeon aged, 51 had spawned once (8-14 yr; $\bar{X}$ = 10) and 12 had spawned a second time (14-20 yr; $\bar{X}$ = 17.9). In the Hudson River, tagged males returned to the spawning grounds in each of

Table 7.—Average percent weight gain ($\bar{WG}$) and time at large ($\bar{\Delta T}$) of mature, adult, shortnose sturgeon (+70 cm) between successive captures June-September in the same year in the Saint John estuary, Canada.

Month of capture and recapture	Reproductive females N	$\bar{WG}$ (%)	$\bar{\Delta T}$ (d)	Nonreproductive adults N	$\bar{WG}$ (%)	$\bar{\Delta T}$ (d)
June-July	7	9.3	41.4	14	5.8	33.3
June-August	5	14.5	59.6	6	2.3	59.0
June-September	8	18.0	84.4	11	8.0	60.3
July-August	4	15.0	43.8	15	3.7	30.1
July-September	5	19.5	63.6	8	3.8	57.7
August-September	4	17.7	47.5	7	2.8	29.8

two successive years (Dovel 1981 see Table 2, footnote 15). Marchette and Smiley (1982 see Table 2, footnote 24), also using check zones, identified a 3-yr spawning periodicity for one male and two females from the Pee Dee River, S.C.

Spawning period and location

Spawning occurs between February and May depending on latitude. Ripe and spent females were present in the Altamaha River, Ga., during February (Heidt and Gilbert 1978 see Table 2, footnote 27), and during January to April in the Savannah, Santee, and Pee Dee Rivers, S.C. (Marchette and Smiley 1982 see Table 2, footnote 24). Ripe and running-ripe females occur during the middle 2 wk of April in the Delaware (Meehan 1910; Hoff 1965), the last week of April and first week of May in the Hudson (Greeley 1937; Pekovitch 1979 see Table 2, footnote 14), the first 2 wk of May in the Connecticut (Taubert 1980a; Buckley 1982) and the Androscoggin (Squiers 1982 see Table 2, footnote 4), and the middle 2 wk of May in the Saint John River, Canada (Dadswell 1979; Anonymous 1980 see Table 2, footnote 2).

Temperature is probably the major factor governing spawning. Meehan (1910), Heidt and Gilbert (1978 see Table 2, footnote 27), Taubert (1980a), Dadswell (1979), and Buckley and Kynard (1981) all reported shortnose sturgeon spawning to occur between 9° and 12°C. Other apparent factors influencing spawning are the occurrence of freshets and substrate character. Taubert (1980a), Dadswell (1979), Buckley (1982), and Squiers (1982 see Table 2, footnote 4) indicated spawning occurs during or soon after peak flows in the spring. Spawning grounds examined to date in the north are in regions of fast flow (40-60 cm/s) with gravel or rubble bottoms (Taubert 1980a; Pekovitch 1979 see Table 2, footnote 14; Anonymous 1980 see Table 2, footnote 2; Buckley 1982). Locations are generally well upriver of the summer foraging and nursery grounds (rkm 100-200). In South Carolina, on the other hand, spawning occurs in flooded, hardwood swamps along inland portions of the rivers (Savannah, Pee Dee; Marchette, unpubl. data).

Ratio and distribution of sexes on spawning grounds

Pekovitch (1979 see Table 2, footnote 14) found a ratio of 2.5:1 males to females on the spawning grounds between rkm 135 and 140 on the Hudson River during 1979. Taubert (1980b) found a ratio of 3.5:1 males to females on the Holyoke Pool spawning grounds over two spawning seasons.

There appeared to be no tendency for sexes to segregate on the spawning grounds. There is some evidence to suggest males migrate to the spawning ground first (Dovel 1981 see Table 2, footnote 15).

3.17 Spawn

Shortnose sturgeon eggs are dark brown to black with a light-gray polar body (Meehan 1910; Dadswell 1979). Egg development in the gonad is illustrated in Figure 10. Size change is marked during late summer and early fall (Dadswell 1979). Ripe eggs have a diameter of 3.00-3.20 mm (Table 6; Dadswell 1979) and size does not change after fertilization or water hardening (Reed;[12] Buckley and Kynard 1981). In the Saint John River, Canada, shortnose sturgeon eggs are often parasitized by *Polypodium* sp. (≅ 50% of females) but the number of parasitized eggs per female has never been observed to exceed 1%. The egg is enlarged, light gray in color (Fig. 11; Hoffman et al. 1974), and is most evident in stage IV and V females.

The eggs are separate when spawned but become adhesive within 20 min of fertilization. Adhesiveness is probably due to surface protuberances like the spokes of "iron jackstraws" (Meehan 1910; Markov 1978). Sinking rates of unfertilized and fertilized eggs are 5.2 ± 0.8 and 5.2 ± 0.2 cm/s, respectively (Anonymous 1980 see Table 2, footnote 2).

[12]R. J. Reed, Professor, Massachusetts Cooperative Fishery Research Unit, Department of Forestry and Wildlife, University of Massachusetts, Amherst, MA 01002, pers. commun. June 1975.

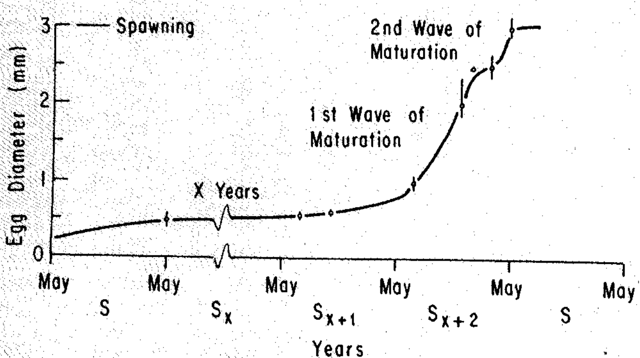

Figure 10.—Duration of ripening conditions and change in mean egg diameter during gonad development between spawning of female shortnose sturgeon. Bars are range of egg diameter.

Figure 11.—Shortnose sturgeon stage V egg (left) and egg parasitized by *Polypodium* sp. (right). Enlarged eggs average 4 mm in diameter.

3.2 Preadult phase

3.21 Embryonic phase

Little is known about embryonic development of shortnose sturgeon but it is probably very similar to other species of *Acipenser* (Ryder 1890; Ginsburg and Dettlaf 1969). Meehan (1910) gave the following description: During development there was little change in the hue (i.e., brown for about two-thirds circumference, grayish white on the other), between 8° and 12°C the eggs hatched 13 d after fertilization, eyes appeared first on day 6 and were light colored, on day 8-9 they darkened, fish shape was distinguishable on day 10. At 17°C, hatching occurs in 8 d but the development period is similar if converted to degree-days (136 vs. 143) (Buckley and Kynard 1981). Near time of hatching, eggs may become clear and amber and emergence is tail first (Anonymous 1980 see Table 2, footnote 2).

Mortality

No data on natural egg mortality are available.

Meehan (1910) reported a fertilization to hatching survival of 0.3% and 6.6% for two attempts under artificial conditions. Buckley and Kynard (1981) reported hatching survival of 19.3%.

3.22 Larval phase

In Meehan's (1910) hatching experiments, no swim-up occurred and the larvae remained for several days at the bottom of the jar, but Buckley and Kynard (1981) found larvae to be active and photopositive during the first 2 d. Larvae of approximately 10-d-old attempt to remain on the bottom or placed themselves under any available cover in aquaria (Pottle and Dadswell 1979 see Table 2, footnote 1; Anonymous 1980 see Table 2, footnote 2). Buckley and Kynard (1981) found week-old larvae to be photonegative and form aggregations with other larvae in concealment.

Hatching size is 7.3-11.3 mm (Taubert 1980a; Anonymous 1980 see Table 2, footnote 2; Buckley and Kynard 1981). Hatchlings < 8.0 mm did not survive (Anonymous 1980 see Table 2, footnote 2). Taubert and Dadswell (1980), Pekovitch (1979, see Table 2, footnote 14), and Bath et al. (1981) have described captured or reared larvae (Table 8).

At hatching, the larvae are tadpolelike and dark gray, with a large yolk sac, the head is closely attached to the yolk sac, the mouth is unopened, and pectoral and pelvic fins are undeveloped (Fig. 12). At 14 mm TL, approximately 10 d after hatching, the barbels are formed, the mouth is large and distinctly *brevirostrum*-like but has teeth (9-12 upper, 8-11 in lower jaw), pectoral but not pelvic fins are present, eye size averages 0.70 mm, the anlage of the dorsal fin is present, and the yolk sac is gone (Fig. 13) (Taubert and Dadswell 1980). By 16.3 mm pelvic fins are present (Fig. 14) and by 20 mm scutes, nose shape, and dorsal and anal fins are characteristic of the species (Fig. 14) (Pekovitch 1979 see Table 2, footnote 14; Anonymous 1980 see Table 2, footnote 2).

Table 8.—Morphological and meristic parameters of shortnose sturgeon larvae from Pekovitch (see Table 2, footnote 14), Taubert and Dadswell (1980), Anonymous (see Table 2, footnote 2), and Bath et al. (1981). Larvae are from (a) Saint John River, Canada; (b) Connecticut River; (c) Hudson River and their status is (1) reared from egg or (2) captured in drift sampling nets.

Locality and status	Total length (mm)	Preanal myomeres	Postanal myomeres	Total	Snout to vent length % TL	Eye diameter	Yolk sac length % TL	Head width (mm)	Mouth width (mm)	MW/HW %	Upper teeth	Lower teeth	Dorsal fin rays	Dorsal scutes	Probable or known age (d)
a, 1	7.3	34	24	58	68	—	—	1.0	—	—	—	—	—	—	<1
a, 1	7.9	35	23	58	68	—	36	0.9	—	—	—	—	—	—	<1
a, 1	8.1	33	24	57	63	—	—	0.9	—	—	—	—	—	—	<1
a, 1	8.6	33	19+	52+	70	0.43	34	1.0	0.28	28	—	—	—	—	<1
b, 2	9.1	34	22	56	69	0.30	31	—	—	—	—	—	—	—	<1
a, 1	9.5	34	24	58	70	0.64	37	1.1	0.34	31	—	—	—	—	1
a, 1	9.6	35	24	59	67	0.64	34	1.1	0.42	38	—	—	—	—	1
b, 2	10.0	34	20	54	70	0.32	32	—	—	—	—	—	—	—	<1
a, 1	10.1	36	24	60	63	0.57	32	1.1	0.45	41	—	—	—	—	1
b, 2	11.0	33-36	20-21	53-57	67	0.32	—	—	—	—	—	—	—	—	<1
b, 2	11.1	34	22	56	65	—	—	—	—	—	—	—	—	—	1?
b, 2	11.3	33-34	22-23	55-57	68	0.34	—	—	—	—	—	—	—	—	<1
b, 2	12.5	33	22	55	66	—	—	—	—	—	—	—	—	—	1?
a, 2	13.0	34	22	56	61	0.79	—	2.0	1.50	75	—	—	—	—	8
a, 2	14.7	34	22	56	61	0.79	—	2.1	1.50	71	12	11	14	—	8
c, 2	15.3	—	—	—	59	0.70	—	2.0	1.50	75	—	—	—	—	10?
c, 2	15.5	—	—	—	61	0.70	—	2.0	1.50	75	—	—	—	—	10?
c, 2	15.6	—	—	—	58	0.70	—	2.0	1.50	75	—	—	—	—	10?
c, 2	16.0	—	—	—	55	0.70	—	2.3	1.50	65	—	—	—	—	10?
a, 1	16.2	35	26	61	62	0.86	—	2.5	2.07	83	9	10	15	—	10
c, 2	16.3	37	21	58	54	—	—	—	—	—	—	—	16	—	10
a, 1	17.1	35	24	59	58	1.00	—	2.6	2.28	87	11	8	14	—	13
a, 1	17.2	—	—	—	61	0.85	—	2.8	2.00	71	—	—	16	—	13
c, 2	17.5	36	22	58	57	—	—	—	1.80	—	—	—	16	—	15?
c, 2	18.0	37	22	59	58	—	—	—	1.80	—	—	—	17	—	15?
c, 2	18.2	37	22	59	58	—	—	—	1.60	—	—	—	15	—	15?
a, 1	20.4	—	—	—	59	1.07	—	3.1	2.85	92	10	6	17	8	28

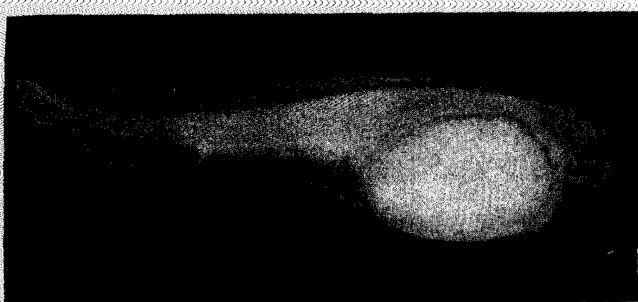

Figure 12.—One- or 2-d old, 10 mm TL shortnose sturgeon protolarvae from the Holyoke Pool, Connecticut River. Note large yolk sac, continuous fin fold, lack of barbels, and no lateral fins (courtesy of B. Taubert, Univ. of Mass.).

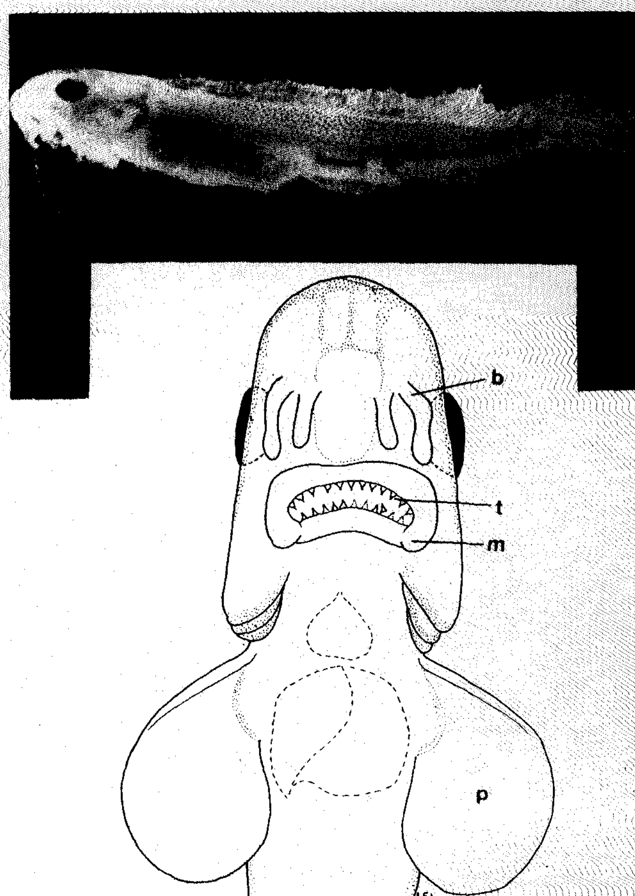

Figure 13.—Upper. Approximately 10-d-old, 14.7 mm TL shortnose sturgeon mesolarvae from the Saint John River, Canada. Note: barbel (b) just anterior to eye on ventral surface and anlage (a) dorsal fin. Lower. Ventral view of head of 14.7 mm TL mesolarvae illustrating mouth (m), teeth (t), barbels (b), and pectoral fins (p).

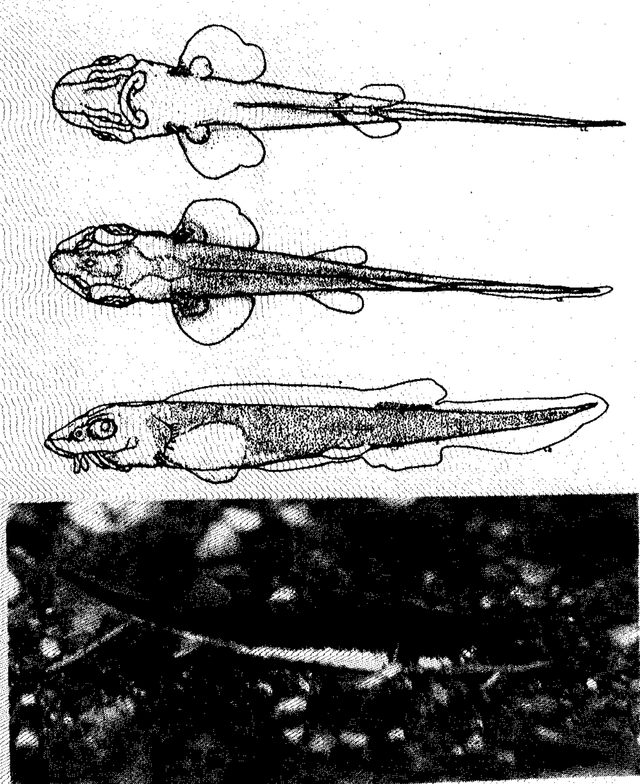

Figure 14.—Upper. Ventral, dorsal, and lateral views of 16.3 mm TL shortnose sturgeon from the upper Hudson River (after Pekovitch 1979 see Table 2, footnote 14). Lower. Lateral view of 20 mm shortnose sturgeon reared in captivity from Connecticut River stock (courtesy of Buckley, Univ. Mass).

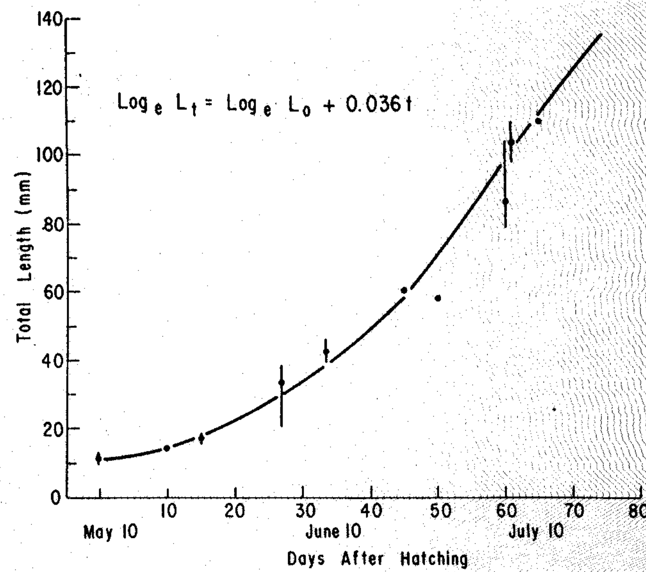

Figure 15.—Larval growth of shortnose sturgeon. Figure is composite of data from the Saint John River, Canada, the Connecticut River (Taubert 1980a), and the Hudson River (Pekovitch 1979 see Table 2, footnote 14). May 10th was selected as mean hatching date in all three river systems.

Growth of fry

Early growth of shortnose sturgeon is rapid (Fig. 15). This species attains between 14 and 30 cm by the end of its first growing season, depending on latitude. Juveniles are between 15 and 19 cm during July of their second summer season in the Saint John River (Fig. 16) (Dadswell 1979). Evidence from the Hudson River suggests the juveniles may reach 25.0 cm by the end of their first growing season (Pekovitch 1979 see Table 2, footnote 14) and growth averages 3.0 mm every 10 d (Fig. 15). Growth may be even more rapid in the southern United States (Heidt and Gilbert 1978 see Table 2, footnote 27).

A growth equation for shortnose larvae using data from the Hudson, Connecticut, and Saint John Rivers was derived as follows:

$$\text{Log}_e L_t = \text{Log}_e L_0 + 0.036\, t$$

where L_0 = 10.7 mm and t is time in days from hatching date (chosen as 10 May). In the Saint John River, Canada, shortnose sturgeon exhibit a two-phase growth curve (Fig. 17) with a slow growing "parr" stage between ages 1 and 9 (Pottle and Dadswell 1979 see Table 2, footnote 1). Similar growth patterns are known for Russian sturgeon species (Pavlov 1971).

Survival

No information on natural survival rates of shortnose sturgeon larvae and juveniles is available.

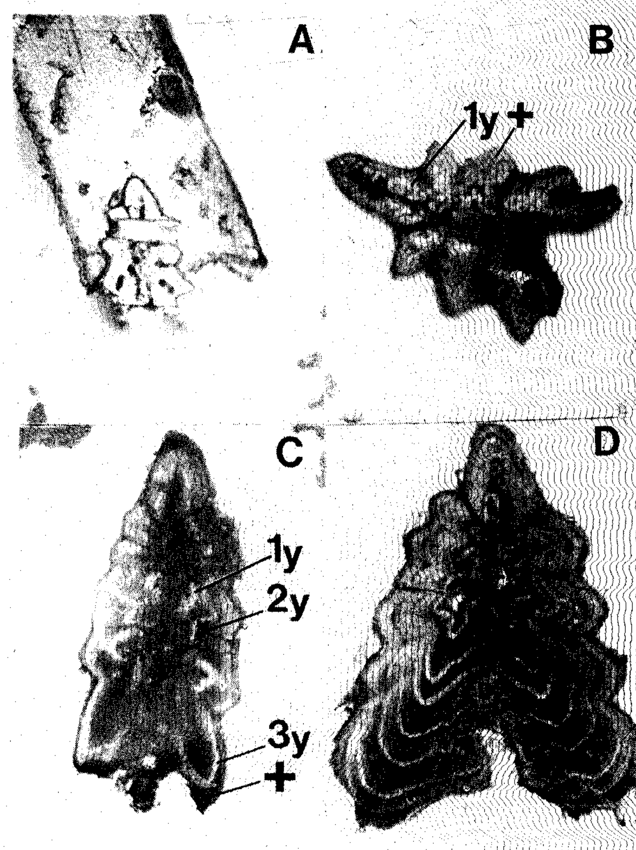

Figure 16.—Transverse sections of the marginal ray of the pectoral fin of shortnose sturgeon showing annuli. Dark zones are summer-formed dense bone; translucent zones, winter bone. (A) 14.7 cm, captured 20 May 1979, 1 yr. (B) 19.2 cm, 1 August 1979, 1 + yr. (C) 29 cm, 11 July 1979, 3 + yr. (D) 45 cm, 9 yr (Pottle and Dadswell 1979 see Table 2, footnote 1).

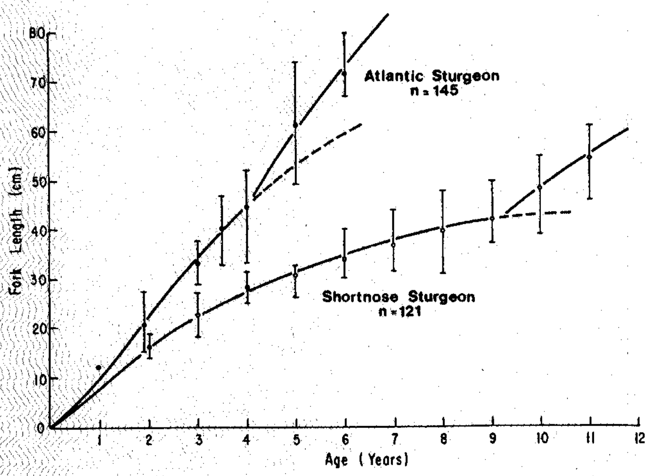

Figure 17.—Juvenile growth of shortnose sturgeon from age 1 to 11 in the Saint John River, Canada (Pottle and Dadswell 1979 see Table 2, footnote 1). Bars represent range of length at age and open dots are mean size.

Predators

The only record of predation on larval or juvenile shortnose sturgeon is the occurrence of 24 juveniles approximately 5 cm FL found in perch (*Perca flavescens*) stomachs from the Androscoggin River, Maine (Squiers[13]).

3.23 Adolescent phase

Young shortnose sturgeon begin to resemble adults by the time they are 20-30 mm in length (Fig. 18), but they remain juveniles until 45-55 cm FL or from 3 to 10 yr of age, depending on latitude.

[13]T. S. Squiers, Fisheries Biologist, Maine Department of Marine Resources, Augusta, ME 04333, pers. commun. October 1976.

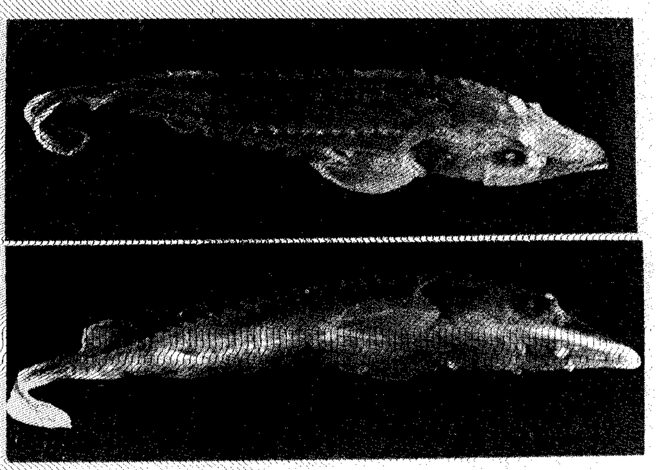

Figure 18.—Dorsal and ventral views of 5 cm TL, young-of-the-year shortnose sturgeon taken from the stomach of a perch captured in the Androscoggin River, Maine.

3.3 Adult phase (mature fish)

3.31 Longevity

The oldest shortnose sturgeon determined to date was a 67-yr-old female from the Saint John River, Canada; the oldest male examined, also from the Saint John River, was 32 yr (Dadswell 1979). Maximum ages determined to date for other river systems are less but may be a reflection of smaller sample size. They are: Kennebec, 40 yr (Squiers[14]); Connecticut, 34 yr (Taubert 1980b); Hudson, 37 yr (Dovel 1981 see Table 2, footnote 15); Pee Dee, 20 yr (Marchette and Smiley 1982 see Table 2, footnote 24); Altamaha, 10 yr (Heidt and Gilbert 1978 see Table 2, footnote 27), but based on a small female (89 cm FL). In general, northern populations of shortnose sturgeon have a life span similar to other *Acipenser*, but southern populations may be relatively short-lived.

3.32 Hardiness

No research has been done on the physiological hardiness of shortnose sturgeon.

Shortnose sturgeon have been captured in the Altamaha River in 34°C water but Dadswell (unpubl. data) found young from the Saint John River, Canada, to experience distress and/or rapid mortality at temperatures over 25°C.

Shortnose sturgeon are known to live in salinities up to 30 ‰ (Holland and Yelverton 1973; Marchette and Smiley 1982 see Table 2, footnote 24).

Dovel (1981 see Table 2, footnote 15) found that shortnose sturgeon from the Hudson estuary have severe cases of fin rot and body sores, presumably from industrial pollutants, but are reasonably healthy otherwise (i.e., weight-length relation normal; Fig. 19).

3.33 Competitors

Shortnose sturgeon probably have no other competitors for spawning area since they utilize the habitat early in the spring and

[14]T. S. Squiers, Fisheries Biologist, Maine Department of Marine Resources, Augusta, ME 04333, pers. commun. November 1981.

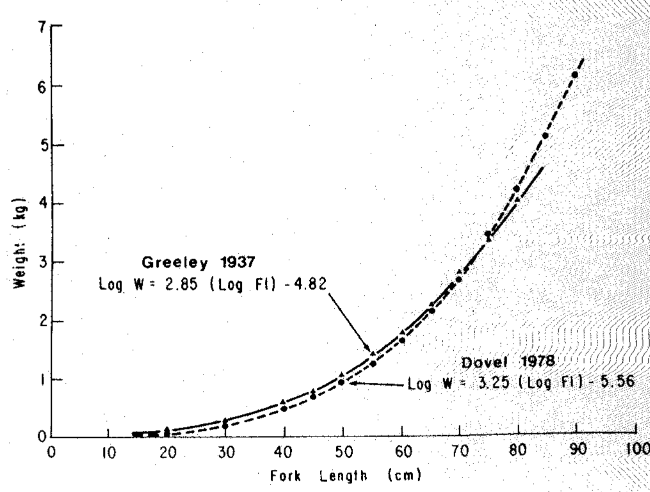

Figure 19.—Weight-length relationships of shortnose sturgeon from the Hudson River, N.Y. There was a 40-yr interval between the two studies.

temporally avoid the spawning of Atlantic sturgeon. Other possible competitors could be walleye, *Stizostedium vitreum*, and/or spring-spawning rainbow trout, *Salmo gairdneri*.

Shortnose sturgeon compete for food with most other benthic feeders, particularly those which exploit molluscs. In the Saint John River, Canada, juveniles apparently avoid competition with suckers (*Catostomus*) and Atlantic sturgeon, *Acipenser oxyrhynchus*, by spatial separation, i.e., juveniles occupy the deep, freshwater channels; the suckers, the shallows; the Atlantics the deeper saline parts of the estuary (Dadswell 1979). A large degree of habitat overlap occurs but darkness and/or turbidity may enhance the success of the sturgeon because of the presence of barbels.

In the Saint John River, Canada, shortnose sturgeon and whitefish, *Coregonus clupeaformis*, compete for gastropods in the upper estuary and shortnose sturgeon and winter flounder, *Pseudopleuronectes americanus*, for *Mya arenaria* in the lower estuary. Competition with the whitefish, however, is limited because the two fish populations are segregated by temperature (Fig. 20) and there appears to be some resource partitioning between the two (Fig. 21). The sturgeon utilize the gastropods during summer, the whitefish, during the cooler period of the year; the sturgeon select the smaller *Amnicola* and *Valvata*, the whitefish, the larger *Lymnaea* and *Physa*.

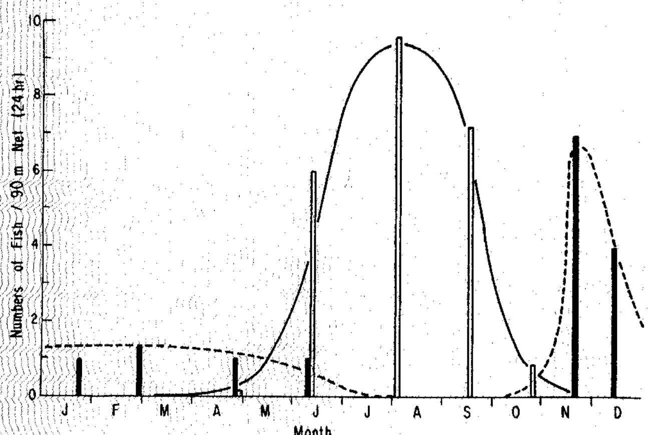

Figure 20.—Utilization of the same feeding site in the Saint John River, Canada, by whitefish (dark bars) and shortnose sturgeon (open bars) on a seasonal basis.

Competition with other fish species for food resources in central and southern Atlantic coast estuaries has not been studied. More intense competition would, however, be expected because of the large and complex fish communities present in the region.

Adult shortnose sturgeon may compete for space with similar sized juvenile Atlantic sturgeon. In the Saint John River, Canada, the two rarely occupy the same habitat and the separation seems to be based on a salinity relationship. Large Atlantic sturgeon juveniles predominate in water > 3 ‰ and shortnose adults in < 3 ‰ (Appy and Dadswell 1978; Dadswell 1979). In the saline water of Winyah Bay, S.C., Atlantic sturgeon outnumber shortnose sturgeon 2 to 1 (Marchette and Smiley 1982 see Table 2, footnote 24) and may compete with them.

3.34 Predators

Adult shortnose sturgeon may have few predators. In general, they are one of the larger fish occurring in their freshwater

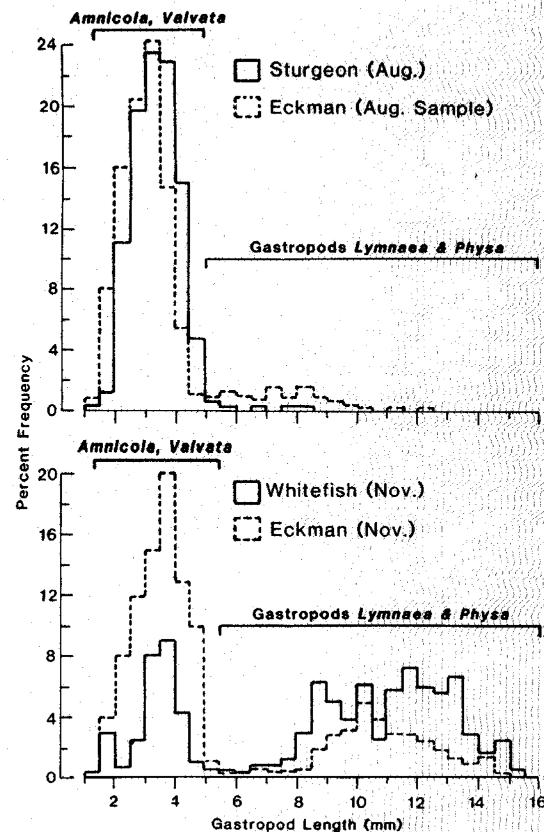

Figure 21.—Size and frequency of gastropods found in stomachs of shortnose sturgeon and lake whitefish feeding on the same resource but at different times of the year.

habitat. In the south, alligators; gars; and striped bass, *Morore saxatilis*; may be suspected as predators. In marine habitats, they could be preyed upon by sharks or seals but the only evidence for this may be the occasional specimen lacking a tail (see section 3.35).

3.35 Parasites, diseases, injuries, and abnormalities

A checklist of parasites recorded from shortnose sturgeon is given in Table 9. Intensity of infestation is low in most cases except for *Capillospirura*. None appear harmful to the sturgeon.

No diseases have been recorded from shortnose sturgeon.

Abnormalities and healed injuries appear to be a common occurrence among shortnose sturgeon. Fried and McCleave (1974) described two shortnose sturgeon from Montsweag Bay, Maine, one with only one barbel and one with forked barbels. They also observed a bilaterally blind specimen. Table 10 summarizes the numerous abnormalities and healed injuries observed during 6 yr of sampling in the Saint John estuary, Canada (Dadswell, unpubl. data). One blind specimen was observed with the eyes completely overgrown by flesh, another had no suggestion of an eye on its right side. The first fish was large and otherwise in excellent condition and was completely black in color, both dorsally and ventrally. Figure 22 illustrates two other findings: No nasal septum (3 specimens); no tail (observed twice). Dovel (1981 see Table 2, footnote 15) found that many adult shortnose sturgeon from the Hudson River have severe cases of fin rot and abdominal sores. Both problems were thought related to industrial pollution. Pekovitch (1979 see Table 2, footnote 14)

Table 9.—Parasites recorded from shortnose sturgeon.

Group and species	Parasite location	Capture locality	Authority
Coelenterata			
Polypodium sp.	Eggs	Saint John River[1]	Hoffman et al. (1974)
Diclybothrium armatum	Gills	Saint John River[1]	Appy and Dadswell (1978)
Spirochis sp.	Mesenteric blood vessels	Saint John River[1]	Appy and Dadswell (1978)
Nitzschia sturionis	Gills	N.Y. Aquarium (may be unnatural infection)	MacCallum (1921)
Nematoda			
Capillospirura pseudoargumentosus	Gizzard	Saint John River[1]	Appy and Dadswell (1978)
Acanthocephala			
Fessesentis friedi	Spiral valve	Saint John River[1]	Appy and Dadswell (1978)
Echinorhynchus attenuatus	?	Woods Hole	Sumner et al. (1911)
Hirundinea			
Calliobdella vivida	External	Connecticut River	Smith and Taubert (1980)
Piscicola milneri	External	Connecticut River	Smith and Taubert (1980)
Piscicola punctata	External	Connecticut River	Smith and Taubert (1980)
Arthropoda			
Argulus alosa	External	Saint John River[1]	Appy and Dadswell (1978)
Pisces			
Petromyzon marinus	External	Saint John River[1]	Dadswell (pers. obs.)

[1]Saint John River, N.B., Canada.

Table 10.—Abnormalities and healed injuries found among shortnose sturgeon from the Saint John River, Canada, and the Hudson River, N.Y.

Condition	Times observed	Remarks
Total blindness (no eyes)	1	Birth defect, entire sturgeon melanistic
One eye blind	1	Eye completely missing
Lacking nasal septum	3	Birth defect
Bent backbone, shortened caudal peduncle	4	Birth defect?
Lateral spine curvature (scoliosis)	1	Birth defect?
Extra pelvic fin	2	Birth defect
Loss of pelvic or pectoral fin	3	Healed injury
No tail	2	Healed injury, extra long rays in dorsal and anal fin
Extreme blunt nose	8	Healed injury Sometimes nose cleft
U-shaped snout	21	Genetic (Hudson only)
Fin rot	76% of population	Hudson River only

described a physical deformity involving a U-shaped section missing from the snout of shortnose sturgeon in the Hudson River. A total of 21 specimens, one as large as 87 mm TL, had the deformity and he thought the trait was probably inherited.

3.36 Physiology and biochemistry

No data available.

3.4 Nutrition and growth

3.41 Feeding

Time of day

Dadswell (pers. obs.) found shortnose sturgeon were most active (most readily captured) during night or on windy days when water

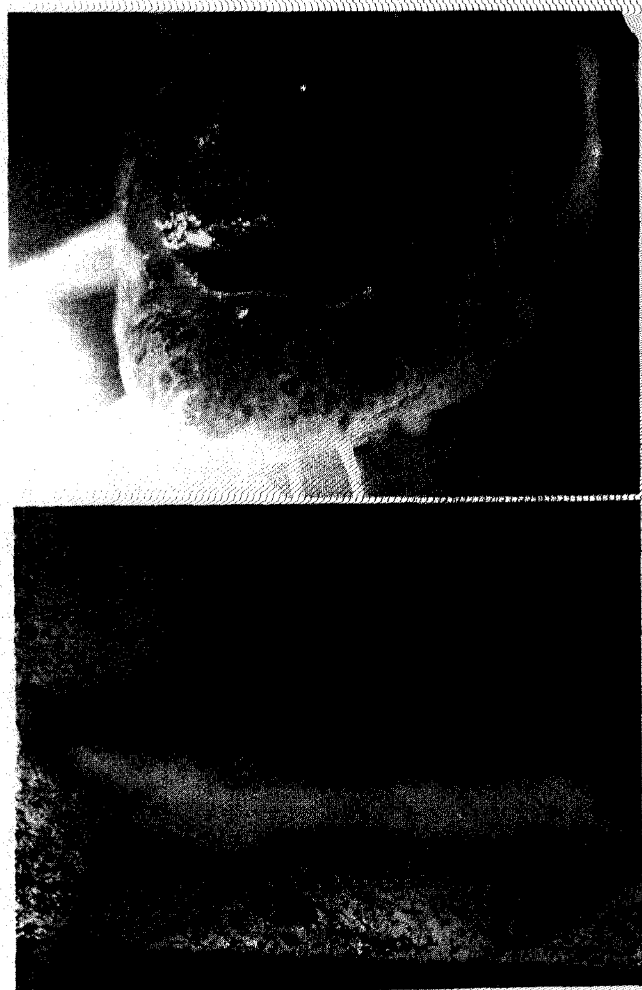

Figure 22.—Defects and/or injuries of shortnose sturgeon: top, no nasal septum; bottom, caudal fin missing.

turbidity was high. Gill net catches were large during these periods and sampled fish always contained full gastrointestinal tracts. Dovel (1978 see Table 2, footnote 13) described Hudson River shortnose sturgeon as moving into shallows during the night, presumably to feed. Marchette and Smiley (1982 see Table 2, footnote 24) observed shortnose sturgeon feeding at night on molluscs off the undersides of lily pads.

Place

All feeding of shortnose sturgeon seems to be either benthic or off plant surfaces. In freshwater portions of the Saint John estuary, Canada, adult shortnose sturgeon foraged in weedy backwaters or along the river banks over mud bottoms in depths of 1-5 m (Dadswell 1979). During late summer, feeding areas tended to be in deeper water (5-10 m), perhaps in response to higher temperatures in the shallows. What little feeding occurred in freshwater during the fall and winter took place in deep water (15-25 m). Juvenile shortnose sturgeon feed primarily in the deep channels (10-20 m) over sandy-mud or gravel-mud bottoms (Pottle and Dadswell 1979 see Table 2, footnote 1).

In saline water of the lower Saint John estuary, adult shortnose sturgeon feed over sandy-mud or mud bottoms in 5-10 m depths, both in summer and winter. McCleave et al. (1977) found shortnose sturgeon in Montsweag Bay (salinity 18-25 $^0/_{00}$) were feeding over mud-tide flats, mostly in 1-5 m depths. Townes (1937) described the shortnose sturgeon as feeding in coves along the Hudson River over mud bottoms in 4-10 m of water. Marchette and Smiley (1982 see Table 2, footnote 24) found the summer feeding habitat was characterized by shallow water with sandy bottoms and emergent macrophytes and the winter feeding habitat with deeper water and mud bottom.

Manner of feeding

The shortnose sturgeon, particularly the young, may simply use its protuberant mouth to vacuum the bottom extracting substrate as well as animals. Curran and Ries (1937) described shortnose sturgeon stomachs from Hudson River fish as having 85-95% mud intermingled with plant and animal debris. During winter in South Carolina, sturgeon stomachs contained 90% by volume nonfood matter (Marchette and Smiley 1982 see Table 2, footnote 24). Dadswell (1979) found a similar situation among juvenile shortnose sturgeon from the Saint John River implying they employed random suctorial feeding.

The stomach contents of many adults from the Saint John River, Canada, and Winyah Bay, S.C., contained little or no nonfood matter. In most adults examined from freshwater portions of the estuary, crop contents were solely food organisms, implying either efficient separation of food and bottom debris between mouth and crop (possibly with ejection of debris out through the gills), or feeding was precisely oriented and took place off vegetative surfaces rather than off mud (Marchette, pers. obs.). The latter possibility is likely a normal occurrence since major shortnose sturgeon prey such as the small gastropods *Annicola limnosa* and *Valvata* spp. (Dadswell 1979), live mainly on the leaves and stems of submerged macrophytes. Stomach contents of adults feeding in saltwater on *Mya arenaria* or *Corbicula manilensis* however, often had a high portion of mud and bottom debris (30-60%), implying that in the situation of partially buried food, they probably vacuumed the bottom.

Regular spatial dispersion of foraging shortnose sturgeon captured in gill nets suggests they feed individually (Dadswell, pers. obs.).

Frequency

Feeding frequency of individual adult shortnose sturgeon is unknown but completely filled gastrointestinal tracts at all times of daily capture during summer in the Saint John River, Canada, suggest feeding is continuous.

Variation of feeding with availability, season, age, size, sex, and physiological condition

The ventral, protrusible mouth and barbels of the shortnose sturgeon are adaptations for a diet of small, live, benthic animals. Adult shortnose sturgeon (+50 cm) generally feed on whatever mollusc is readily available. In the Saint John River, Canada, Dadswell (1979) found shortnose sturgeon fed on *Mya arenaria* in saline water, *Macoma balthica* where it was dominant in brackish water, *Amnicola limnosa* and *Valvata* spp. in freshwater of high chloride content (100-1,000 ppm), and *Pisidium* spp. and *Elliptio complanata* in permanent freshwater regions. Marchette and Smiley (1982 see Table 2, footnote 24) found molluscs were abundant in the sturgeon's diet in freshwater and polychaetes in saltwater. Juvenile shortnose sturgeon feed primarily on benthic insects and crustaceans and their diet is dominated by crustaceans where they are most available and insects where they are most abundant (Townes 1937; Currand and Ries 1937; Dadswell 1979).

Feeding in freshwater portions of the Saint John River, Canada, and Winyah Bay, S.C., is largely confined to periods when water temperature exceeds 10°C (Table 11; Dadswell 1979; Marchette and Smiley 1982 see Table 2, footnote 24). During the warmwater season, gastrointestinal tracts of New Brunswick sturgeon were crammed with prey but in South Carolina many fish were empty. Feeding in freshwater was minimal during winter. At most, a few shortnose sturgeon were found to contain 1-5 small amphipods or isopods. Shortnose sturgeon captured in saline water, however, were found to feed all year but food volume in the gut during winter was about half the summer level (Table 11; Dadswell 1979; Marchette and Smiley 1982 see Table 2, footnote 24). Reduced feeding activity during winter was probably a result of low water temperature.

Dadswell (1979) found that female shortnose sturgeon ceased feeding about 8 mo before spawning. The stomachs of all females examined with stage III or more developed gonads after the beginning of August through to when spawning occurred were empty. Developing males, on the other hand, feed during fall and winter if they are in saline water. Immediately after spawning males and females fed heavily.

3.42 Food

Juvenile shortnose sturgeon eat available benthic crustaceans or insects (Table 12). Townes (1937), Curran and Ries (1937), Dadswell (1979), Pottle and Dadswell (1979 see Table 2, footnote 1), and Taubert (1980b) all found *Hexagenia* sp., *Chaoborus* sp., *Chironomus* sp., *Gammarus* sp., *Asellus* sp., and *Cyathura polita* to be important prey items. Pottle and Dadswell (1979 see Table 2, footnote 1) found young shortnose sturgeon (20-30 cm FL) often feed extensively on Cladocerans. Adult shortnose sturgeon from

Table 11.—Incidence, mean volume, mean dry weight, and fullness of food in stomachs of adult shortnose sturgeon captured in freshwater (<3 ‰) and saline (>3 ‰) portions of the estuary, Saint John River, Canada (N.B.), and Winyah Bay, S.C. (S.C.), in relation to month. Fullness is Bleguard's index ($W \times 10{,}000$) / W_f where W = weight of ration and W_f = weight of fish.

Month	Sample size N.B.	Sample size S.C.	Number empty N.B.	Number empty S.C.	Incidence (%) N.B.	Incidence (%) S.C.	Volume (ml) N.B.	Volume (ml) S.C.	Dry weight (g)	Index of fullness N.B.	Index of fullness S.C.
Freshwater											
January	8	0	8	0	0.0	—	0.0	—	0.00	0.0	—
February	10	0	9	0	10.0	—	0.6	—	0.28	0.7	—
March	8	0	8	0	0.0	—	0.0	—	0.00	0.0	—
April	7	6	5	4	28.6	33.3	2.0	32.0	0.19	2.5	21.2
May	9	3	3	2	66.6	33.3	16.0	2.5	7.32	12.1	2.5
June	12	8	1	7	91.6	12.5	21.9	35.5	9.56	15.7	22.2
July	16	13	4	6	75.0	53.8	30.1	28.2	9.73	22.4	16.3
August	24	16	4	12	83.3	25	40.7	40.5	12.52	25.6	27.1
September	10	0	1	0	90.0	—	40.2	—	17.83	24.8	—
October	3	0	2	0	33.3	—	20.1	—	7.88	12.4	—
November	4	0	3	0	25.0	—	1.4		0.31	3.8	—
December	5	0	4	0	20.0	—	0.5	—	0.18	1.0	—
Saline water											
September	16	0	2	0	87.5	—	37.4	—	10.85	24.5	—
December	—	6	—	1	—	83.0	—	—	12.1		
February	8	6	2	5	75.0	16.7	21.0	0.5	8.20	16.5	0.1
March	—	1	—	1	—	0.0	—	0.0	—	—	0.0
April	2	—	0	—	100.0	—	19.6	—	1.49	2.5	—

the Saint John River, Canada, eat mostly molluscs (Dadswell 1979). Marchette and Smiley (1982 see Table 2, footnote 24) found *Physa* sp. (53%), *Heliosoma* sp. (47%), and *Corbicula manilensis* (33.3%) to be the most commonly occurring items in stomachs of fish captured in freshwater in South Carolina (Table 13). Curran and Ries (1937) combined adult and juvenile food data, making it impossible to interpret their findings beyond the fact that molluscs constituted 25-53% by volume of the gut contents of all their sampled fish. Benthic crustaceans and insects appear to be relatively more important in the diet of adult shortnose sturgeon from the upper Connecticut River (Taubert 1980b; 4,000+ mayflies in one stomach) and the Hudson River (Curran and Ries 1937), but these findings may be a reflection of food availability rather than a preference change. Dadswell (1979) and Marchette and Smiley (1982 see Table 2, footnote 24) found that electivity of shortnose sturgeon for preferred prey was marked and it is possible the occurrence of nonpreferred prey in the gut is a byproduct of the suctorial feeding method. McCleave et al. (1977) found adult shortnose sturgeon in Montsweag Bay (salinity 18-24 ‰) were feeding on *Mya arenaria*, *Crangon septemspinosa*, and small flounder, Dadswell (1979) found *Mya arenaria* dominated the diet in the lower Saint John estuary (20 ‰), and Marchette and Smiley (1982 see Table 2, footnote 24) found mollusc-shell fragments as well as polychaetes in all sampled shortnose sturgeon.

3.43 Growth rate

Growth in length and weight of shortnose sturgeon has been reported from the Saint John River, Canada (Dadswell 1979), the Kennebec River (Squiers and Smith footnote 7), the Connecticut River (Taubert 1980b; Buckley 1982), the Hudson River (Greeley 1937; Pekovitch 1979 see Table 2, footnote 14; Dovel 1981 see Table 2, footnote 15), the Pee Dee-Winyah Bay region (Marchette and Smiley 1982 see Table 2, footnote 24), and the Altamaha River (Heidt and Gilbert 1978 see Table 2, footnote 27). Because of the slow growth of this species, ageing, which is best done by cross-sectioning a pectoral ray, can be difficult (Fig. 23). The first year's growth (Fig. 16) is often lost by sectioning too far from the body or by subsequent growth processes (Fig. 23). Tight belts of annuli, thought to be caused by slow growth during gonad ripening (Roussow 1957), also make interpretation difficult. Recently, Stone et al. (1981)[15] have developed a method for Giemsa staining of decalcified ray cross sections which improves readability.

Figure 24 shows the known growth rates in length of shortnose sturgeon for its latitudinal range and Figures 25, 26, 27, 28, and 29 illustrate length and weight growth for shortnose sturgeon of different age and sex in the Saint John River, Canada (Dadswell 1979), and the Pee Dee-Winyah system, S.C. (Marchette and Smiley 1982 see Table 2, footnote 24).

Shortnose sturgeon grow fastest in the southern portion of their range but apparently attain smaller maximum size than in the north (Fig. 29; Table 14). The von Bertalanffy growth parameter K varies from 0.044 to 0.149 over the north to south latitudinal range of the species. Juvenile growth is rapid in the south and shortnose sturgeon reach 50 cm after only 2-4 yr (Fig. 24). Growth of juveniles is very similar for the three populations so far studied in the central portion of the range. The Holyoke Pool of the Connecticut River has the slowest growing adults known to date (Fig. 24). This slow growth is probably a reflection of early maturity, and the limited food resources available in the freshwater portion of the river to which the population is confined (Taubert 1980b). The maturity inflection (depression of growth rate) of the length-growth curve is very obvious for the Holyoke Pool population (Fig. 24). Growth of juveniles is slowest in the

[15]Stone, W. B., A. M. Narahara, and W. L. Dovel. 1981. Giesma stained sections of pectoral fin rays for determining the age of sturgeons. Unpubl. ms., 4 p. N.Y. Dep. Environ. Conserv.

Table 12.—Percent occurrence (%) and mean percent volume (%V) of prey in stomachs of juvenile (<50 cm) and adult (>50 cm) shortnose sturgeon from fresh (<3 ‰) and saline (>3 ‰) portions of the Saint John River estuary, Canada.

	Juveniles				Adults			
	Fresh (*n*=49)		Saline (*n*=8)		Fresh (*n*=50)		Saline (*n*=26)	
	%	%V	%	%V	%	%V	%	%V
ANNELIDA: total	0		0		8		23	
Polychaeta: total	0		0		4	1	23	
Scoleolepides viridis	—		0		—	—	23	13
Hirundinea	0		—		4	1	—	
CRUSTACEA: total	50		100		25		16	
Cladocera								
Eurycercus glacialis	8		—		—	—	—	—
Latona setifera	15		—		—	—	—	—
Ostracoda	20	10	—		0	0	—	
Isopoda: total	30		75		6		12	
Cyathura polita	30	61	75	60	6	4	12	8
Amphipoda: total	30		50		12		0	
Hyalella azteca	0		—	—	12	2	—	
Gammarus tigrinus	30	67	50	45	4	1	0	
Mysidacea: total	10		13		0		0	
Neomysis americana	10	2	13	5	0		0	
Decapoda								
Crangon septemspinosa	—	—	0		—	—	4	2
INSECTA: total	70		63		26		12	
Ephemeroptera	40		—		4		—	
Hexagenia sp.	40	57	—		4	2	—	
Trichoptera	30	38	—		8	2	—	
Diptera	60	63			25		12	
Chironomidae	60	35	63	40	25	3	12	2
Chaoborus punctipennis	20	5	—	—	0	0	—	—
Culicoides sp.	31	—	—	—	—	—	—	—
MOLLUSCA: total	10		13		100		95	
Gastropoda: total	10		13		94		23	
Heliosoma anceps	0		—		66	8	—	
Eyraulus deflectus	0		—		26	2	—	
Physa ancillaria	0		1		14	2	—	
Lymnaea elodes	0		—		60	10	—	
Valvata tricarinata	0		—		62	16	—	
Valvata sincera	0		0		56	5	4	1
Amnicola limnosa	10	15	13	10	88	64	19	5
Pelecypoda: total	0		0		52		95	
Elliptio complanata	0		—		1	1	—	
Sphaerium sp.	0		—		30	18	—	
Pisidium sp.	0		—		12	2	—	
Macoma baltica	—		0		—		38	40
Mya arenaria	—		0		—		81	85
Pisces	0		0		2		4	
Anguilla rostrata (larvae)	0		0		2	10	4	5

Table 13.—Percent occurrence (%) and mean percent volume (% V) of prey in stomachs of adult shortnose sturgeon from fresh (<3 ‰) and saline (>3 ‰) portions of the Winyah Bay estuary, S.C.

	Fresh (n = 15)		Saline (n = 6)	
	%	% V	%	% V
Annelida				
Polychaeta	—	—	—	—
Crustacea				
Amphipoda	26.6	0.9	16.7	0.5
Isopoda	20.0	0.25	—	—
Insecta				
Euphemeroptera				
Hexagenia sp.	13.3	51.4	—	—
Diptera				
Chironomidae	6.6	0.2	—	—
Mollusca				
Corbicula manilensis	33.3	64.3	33.3	0.75
Heliosoma sp.	46.6	12.3	—	—
Physa sp.	53.3	85.9	—	—
Shell fragments	6.6	16.0	100.0	89.7
Vegetative matter	20.0	3.5	—	—
Detritus	6.6	40.0	33.3	15.0
Sand	13.3	80.0	—	—

Saint John River, Canada, but adult growth is sustained throughout life, resulting in a larger maximum size in this population. Figure 25 illustrates the different growth rates between adult and juvenile shortnose sturgeon in the Saint John River. The maturity inflection which begins between ages 7 and 10 is overridden when the juveniles migrate to the inshore regions of the lower estuary and a richer food base, resulting in subsequent growth increment increase (Fig. 30; Dadswell 1979). A similar behavior pattern and growth change occurs in South Carolina (Fig. 30; Marchette and Smiley 1982 see Table 2, footnote 24). Most of the Holyoke population is apparently unable to carry out such a migration (Taubert 1980b) and slow adult growth rates may be the result. The smaller L_∞ of adults in the Kennebec and Hudson Rivers, as compared with the Saint John may be due to stress caused by pollution. In other southern populations, smaller L_∞ is probably an expression of younger maturity and more frequent gonad ripening because of faster juvenile growth and warmer water temperatures. This phenomenon is common to fishes with distinct populations over a south-north latitudinal range (Jones 1976). The weight-age relationship of shortnose sturgeon from four studied populations is illustrated in Figure 31. Weights of stage V females from Altamaha River (Heidt and Gilbert 1978 see Table 2, footnote 27) were adjusted to reflect stage II condition (× 0.80). Weight gain is rapid in the south, slower but sustained in the north, and least during the freshwater stage or for solely freshwater populations (Holyoke). The weight-age relationship for the entire life span of shortnose sturgeon in the Saint John River, Canada, is illustrated in Figure 26. The von Bertalanffy growth equation for this population is $W_t = W_\infty\ (1-e^{-0.047(t-2.061)})^3$.

Average length and weight gain/year in various populations are: 5 cm/yr and 400 g/yr, Altamaha River; 2.0 cm/yr and 260 g/yr, Kennebec River; 1.3 cm/yr and 167 g/yr, Holyoke Pool; 1.5 cm/yr and 300 g/yr, Saint John River, Canada. Dadswell (1979) found in a capture-recapture study over a 4-yr period in the Saint John River that observed average length and weight gain among recaptured shortnose sturgeon was 0.72 cm/yr and 490 g/yr (Table 15). Taubert (1980b) found growth of recaptured fish was 1.8 cm/yr. Buckley (1982) found ripe adults massed below the spawning site in the Connecticut River lost an average 15% of body weight during winter before spawning.

In the Saint John River, Canada, Dadswell (1979) found male and female shortnose sturgeon had different growth relationships (Figs. 27, 28). Males grew more rapidly until mature but growth rate as adults decelerated at a greater rate than females. A similar growth pattern occurs in males and females from South Carolina (Fig. 29; Marchette and Smiley 1982 see Table 2, footnote 24). More frequent ripening of gonads among males may be the cause of this type of growth relationship.

3.44 Weight-length relationships, condition factors

The weight-length relationship for shortnose sturgeon from the Saint John River is illustrated in Figure 32 (Dadswell 1979). It is essentially similar to weight-length relationships of other sturgeon species. Weight gain is slow for the first years of life, then increases for most of the remainder of the life span.

The weight-length relationships for shortnose sturgeon populations studied to date are given in Table 16. Some were calculated from preliminary data provided by various workers. In general, the relationships are similar. Calculated condition factors were lowest for the Kennebec River (Squiers and Smith footnote 7) and the Holyoke Pool populations (Taubert 1980b). Both these populations are somewhat stressed, the Kennebec by pollution (Squiers et al. 1981 see Table 2, footnote 3), the Holyoke by confinement to freshwater. Figure 19 compares the weight-length relationship of the Hudson River population for studies 40 yr apart; capture gear differences aside, the two relationships are remarkably similar. Dadswell (1979) found no statistical difference (paired t-tests) between the weight-length relationships of various spawning stage and sexes of shortnose sturgeon from the Saint John River, Canada (Fig. 33).

Condition factor ($k = W/L^3$) of shortnose sturgeon in the Saint John estuary varied through the year, reaching a peak in late winter as gonads of ripe fish reached their maximum size, and declining to the lowest level in May after spawning (Table 17). Average summer condition of shortnose sturgeon was 0.87 and recovery to this level occurred soon after spawning, probably because of the increased feeding observed at this time (Dadswell 1979).

3.45 Metabolism

No data are available on the metabolism of shortnose sturgeon.

3.5 Behavior

3.51 Migrations and local movements

Extent of movements

In estuarine and riverine environments where shortnose sturgeon have been tagged and recaptured, they are known to move considerable distances. In the Saint John estuary, the mean minimum distance travelled by those shortnose sturgeon which moved more than 1 km between recaptures was 22.9 ± 6.7 km. The maximum channel distance travelled between tagging and recapture was 160 km (Dadswell 1979). The mean minimum rate of upstream movement of 11 shortnose sturgeon in the Saint John River between June and August was 4.0 ± 1.5 km/d (Fig. 34). In the Altamaha River, Ga., a shortnose sturgeon moved 193 km

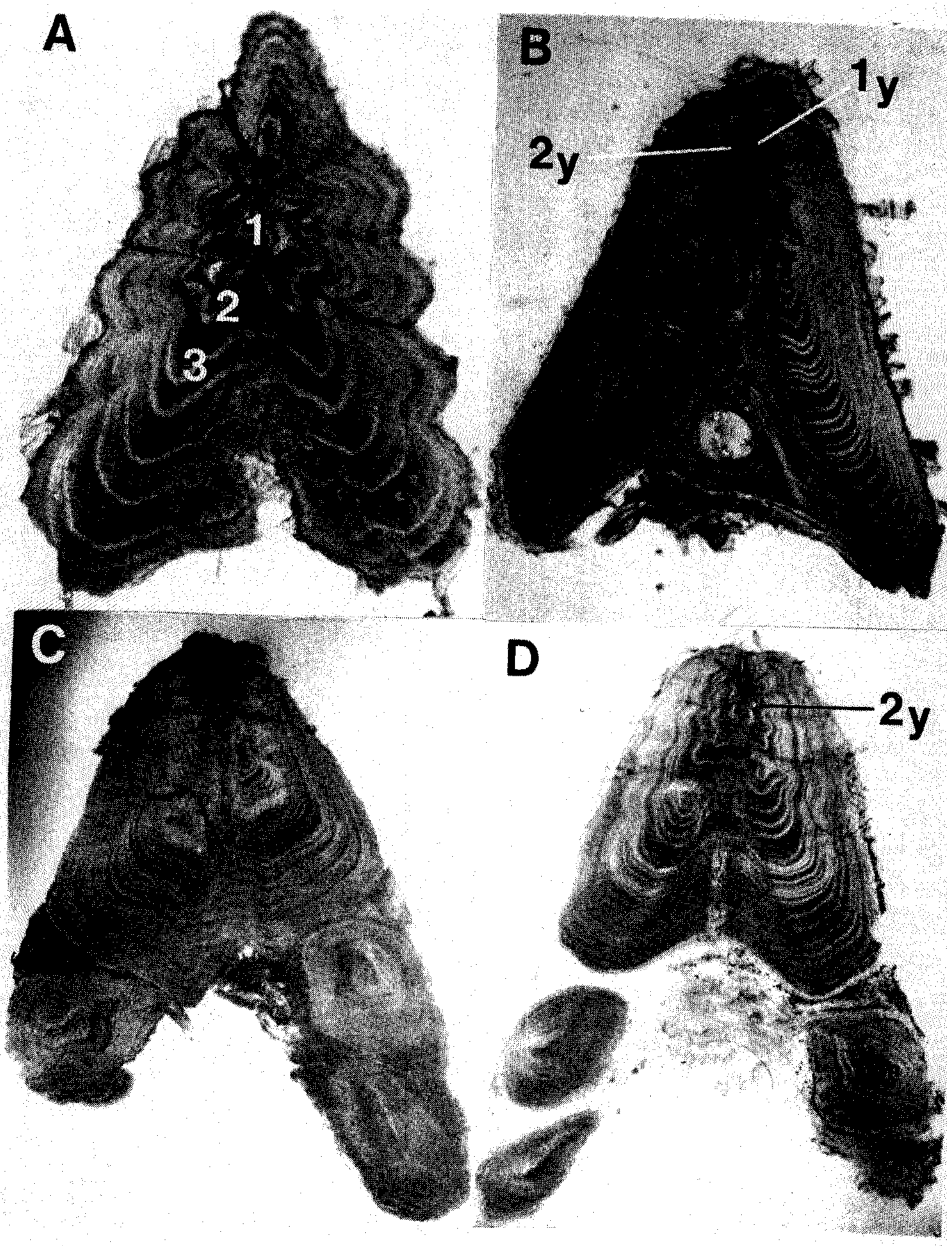

Figure 23.—Transverse sections of the marginal ray of the pectoral fin of shortnose sturgeon showing annuli. Dark zones are summer-formed dense bone; translucent zones, winter period. (A) Juvenile: 45 cm, 0.8 kg; 9 yr (×18). (B) Male: 97 cm, 9.4 kg; 27 yr (×8) (annuli 17 and 19 each have a false annulus associated; year 1 is almost obscured, arrow). (C) Female: 112 cm, 12.5 kg; 40 yr (×5). Matured age 11, spawned at 21, 26, 32, 37 yr. (D) Female: 86 cm, 6.1 kg; 23 yr (×5). Matured at 10, spawned at 16, but no later spawning checks discernible.

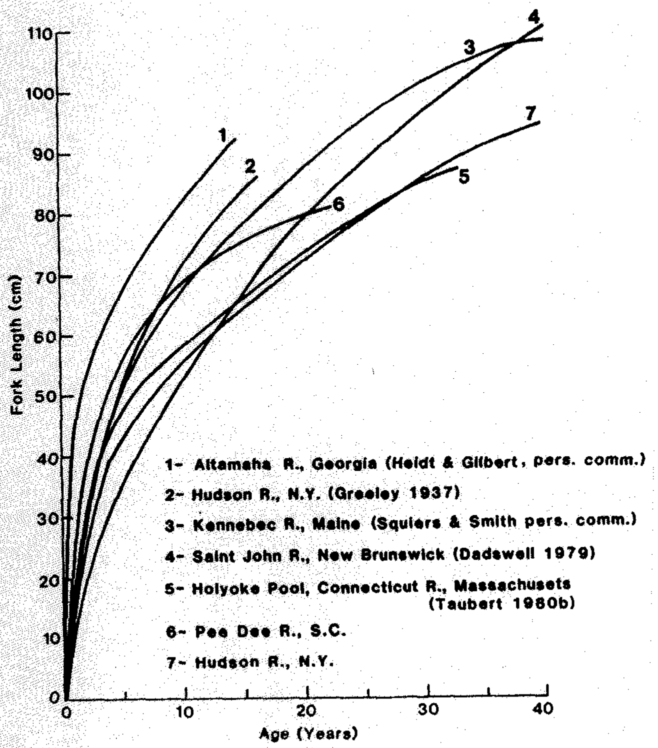

Figure 24.—Growth of shortnose sturgeon in various rivers within the species range. (Sexes combined.)

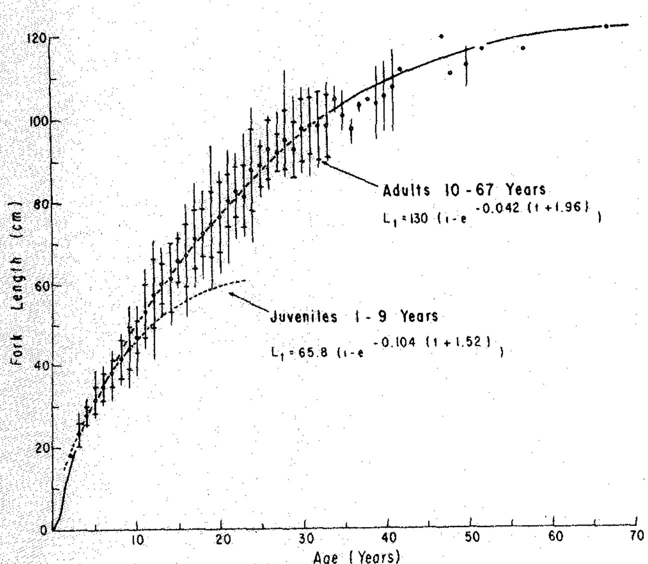

Figure 25.—Growth of juvenile and adult shortnose sturgeon from the Saint John River, Canada. Bars represent range and crossbars 95% confidence limits of year sample. Note sharp change in growth pattern at age 9-10.

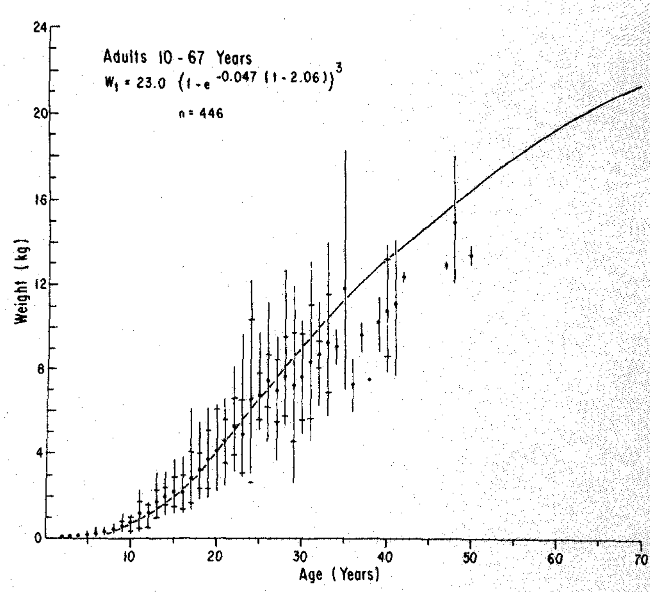

Figure 26.—Weight-age relationship for shortnose sturgeon from the Saint John River, Canada.

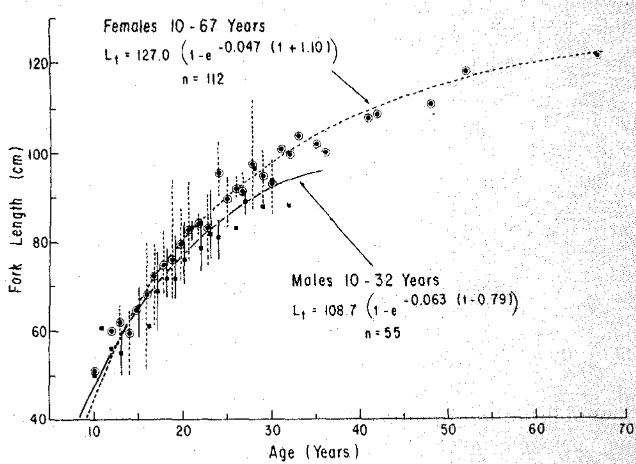

Figure 27.—Growth of male and female shortnose sturgeon from the Saint John River, Canada, fork length versus age.

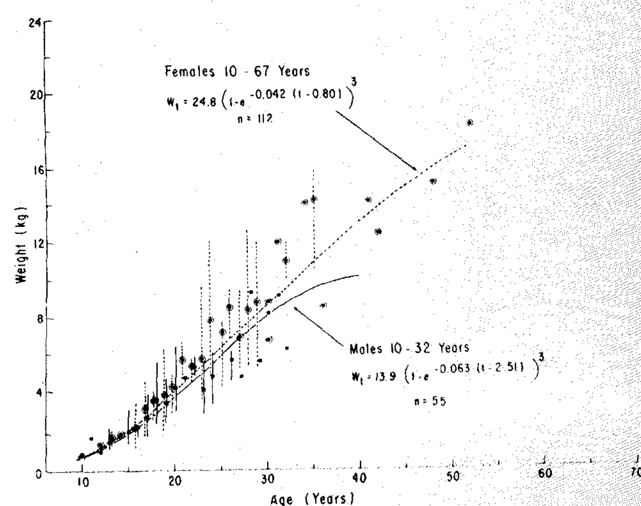

Figure 28.—Growth of male and female shortnose sturgeon from the Saint John River, Canada, weight versus age.

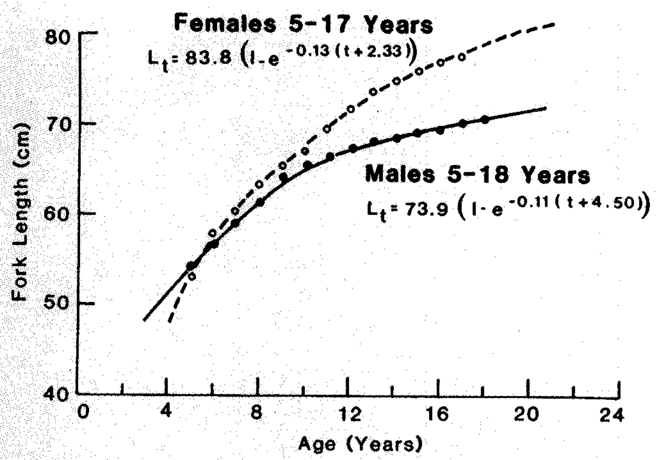

Figure 29.—Growth of male and female shortnose sturgeon from the Pee Dee-Winyah system, S.C.

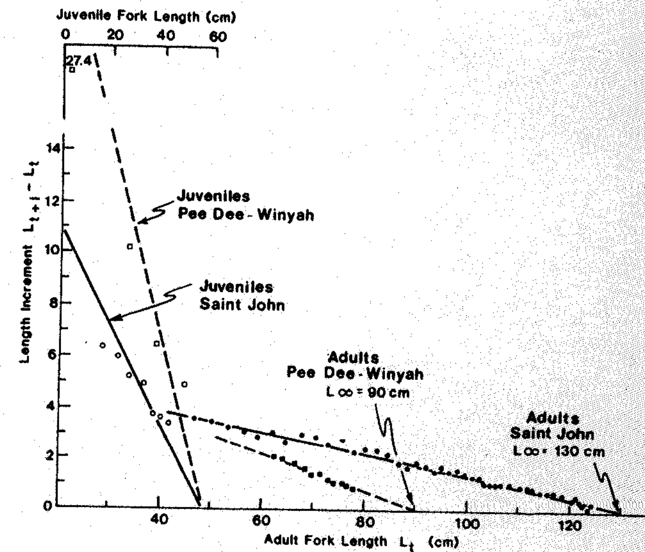

Figure 30.—Yearly length-increment change during growth of shortnose sturgeon from the Saint John estuary, Canada, and the Pee Dee-Winyah estuary, S.C. Growth increments of < 50 cm (open circles) and > 50 cm (solid circles).

Table 14.—Von Bertalanffy growth parameters for length relationships of shortnose sturgeon populations of eastern North America.

Locality	Latitude	L_∞ (FL)	K	t	Source
Altamaha R., Georgia	32°N	97.0	0.149	−3.15	Heidt and Gilbert[1]
Pee Dee-Winyah, S.C.	34°N				
Females		83.8	0.133	−2.33	Marchette and
Males		73.9	0.114	−4.50	Smiley (see
Combined		87.0	0.093	−6.02	Table 2, footnote 24)[1]
Hudson R., N.Y.	42°N				
Females		102.6	0.079	−3.17	Greeley (1937)[1]
Males		57.9	0.305	−1.80	
Combined		106.4	0.044	6.39	Dovel (see Table 2, footnote 15)[1]
Connecticut R.	43°N				
Lower		100.0	0.073	−2.73	Buckley (unpubl. data)[1]
Holyoke Pool, Mass.		87.8	0.084	−2.64	Taubert (1980b)
Kennebec R.,	44°N	[2]93.8	0.098	−3.89	Squiers and Smith (see text footnote 7)
Saint John R., Canada	45°N				
Females		127.0	0.047	−1.10	Dadswell (1979)
Males		108.7	0.063	0.79	
Combined		130.0	0.042	−1.96	

[1]Calculated from original data by Dadswell.
[2]Sturgeon longer than this were observed.

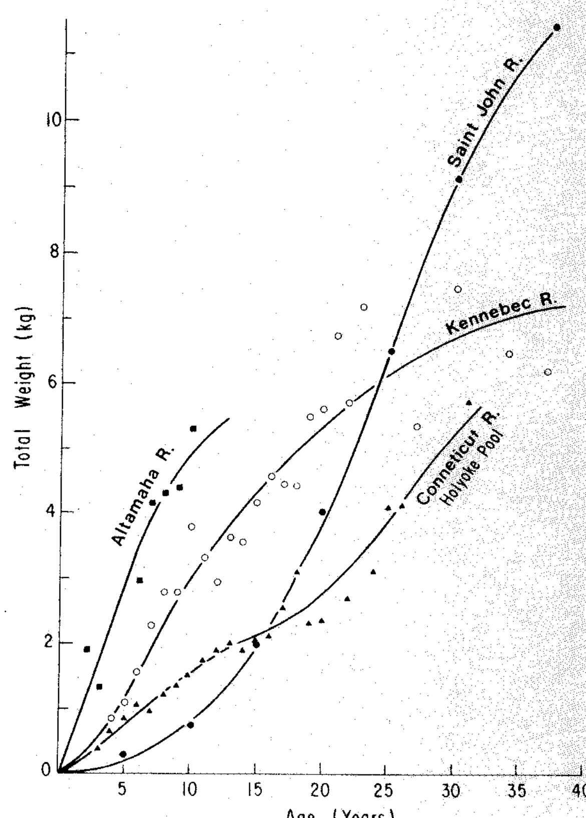

Figure 31.—Weight-age relationship of shortnose sturgeon from four rivers spanning the range of the species.

Table 15.—Observed mean length ($\Delta\bar{L}$) and mean weight ($\Delta\bar{W}$) change of tagged shortnose sturgeon during 1 to 4 yr at large in the Saint John estuary, Canada. Obvious large 1-yr weight increases due to female gonad maturation were excluded from data.

Period at large	ΔT (yr)	N	$\Delta\bar{L}$ (cm)	$\Delta\bar{W}$ (kg)	$\Delta\bar{L}/\Delta T$	$\Delta\bar{W}/\Delta T$
1973-74	1	32	0.8	0.2	0.8	0.2
1974-75	1	19	0.7	0.1	0.7	0.1
					mean $\Delta\bar{L}/\Delta T$=0.75	$\Delta\bar{W}/\Delta T$=0.15
1973-75	2	15	1.3	0.5	0.65	0.25
1974-76	2	19	1.4	1.5	0.70	0.75
1975-77	2	4	2.2	1.2	1.1	0.60
					mean $\Delta\bar{L}/\Delta T$=0.82	$\Delta\bar{W}/\Delta T$=0.53
1973-76	3	2	0.0	2.8	0.0	0.93
1974-77	3	11	3.7	2.4	1.23	0.80
					mean $\Delta\bar{L}/\Delta T$=0.62	$\Delta\bar{W}/\Delta T$=0.86
1973-77	4	4	2.2	1.2	0.55	0.30
					All data mean $\Delta\bar{L}/\Delta T$=0.72	$\Delta\bar{W}/\Delta T$=0.49

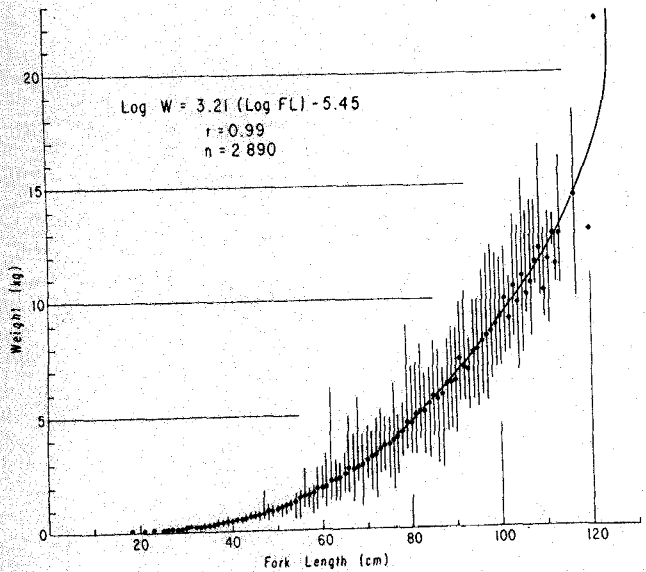

Figure 32.—Weight-length relationship for shortnose sturgeon from the Saint John River, Canada. Circles are mean weight for 1 cm length increments, bars are range of weight.

downstream in 11 d (Heidt and Gilbert 1978 see Table 2, footnote 27) and in the Connecticut River one radio-tagged shortnose sturgeon moved 60 km in 2 d (Buckley, unpubl. data). McCleave et al. (1977), using sonic tags, documented a mean daily rate of shortnose sturgeon movement of about 20 km in Montsweag Bay, Maine. Shortnose sturgeon movement during the Montsweag study appeared to be predominately nondirected, random feeding movements, often into very shallow water.

On the other hand, Taubert (1980b), using radio tags, found that for the landlocked population of shortnose sturgeon in the Holyoke Pool, Connecticut River, individuals had small home ranges which they inhabited year around unless they migrated upstream in spring to spawn. No general migration of the population to spawning or overwintering sites was observed, but it may have gone unnoticed because of small population size. It appeared that the tagged sturgeon had the ability to leave their home area

Table 16.—Weight-length relationships for shortnose sturgeon populations from the east coast of North America.

Locality	Relationship	Source
Altamaha R., Georgia	[1]LogW = 2.95(LogFL)−5.01	Heidt and Gilbert[2]
Pee Dee R., S.C.	LogW = 3.06(LogFL)−5.29	Marchette and Smiley (see Table 2, footnote 24)
Delaware R., N.J.	[1]LogW = 3.11(LogFL)−4.25	Hastings (see Table 2, footnote 19)[2]
Hudson R., N.Y.	[1]LogW = 2.85(LogFL)−4.82	Greeley (1937)[2]
Hudson R., N.Y.	[1]LogW = 3.25(LogFL)−5.56	Dovel (see Table 2, footnote 13)[2]
Hudson R., N.Y.	[3]LogW = 2.73(LogTL)−10.12	Pekovitch (see Table 2, footnote 14)
Holyoke Pool Connecticut R., Mass.	[3]LogW = 3.03(LogFL)−5.23	Taubert (1980b)
Lower Connecticut R.	LogW = 2.98(LogFL)−5.08	Buckley (unpubl. data)
Kennebec R., Maine	[1]LogW = 3.10(LogFL)−4.90	Squiers and Smith (see text footnote 7)
Saint John R., Canada	[1]LogW = 3.20(LogFL)−5.45	Dadswell (1979)

[1]W in kg, FL in cm.
[2]Calculated by Dadswell.
[3]W in g, TL in mm.

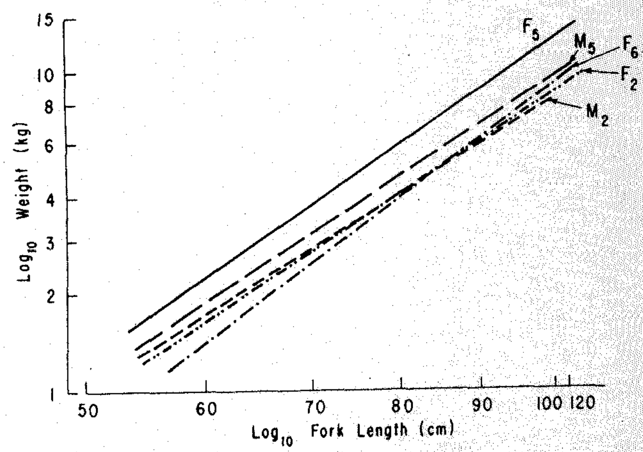

Figure 33.—Log-log regressions of weight-length relationships for stage II, and V male and stage II, V, and VI female shortnose sturgeon from the Saint John River, Canada.

Table 17.—Mean condition factor ($K = [W \times 10] / L^3$) by month for shortnose sturgeon in the Saint John estuary, Canada.

Month	K	Month	K
January	0.85	July	0.82
February	1.12	August	0.86
March	1.28	September	0.91
April	0.91	October	1.11
May	0.73	November	1.19
June	0.88		

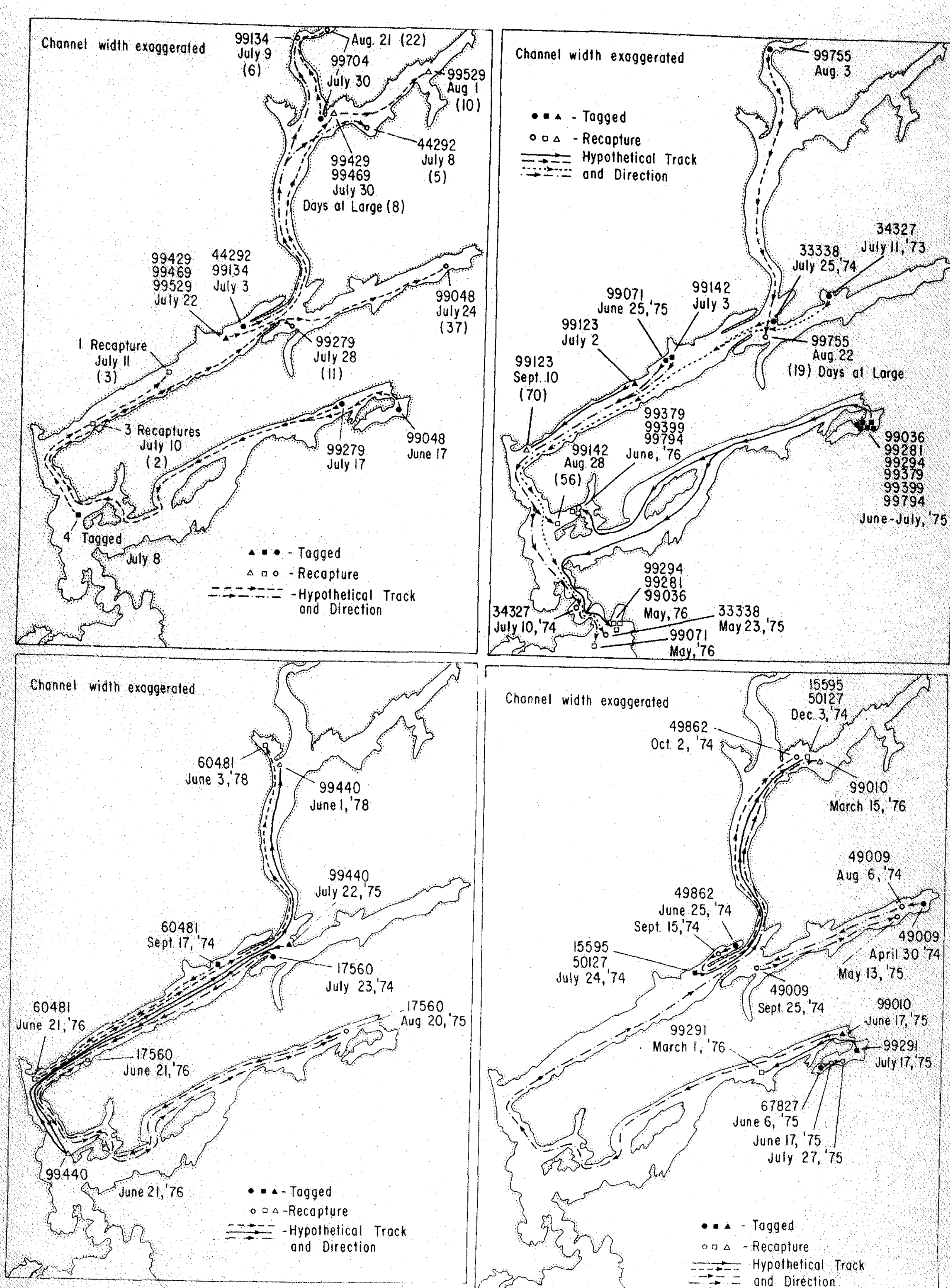

Figure 34.—Movement of selected shortnose sturgeon in the Saint John estuary, Canada: Top left, short-term movement, July-August, movement predominantly upstream; top right, movement between late summer to early spring, generally downstream; bottom left, long-term migratory movement; bottom right, residential behavior during summer and movement to winter concentration sites. Numbers in parentheses under dates in top figures indicate number of days at large between capture and recapture.

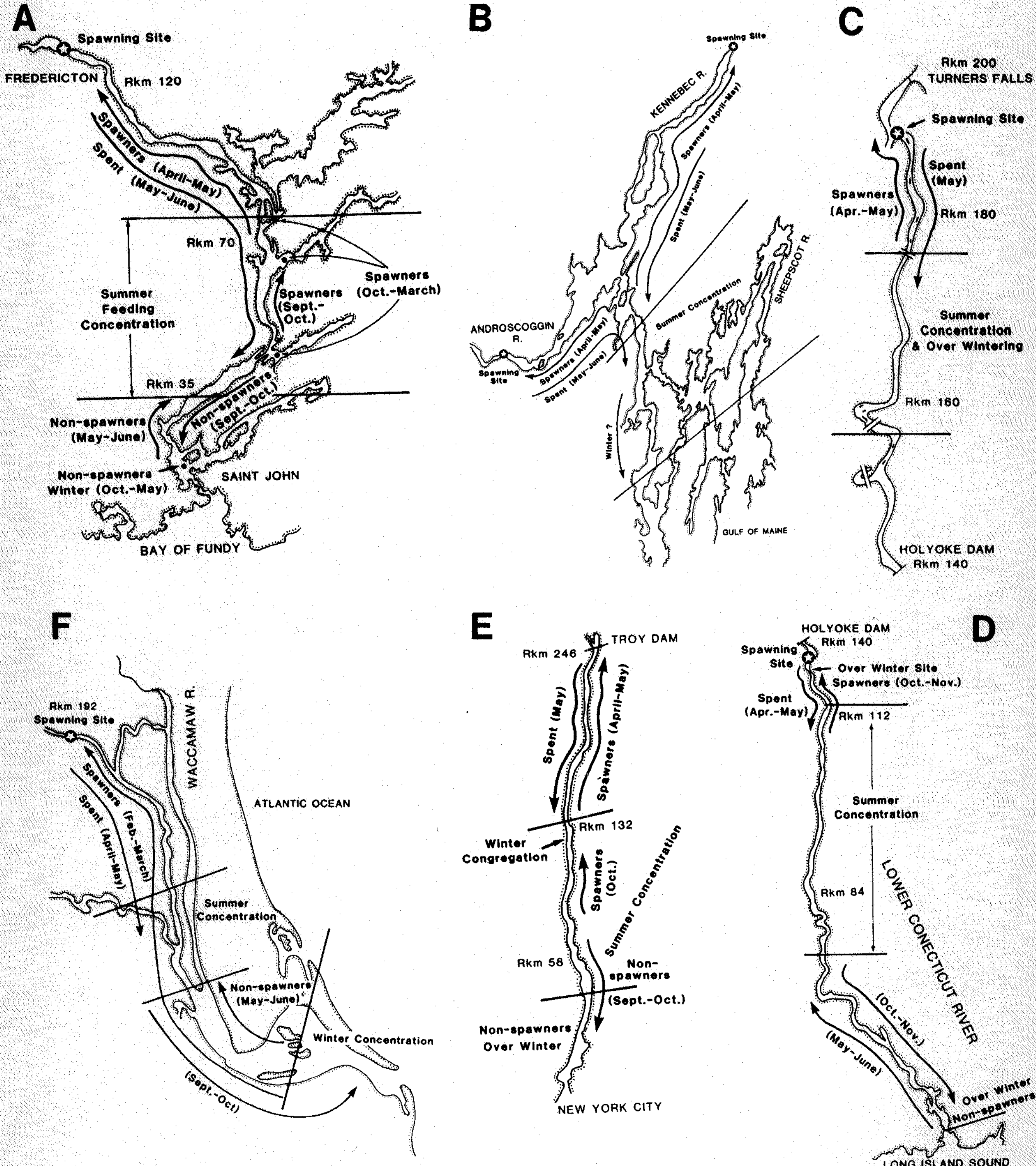

Figure 35.—Migration patterns of various life stages of shortnose sturgeon in river systems studied to date. A) Saint John River, Canada; B) Kennebec River, Maine; C) Holyoke Pool, Connecticut River, Mass.; D) Lower Connecticut River; E) Hudson River, N.Y.; F) Pee Dee-Winyah Bay system, S.C.

and return after long-distance movements. Buckley (1982) found that radio-tagged shortnose sturgeon in the lower Connecticut River also tended to stay in localized areas during summer but migrations occurred in spring and fall similar to those in other rivers (Fig. 35). He found the mean daily rate of migration against the current, from feeding grounds to spawning grounds, was 0.82 ± 0.47 km/d.

To date shortnose sturgeon have not been shown to move in the sea away from the influence of their home river system (Fig. 7). As recent studies suggest, continued research may reveal that marine movements of this species are extensive (Wilk and Silverman 1976; Holland and Yelverton 1973; Marchette and Smiley 1982 see Table 2, footnote 24).

Direction and mode of migratory movements

The normal pattern of migration in shortnose sturgeon conforms to the simple model of Harden Jones (1968) in which, during life, fish move between feeding, wintering, and spawning areas (Fig. 35).

Seasonal gill net catch data from discrete estuarine localities in the Saint John River demonstrated bimodal abundance peaks in the mid-estuary and a unimodal peak in the upper estuary (Fig. 36; Dadswell 1979). Recaptures of tagged shortnose sturgeon in the Saint John River indicate changing abundance patterns which represent annual migration upriver in spring-summer and downriver in fall by most of the nonripening portion of the population (Fig. 34). Some ripening males carried out a similar migration but

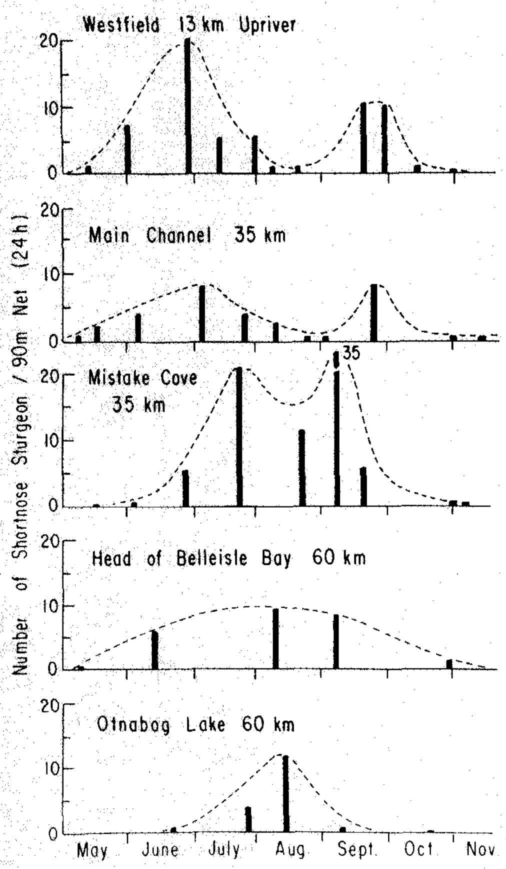

Figure 36.—Number of shortnose sturgeon captured per standard gill net set in various localities of the Saint John River, Canada, during May to November.

many ripening males and females either migrated farther upriver in the fall or remained at upriver locations over winter (Fig. 34; Dadswell 1979; Buckley 1982). Abundance peaks during downstream migration were of shorter duration, suggesting this migratory phase was more rapid.

Squiers and Smith (footnote 7) reported similar behavior of shortnose sturgeon in the Kennebec River. Recaptures of tagged shortnose sturgeon during July occurred upstream of June tagging sites and downstream sites had bimodal abundance peaks, while upstream sites had unimodal peaks.

Heidt and Gilbert (1978 see Table 2, footnote 27) and Gilbert and Heidt (1979), however, observed a different migration pattern in the Altamaha River, Ga. There, shortnose sturgeon were found upstream during February and March while spawning but during the remainder of the year were taken only in the first few kilometers of the river within tidal influence. Marchette and Smiley (1982 see Table 2, footnote 24; Fig. 8b) reported a similar migration pattern in the tributaries of Winyah Bay, S.C., with adults spending the winter in the estuary or the sea within 5,000 m of shore. Documentation of shortnose sturgeon movements in the Hudson River is still in progress but current information suggests a combination of patterns occur. There is a spawning run in spring to the upper reaches of the estuary (rkm 130-150; Dovel 1981 see Table 2, footnote 15; Pekovitch 1979 see Table 2, footnote 14; Greeley 1937), many actively feeding adults occur in the river during summer (Curran and Ries 1937; Dovel 1978 see Table 2, footnote 13), and adults are also captured in the sea during summer about the mouth of the river (Schaefer 1967; Wilk and Silverman 1976). In the Holyoke Pool of the Connecticut River, shortnose sturgeon were found to move only short distances except during upstream spawning migration (Taubert 1980b). In the lower Connecticut River, movement patterns are similar to those in the Saint John River (Kynard et al. 1982;[16] Buckley 1982; Fig. 35). Dadswell (1979) found that a portion of the Saint John River shortnose sturgeon population migrated to the Bay of Fundy but remained close to the river mouth.

In contrast with the migratory behavior of the adults, juvenile shortnose sturgeon are nonmigratory and largely confined to the inland riverine portion of estuaries upstream of the salt wedge (Pottle and Dadswell 1979 see Table 2, footnote 1). In the Saint John River, juveniles are only captured seaward of the normal salt-wedge excursion region during flood periods (Dadswell 1979). The mean length of shortnose sturgeon in the under 45 cm size group was least in upriver portions of the estuary and the length difference between size classes with a mean length of < 45 cm and > 45 cm was greatest in downstream and lacustrine regions (Table 3). These data suggest there is a gradual downstream movement of juveniles as they become older. Recent work has shown that the major juvenile concentration is just inland of the salt wedge and they move in the estuary according to salt-wedge perturbations (Pottle and Dadswell 1979 see Table 2, footnote 1). Dovel (1978 see Table 2, footnote 13) found a similar distributional relationship for juvenile shortnose sturgeon in the Hudson River.

Time or season of migration

Spawning migrations to the upstream spawning grounds occur in spring or fall. Spring movement onto the spawning grounds ap-

[16]Kynard, B., J. Buckley, and W. Gabriel. 1982. Shortnose sturgeon biology below Holyoke Dam. Mass. Coop. Fish. Res. Unit, Univ. Mass., Amherst, 8 p.

pears to be initiated by water temperatures rising above 8°C (Pekovitch 1979 see Table 2, footnote 14; Taubert 1980a; Anonymous 1980 see Table 2, footnote 2). Limited available data suggest males migrate upstream in the fall to winter holding areas before females and perhaps occupy the spawning grounds first (Pekovitch 1979 see Table 2, footnote 14; Anonymous 1980 see Table 2, footnote 2). However, sampling of overwintering fish on the spawning grounds below Holyoke Dam on the Connecticut River revealed the ratio of males to females was 1:1 (Buckley 1982).

Feeding migrations occur immediately after spawning. Spent fish in the Saint John and Connecticut Rivers migrate back downstream rapidly and join the slower, general upstream movement of the remainder of the population (Fig. 35; Dadswell 1979; Buckley 1982). Upstream migration during summer in the Saint John River, Canada, and Kennebec River may be the adaptational response of a warmwater species to environmental conditions at the northern end of its range. However, in both the Saint John and Winyah systems, the abundance of shortnose sturgeon on foraging grounds was highest in mid-estuary where salinities averaged 1 ‰ (Fig. 8; Dadswell 1979; Marchette and Smiley 1982 see Table 2, footnote 24). During summers of high river flow (i.e., reduced estuarine salinity) summer abundance peaks in the Saint John River were displaced seaward. The opposite situation occurred during summers with reduced flows (i.e., increased estuarine salinity). In addition, interspecific competition with juvenile Atlantic sturgeon may influence distribution of shortnose sturgeon. Dadswell (1979) found that juvenile Atlantic sturgeon dominated catches in higher salinities (> 3 ‰) and adult shortnose sturgeon dominated catches in freshwater. Rapid downstream migration, which occurs in early fall in the Saint John and Pee Dee Rivers, was probably in response to seasonal cooling (Figs. 8, 34). Salinity relationships during this period seemed of little consequence as large numbers of shortnose sturgeon occupied lower estuary foraging grounds in salinities over 20 ‰ (Dadswell 1979; Marchette and Smiley 1982 see Table 2, footnote 24). Squiers and Smith (footnote 7) noted a similar occurrence in the Kennebec estuary.

Wintering migrations occur in autumn, specifically during the last few weeks of September in the Saint John River, Canada (Dadswell 1979). Wintering sites are discrete (Fig. 8) and generally occur in deep areas of lakes and river channels or in halocline regions of the lower estuary (Dadswell 1979). Overwintering sites in the lower Saint John estuary are characterized by salinities averaging 20 ‰ and temperatures of 2°-13°C. They are usually occupied by nonripening adults, stage IV males and large juveniles. Freshwater overwintering sites were characterized by depths in excess of 10 m, moderate tidal currents, and cold water (0°-2°C) and were occupied mainly by juveniles and stage IV females (Dadswell 1979).

Buckley (1982) found one overwintering site for ripe adults in the Connecticut River was a discrete 1,500 m section below the Holyoke Dam. Other shortnose sturgeon moved to the estuary for the winter.

Dovel (1979,[17] 1981 see Table 2, footnote 15) and Pekovitch (1979 see Table 2, footnote 14) found a similar wintering behavior of shortnose sturgeon in the Hudson River. Concentration of shortnose sturgeon occurred in deep parts of the estuary in both fresh and brackish water from Kingston to the George Washington Bridge (rkm 94-12). Greeley (1935) reported a ripe, female, shortnose sturgeon captured at Albany during the winter of 1934.

In the Pee Dee-Winyah system, S.C., a temperature decline of 2°-3°C stimulated downriver migration in September to overwintering sites. Overwintering sites were in the lower estuary in channels leading into shallow estuarine lakes, in the estuary proper, and in the ocean within 5,000 m of the beach (Marchette and Smiley 1982 see Table 2, footnote 24). Overwintering sites had surface water temperatures of 5°-10°C and salinities of 18-30 ‰.

Changes in pattern with age and condition

See juveniles and spawning migrations above.

3.52 Shoaling

Shoaling or schooling of shortnose sturgeon has not been reported for young-of-the-year or juveniles, although it is known to occur in other sturgeon species (Scott and Crossman 1973). Most workers report that capture of shortnose sturgeon in gill nets suggests the adults space themselves evenly over the foraging area with no suggestion of shoaling.

Dadswell (1979), however, found that although there was a general upriver movement of the entire population during summer, multiple recaptures of individual shortnose sturgeon within confined areas during July-September suggested that once reaching a certain locality a portion of the population became resident there (Fig. 34). Additionally, the incidence of recapture of individuals in a particular locality from year to year was high (Table 18). Either sampling merely intercepted the movement pattern at the same time and place annually, which suggests a regular, cohort-type migration, or segments of the population "homed" to foraging areas. Both Taubert (1980b) and Buckley (1982) have observed similar behavior in the Connecticut River. There, radio-tagged sturgeon occupied small home ranges to which they returned after migration.

A further striking feature about shortnose sturgeon recaptures in the Saint John River, Canada, and the Connecticut River was their tendency to be grouped (Dadswell 1979; Buckley 1982). Shortnose sturgeon which had been captured and tagged in the same locality on the same day one year were recaptured together in the same or a different locality after a 1-yr or more interval. On the Saint John River, nine shortnose sturgeon tagged in a single day were recaptured together after periods at liberty of 1 yr or more. Also, on seven occasions in the Saint John River shortnose sturgeon tagged in sequence were recaptured together, often side by side, after 1- to 3-yr intervals. The probability of the latter event occuring at random is 1.88×10^{-24} and is highly unlikely.

3.53 Responses to stimuli

Environmental stimuli

No research on shortnose sturgeon has been carried out in this field.

Artificial stimuli

While transporting adult shortnose sturgeon, Dadswell (pers. obs.) found they tolerated light and temperature variations well but were very susceptible to mechanical shock. A small accident

[17]Dovel, W. L. 1979. Atlantic and shortnose sturgeon in the Hudson River estuary. Rep. for U.S. Environ. Prot. Agency, The Oceanic Soc., Conn., 26 p.

Table 18.—Numbers of shortnose sturgeon in the Saint John River, Canada, recaptured during July and August in the same site during the year of initial tagging and in subsequent years in the same or a different site. Site defined as area within 1 km radius of original capture site.

	Recaptures								
	Same site and year[1]			After 1 yr		After 2 yr		After 3 yr	
Tagging site	1X	2X	3X	Same[2]	Diff.	Same	Diff.	Same	Diff.
Mistake Cove[3]	47	4	1	48	12	4	2	1	2
Belleisle Bay	27	2	1	6	7	1	1	1	0
Darlings Lake	24	3	1	No sampling subsequent years					
Tennants Cove	4	0	0	10	4	5	6	0	3
Otnabog Lake	3	0	0	4	0	3	2	2	0
Total	105	9	3	[4]68	23	13	11	4	5

[1]Recapture efforts at a minimum of 4-wk intervals.
[2]Total effort in alternate sites 4X effort in any one original tagging site except Mistake Cove where alternate effort only 2X more.
[3]Total initial tagging effort in Mistake Cove was twice that of other sites.
[4]Incidence of "Homing" 1st yr 68/91 = 0.75, 2nd yr 13/24 = 0.59, 3rd yr 4/9 = 0.44.

on the highway in which the shortnose sturgeon were knocked about in their transport tank, but during which no water spilled, resulted in instantaneous, complete mortality of nine specimens of all sizes. Before and after that accident, large numbers of shortnose sturgeon have been transported in both New Brunswick and South Carolina for up to 15 h, held in tanks for 15 d, and handled during experiments for periods up to 1.5 yr with no mortality.

4 POPULATION

4.1 Structure

4.11 Sex ratio

Among adult shortnose sturgeon from the Saint John River, the ratio of females to males in the general population was 2:1 (Dadswell 1979); in the Pee Dee River it was 1:1 (Marchette and Smiley 1982 see Table 2, footnote 24). In both studies, adults were either randomly selected from the daily catch and sacrificed or were net mortalities and, since sex can not be determined prior to dissection, observed sex ratio was likely a true representation of the adult population. At younger ages, the ratio of females to males was 1:1, but among shortnose sturgeon over 20 yr old in the Saint John River, Canada, and 10 yr old in the Pee Dee River, S.C., females were more numerous (Table 19). The observed population structure was thought an expression of a shorter life span for males (Dadswell 1979). Greeley (1937) found a ratio of 1.42:1 females to males among Hudson River shortnose sturgeon. Meehan (1910) found that among a sample of over 100 shortnose sturgeon from the Delaware River, taken at random from commercial fishermen catches, females represented more than 50%. Gilbert and Heidt (1979) captured four females and three males from the spawning run in the Altamaha River, but their sampling was limited and the sex ratio is probably not representative.

During 1977 and 1978 Taubert and Reed (1978)[18] captured 14 males and 4 females on the spawning grounds in the Holyoke Pool and Pekovitch (1979 see Table 2, footnote 14) captured 157 males and 63 females on the spawning grounds in the Hudson River. The preponderance of males to females during the spawning runs is a common occurrence among *Acipenser* species (Vladykov and Greeley 1963; Cuerrier 1966; Magnin 1966), and among fish in general, and without adequate sampling cannot be regarded as representative of the population as a whole.

Table 19.—Sex ratio of shortnose sturgeon from the Saint John River, Canada, and the Pee Dee River, S.C., as related to age.

Saint John, Canada			Pee Dee, S.C.		
Age	Number	% female	Age	Number	% female
5-9	—	—	5-7	4	30.8
10-14	17	47.1	5-10	12	40.0
15-19	60	55.0	11-13	11	78.6
20-24	42	76.0	13-15	5	83.3
25-29	31	81.0	16-18	4	80.0
30-34	16	81.2	Total	36	$\bar{X}$ = 62.5
35-70	5	100.0			
Total	171	$\bar{X}$ = 70.6			

4.12 Age composition

Shortnose sturgeon may not exhibit strong year-to-year variation in year class strengths due to their long life span. Dadswell (1979) found that among a relatively nonbiased sample (ages 15-50) there was a regular decrease in year class size with age and no particular abundance of any one year class (Fig. 37).

Perhaps among southern populations, which have shorter life spans, year class strength will be observable.

4.13 Size composition

Figure 38 illustrates the size composition of captured shortnose sturgeon during 3 yr sampling on the Saint John River. In the size range adequately sampled by the gear (60-120 cm), no predominance or stratification of sizes was observed. The relatively greater catches of large shortnose sturgeon during 1974 was attributed to the greater selectivity of the large mesh gill nets (Fig. 39). When selectivity and effort were adjusted for, no size class dominance was observed (Table 20) (Dadswell 1979).

[18]Taubert, B. D., and R. J. Reed. 1978. Observations of shortnose sturgeon (*Acipenser brevirostrum*) in the Holyoke Pool, Connecticut River, Massachusetts. Rep. to Northeast Utilities Service Co., Hartford, Conn., 24 p.

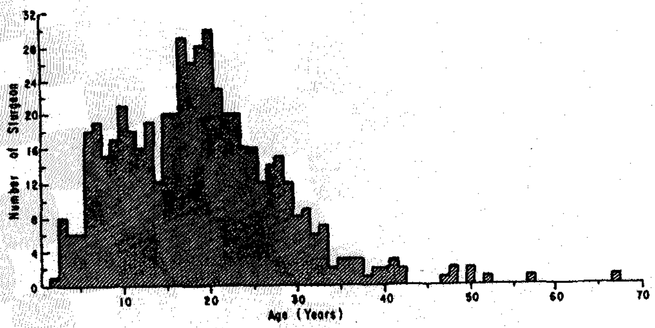

Figure 37.—Age composition of shortnose sturgeon sampled from the Saint John River, Canada. Predominance of fish around age 20 is an artifact of gill net selectivity for that size of sturgeon. Fewer shortnose sturgeon of younger age reflects small amount of effort with nets selective for that size and the differential distribution of juveniles and adults (Dadswell 1979).

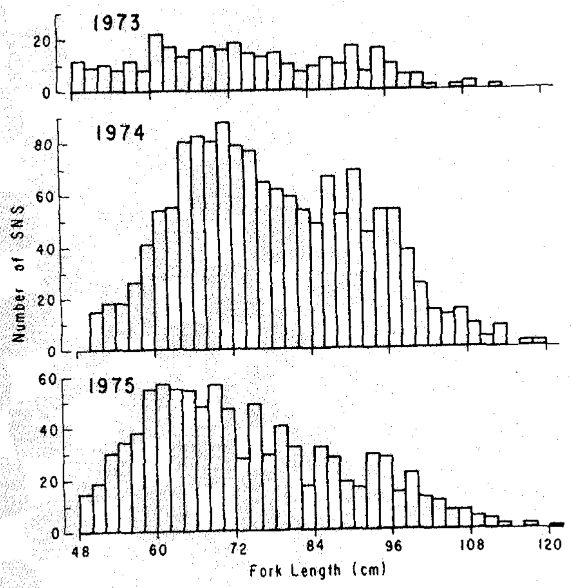

Figure 38.—Size composition of gill net catches of shortnose sturgeon from the Saint John River, Canada, during each of 3 yr.

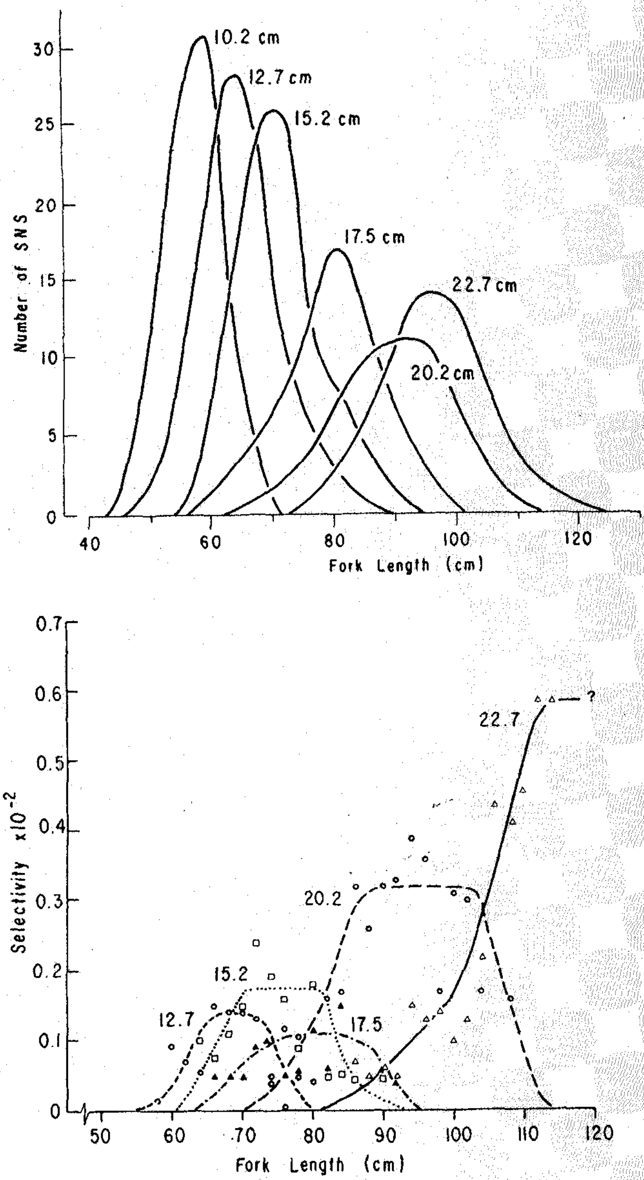

Figure 39.—Indirect selectivity (top) and direct selectivity (bottom) of #12 monofilament gill net of various stretched-mesh sizes for shortnose sturgeon. Note the greater efficiency of large mesh size nets.

Maximum size

The maximum known size for shortnose sturgeon is a 122 cm FL, 143 cm TL female captured in the Saint John estuary (Dadswell 1979). Total weight of this sexually resting (stage II) individual was 23.6 kg (52 lb.) The specimen is deposited at the Royal Ontario Museum, Toronto, Canada (Cat. No. ROM 34310). Shortnose sturgeon longer than 100 cm FL and weighing more than 10 kg are common in the Saint John River (Gorham and McAllister 1974). The largest male on record is a 97.0 cm FL, 108 cm TL, 9.4 kg specimen from the Saint John estuary (Dadswell 1979).

Maximum size among shortnose sturgeon populations varies over the north to south range of the species (Table 21) with larger maximum sizes known from northern populations. Larger maximum sizes may be found in southern populations after more sampling with large mesh gill nets (20 cm stretched mesh).

Length and weight relationships

See section 3.44.

4.14 Subpopulations

Data collected so far suggest that within each river along the Atlantic seaboard there is one shortnose sturgeon population, except perhaps in the Connecticut River where populations are physically separated by the Holyoke Dam. Whether each river population is a distinct entity from others awaits future chemical or genetic population discrimination studies. Southern populations may mix in the sea. Northern populations appear confined to their separate drainage systems.

Table 20.—Catch by size class and assigned mean age, actual (C_{ac}) and adjusted (C_{ad}) total catches of shortnose sturgeon for various mesh gill nets during 1974 and July-August 1975 in the Saint John River, Canada. Effort by mesh size was: 1974, 15.2 cm = 143 net-nights, 20.2 = 162 net-nights; 1975, all meshes = 24 net-nights. Total adjusted catch $\Sigma C_{ad} = \Sigma C_{ac} / \hat{S}_i X_1 / X_2$ where X_1 is effort/mesh and X_2 is total effort of overlapping catch curves. Selectivities used were smoothed estimates from Figure 39. Underlined counts are from selectivity plateau of each mesh-size curve and were used to calculate total instantaneous mortality.

		1974				1975						
Length (cm)	Age (yr)	15.2	20.6	ΣC_{ac}	ΣC_{ad}	12.7	15.2	17.5	20.2	22.7	ΣC_{ac}	ΣC_{ad}
61-63	14	46	—	46	1,608	39	19	0	—	—	58	2,093
64-66	15	87	—	87	761	34	29	5	—	—	68	1,188
67-69	16	78	2	80	333	28	29	6	2	—	65	754
70-72	17	78	3	81	253	22	40	10	2	—	74	747
73-74	18	47	3	50	127	7	12	7	2	—	28	288
75-76	19	50	6	56	134	9	23	13	4	—	49	487
77-78	20	35	6	41	93	6	10	10	4	1	31	410
79-80	21	37	7	44	94	5	9	17	6	3	40	528
81-82	22	22	15	37	78	2	2	14	8	3	29	508
83-84	23	15	24	39	97	1	3	7	4	2	17	297
85-86	24	14	19	33	118	0	6	14	5	7	32	531
87-88	25	11	33	44	161	1	4	8	8	7	28	439
89-90	26	4	34	38	102	—	1	4	11	2	18	224
91-92	27	2	41	43	109	—	0	2	9	6	17	212
93-94	28	1	38	39	73	—	1	3	8	14	26	324
95-96	29	2	35	37	67	—	—	1	11	14	26	335
97-98	30	—	36	36	69	—	—	0	7	6	13	129
99	31	—	14	14	27	—	—	1	5	6	12	102
100	32	—	15	15	29	—	—	0	2	8	10	105
101	33	—	11	11	21	—	—	0	2	3	5	41
102	34	—	10	10	19	—	—	—	3	4	7	57
103	35	—	5	5	10	—	—	—	1	4	5	36
104	36	—	8	8	15	—	—	—	3	3	6	42
105	37	—	8	8	21	—	—	—	0	2	2	12
106	38	—	5	5	13	—	—	—	1	4	5	33
107	39	—	7	7	27	—	—	—	0	3	3	15
108	40	—	7	7	27	—	—	—	2	4	6	45
109	41	—	4	4	25	—	—	—	1	1	2	25
110	42	—	3	3	18	—	—	—	1	1	2	25
111	44	—	0	0	0	—	—	—	0	3	3	21
112	45	—	1	1	15	—	—	—	—	1	1	7
113	47	—	0	0	0	—	—	—	—	1	1	7
114	48	—	0	0	0	—	—	—	—	0	—	—
115	50	—	—	—	—	—	—	—	—	0	—	0
116	51	—	—	—	—	—	—	—	—	0	—	0
117	53	—	—	—	—	—	—	—	—	1	1	7
118	55	—	—	—	—	—	—	—	—	1	1	7
119	58	—	—	—	—	—	—	—	—	0	—	0
120	61	—	—	—	—	—	—	—	—	1	1	7
Z		0.19	0.14	—	0.12	0.22	0.37	0.15	0.13	0.06	—	0.15

4.2 Abundance and density (of population)

4.21 Average abundance—estimation of population size

Adequate estimation of the population size of shortnose sturgeon in most river systems requires the use of multiple-census population models because of the size of the systems and the different behavior of various age and spawning groups (Dadswell 1979).

Using gill net mark-recapture data over a 4-yr period, Dadswell (1979) estimated the adult population in the Saint John estuary with a Seber-Jolly population model as 18,000 ± 30% (Table 22). Back calculating through the use of the mortality curve for this population suggests there are about 100,000 shortnose sturgeon in the Saint John estuary.

Estimates of other shortnose sturgeon population sizes have been made for the Kennebec River (Squiers et al. 1981 see Table 2, footnote 3), the Holyoke Pool (Taubert 1980b), the lower Connecticut River (Buckley, unpubl. data), the Hudson River (Dovel 1981 see Table 2, footnote 15), and the Delaware R. (Dadswell, from Hastings 1983 see Table 2, footnote 22) (Table 22). Estimates were largely made by single and/or multiple Peterson types (Schnabel), and recapture levels have met the Peterson validity requirements of $mc > 4N$ (Robson and Regier 1964). All estimates are biased by gear use (gill nets only); nonetheless, population sizes obtained to date are probably good first estimates for the various river systems. Population sizes of shortnose sturgeon in other river systems are unknown to date but the accumulation rate of new captures is similar for both well- and poorly studied populations (Fig. 40). The number of actual, observed shortnose sturgeon in all populations since 1970 is ap-

Table 21.—Maximum known sizes among shortnose sturgeon populations along the Atlantic coast. Lengths are in centimeters, weights in kilograms.

Locality	Sample size	Female			Male			Unsexed			Source
		TL	FL	Wt	TL	FL	Wt	TL	FL	Wt	
Saint John R., Canada	4,500	143.0	122.0	23.6	108.0	97.0	9.4				Dadswell (1979)
Kennebec R., Maine	18	118.1	107.4	8.5	80.7	72.1	2.6				Fried and McCleave (1973)
Kennebec R., Maine	728							120.5	111.0	12.3	Squiers et al. (see Table 2, footnote 3)
Holyoke Pool, Connecticut R., Mass.	270	—	95.1	7.2	87.9	79.2	4.1				Taubert (1980b)
Lower Connecticut R.	360	107.0	97.0	9.2	93.1	83.9	—				Buckley and Kynard (1981)
Hudson R., N.Y.	3,000	105.0	94.5	7.2	99.0	89.0	5.3				Dovel (see Table 2, footnote 15)
Delaware R., N.J.	282	86.4	77.7	5.1	74.0	66.0	2.0	107.0	98.3	8.3	Hastings (see Table 2, footnote 19)
Pee Dee R., S.C.	135	92.7	—	4.3	84.0	—	3.1				Marchette and Smiley (see Table 2, footnote 24)
Lake Marion, S.C.	13							77.5	66.0	2.4	Marchette and Smiley (see Table 2, footnote 24)
Altamaha R., Georgia	37	99.5	87.5	6.6	69.4	58.6	1.9				Heidt and Gilbert (see Table 2, footnote 27)
Saint Johns R., Florida	2	73.5	—	—	—	—	—				Vladykov and Greeley (1963)

Table 22.—Estimates of adult (+50 cm) shortnose sturgeon populations of North American Atlantic coast.

Locality and estimate type	Marked m	Captured c	Recaptured r	Population estimate N (95% conf. limits)	$mc/4\hat{N}$	Source
Saint John R., N.B.						
Seber-Jolly 1973-77	3,705	4,082	343	18,000 ± 30%	>1	Dadswell (1979)
Kennebec R., Maine						
Modified Peterson 1977-80	381	322	7	15,423 ± 66%	>1	Squiers et al. (see Table 2, footnote 3)
Modified Peterson 1977-82	917	233	19	10,741 (6,960-17,038)	>1	From Androscoggin spawners only
Modified Schnabel 1977-80	381	322	13	11,646 (6,998-20,639)		From Androscoggin spawners only
Modified Schnabel 1977-81	703	272	56	7,222 (5,046-10,765)		For total river population
Connecticut R., Conn.						
Holyoke Pool						
Simple Peterson 1976-77	51	162	16	516 (317-898)	>1	Taubert (1980b)
Simple Peterson 1976-78	51	56	4	714 (280-2,856)	>1	Taubert (1980b)
Simple Peterson 1977-78	119	56	18	370 (235-623)	>1	Taubert (1980b)
Simple Peterson 1976-77-78	170	56	24	297 (267-618)	>1	
Lower Connecticut R.						
Schnabel 1977-82	—	—	—	186 (106-359)		Rkm 110-139 Buckley (unpubl. data)
Schnabel 1981	—	—	—	28 (10-55)		Holyoke spawners only (Buckley, unpubl. data)
Schnabel 1982	—	—	—	38 (25-59)		Holyoke spawners only (Buckley, unpubl. data)
Schnabel 1977-82	—	—	—	800		[1]Rkm 04139
Hudson R., N.Y.						
Modified Peterson 1979	350	544	7	[2]23,911 (1,322-68,000)	>1	Calculated Dadswell (total)
Modified Peterson 1979	548	899	38	12,669 (9,080-17,735)	>1	Dovel (see Table 2, footnote 15) (spawners only)
Modified Peterson 1980	811	698	40	13,844 (10,014-19,224)	>1	Dovel (see Table 2, footnote 15) (spawners only)
Modified Peterson 1980	—	—	—	30,311		Dovel (see Table 2, footnote 15) (total population: based on extrapolation of population mortality relationship)
Delaware R.						
Modified Peterson 1981-83	464	99	7	[3]6,452 (3,584-18,434)	>1	Hastings (see Table 2, footnote 19) (Philadelphia to Trenton)

[1]Calculated by Dadswell.
[2]After Pekovitch (see Table 2, footnote 14), sturgeon tagged 1977 and 1978, recaptured 1979.
[3]Sturgeon tagged 1981-Oct. 1982, recaptured Nov. 1982-March 1983.

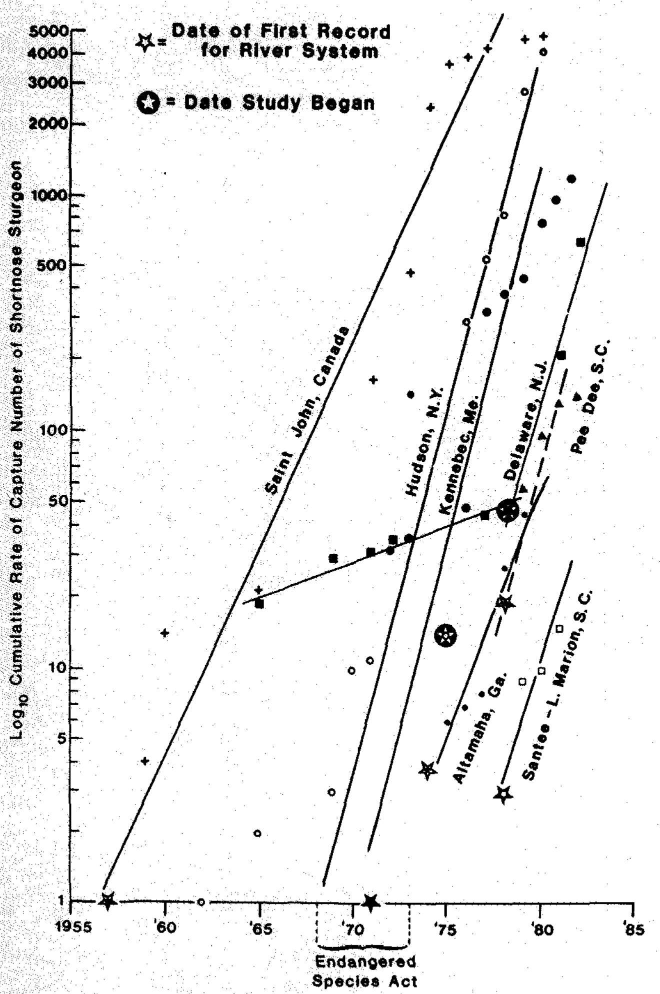

Figure 40.—Log_{10} cumulative total captures for individual known shortnose sturgeon populations in eastern North America.

proximately 11,500 individuals and most are or were tagged with individually numbered tags. The total estimated adult population size for the best known rivers now stands at about 70,000 (Table 22).

4.22 Changes in abundance

Since the size of shortnose sturgeon populations was unknown before the last few years, changes in abundance cannot be accurately determined.

The presence of shortnose sturgeon in the Saint John River, Canada; the Kennebec River, Maine; the Winyah-Pee Dee and Lake Marion systems, S.C.; and the Altamaha River, Ga.; were unknown until the last two decades, but these apparently are some of the larger populations. Ryder (1890) described himself as fortunate when he obtained five shortnose sturgeon from the Delaware River and said the species had not been seen since LeSueur's day, but the Geological Survey of New Jersey (1890) reported a 5:1 ratio of shortnose to Atlantic sturgeon and Meehan (1910) obtained over 100 shortnose sturgeon from the Delaware River in 1908 with relative ease. Since 1969, incidental catches in the lower Delaware have amounted to at least 40 shortnose sturgeon (Table 2; Brundage and Meadows 1982) as well as another 20 observed (Hoff 1965), and recently Hastings (1983 see Table 2, footnote 19), using proper sampling gear in the upper estuary, captured over 600 in 2 yr. Whether the Delaware population changed in abundance between these periods, or fishing effort with proper gear and subsequent reporting varied, can probably never be determined. Beck (1973) described the disappearance of Atlantic sturgeon from the Delaware by 1900 and subsequent decline in fishing effort until the 1950's. But as late as 1909 (Meehan 1910) and 1914 (Smith 1915) shortnose sturgeon were commonly caught by shad fishermen.

Greeley (1937) observed over 100 shortnose sturgeon incidently captured in the Hudson River shad fishery during 1936 but stated the species was rare. Similarly, Dovel (1978 see Table 2, footnote 13) observed about 100 shortnose sturgeon a year as incidental catch in the same fishery during 1976 and 1977. These observations suggest the shortnose sturgeon population in the Hudson River may have been stable during the 40-yr period between the two studies but casts no light on what actual population levels were, especially since the sampling gear (drift gill nets) are inappropriate for shortnose sturgeon. However, when Pekovitch (1979 see Table 2, footnote 14) and Dovel (1981 see Table 2, footnote 15) employed appropriate gear and were able to locate the shortnose sturgeon spawning run in the Hudson River, they captured almost 1,500 during each of the 1-mo periods in 1979 and 1980.

Conversely, McCabe (1942) stated that up to 100 sturgeon/d were caught in commercial gill nets below Holyoke Dam during 1940-42. McCabe reported these as Atlantic sturgeon but some may have been shortnose sturgeon. Neither Taubert (1980b) or Buckley (1982) ever achieved such a catch rate for either species, which may signify a decline. Also, Yarrow (1877) stated that shortnose sturgeon were common in North Carolina rivers, but recently Schwartz and Link (1976) described them as extirpated in the state.

4.23 Average density

Average density of shortnose sturgeon in the environment has only been determined for the Saint John estuary (Dadswell 1976). Population estimates from three or four recapture cycles at 4-wk intervals were made in areas of feeding concentrations during the June-September peak feeding period (Table 23). Average standing crop or density was 5.2 shortnose sturgeon/ha or 1.66 g/m^2. Concurrent benthos studies at these sites determined the average standing crop of benthic molluscs, which constitute the shortnose sturgeon diet, was 24 g/m^2 or a ratio of shortnose sturgeon standing crop to mollusc standing crop of 1:15. Since conversion between mollusc and shortnose sturgeon is direct and the energy transfer found was within the normal range for a one-step conver-

Table 23.—Schnabel population and standing crop estimates of adult shortnose sturgeon for four discrete regions of the Saint John estuary, Canada. Standing crop estimates in g/m^2 were determined using 3.21 kg as the average weight of adult shortnose sturgeon in this population.

Locality	Area (ha)	Recapture attempts	$\hat{N}$	Standing crop SNS/ha	Standing crop g/m^2
Mistake Cove	225	4	1,161	5.16	1.65
Tennants Cove	182	3	1,969	10.81	3.47
Belleisle Bay	387	3	838	2.16	0.69
Darlings Lake	419	4	1,102	2.63	0.84
Mean	303		1,267	5.19	1.66

sion (Odum 1959), density estimates of the shortnose sturgeon, when concentrated on their feeding grounds, appear near the carrying capacity.

Average densities for the whole adult population are possible to calculate for the Saint John, Kennebec, Holyoke Pool and lower Connecticut River, Hudson, and Delaware Rivers (Table 24). Densities range between 0.04 and 0.9 adult shortnose sturgeon/ha. Density estimates are very similar except for the Delaware River where neither the population's size or its estuarine-riverine limits are well known. Population size projections, for rivers with poorly known populations, that use densities calculated for feeding concentrations rather than average densities, such as was done by Masnik and Wilson (1980), are inappropriate.

4.24 Changes in density

See section 3.51 for effects of migration on density. In optimum habitat of the middle Saint John estuary, Canada, peaks occur during early summer and early fall (Fig. 26). At inland estuary habitat a peak occurs in July-August. Wintering site densities peak between October and May. Similar density/abundance changes have been reported for the Kennebec estuary (Squiers and Smith footnote 7), the lower Connecticut (Buckley 1982), the Hudson estuary (Dovel 1978 see Table 2, footnote 13, 1981 see Table 2, footnote 15), and the Pee Dee-Winyah system, S.C. (Marchette and Smiley 1982 see Table 2, footnote 24).

4.3 Natality and recruitment

4.31 Reproduction rates

Annual egg production

Annual egg production estimates for a shortnose sturgeon population have not been done. One problem with any such estimate is determination of what percentage of females in a population spawn each year. Dadswell (1979) estimated one-third of the Saint John shortnose sturgeon female population spawned per year based on the proportion of ripening females present during the preceding summer. If one-third do spawn each year and there are about 12,000 adult females in the Saint John population (two-thirds of total 18,000 since sex ratio 2:1♀ :♂), then approximately 4,000 females spawn each year in that river system. Mean fecundity of 21 females sampled was 94,000 which means total egg deposition could be about a maximum of $4{,}000 \times 94{,}000 = 376 \times 10^6$ eggs/yr in the Saint John River, Canada.

Survival rates

Nothing is known about survival of eggs, larvae, or young-of-the-year shortnose sturgeon in the wild. Survival under hatchery conditions is usually poor due to fungus infections of eggs and death of larvae after yolk sac absorption because of lack of required food (Anonymous 1980 see Table 2, footnote 2; Buckley and Kynard 1981; Dovel 1981 see Table 2, footnote 15).

4.32 Factors affecting reproduction

Density dependent factors

No research has been done which indicates density factors affect reproduction. Shortnose sturgeon are usually found concentrated in a short stretch of their river during the spawning period (Pekovitch 1979 see Table 2, footnote 14; Taubert 1980a; Buckley 1982).

Dadswell (unpubl. data) found one small female (75 cm FL) was resorbing her eggs in September, and because the body cavity contained stage V eggs, it was thought she had not spawned during the spring for unknown reasons.

Physical factors

Shortnose sturgeon spawning grounds are found in the upper reaches of rivers (Taubert 1980a), below dams (Buckley and Kynard 1981; Squiers et al. 1981 see Table 2, footnote 3), in flooded cypress-tupelo swamps (Marchette, pers. obs.), and in riverine regions just above tidal influence (Dadswell 1979; Anonymous 1980 see Table 2, footnote 2; Dovel 1981 see Table 2, footnote 15). Known sites in the north have gravel or rubble substrate, medium to strong current speeds (0.3-0.8 m/s), and are 1-10 m in depth (Taubert 1980a; Anonymous 1980 see Table 2, footnote 2; Buckley 1982; Squiers et al. 1981 see Table 2, footnote 3). They are usually in or near areas of deeper water (Taubert 1980a; Squiers et al. 1981 see Table 2, footnote 3). Some southern sites (Pee Dee and Savannah Rivers) are in backwaters, with little current and 1-3 m in depth (Marchette, pers. obs.).

4.33 Recruitment

Because there are no commercial fisheries for shortnose sturgeon, no recruitment information is available. Dadswell (1976) estimated a possible recruitment of 1,100 15-yr-old shortnose sturgeon to a commercial fishery using a 20 cm stretch mesh,

Table 24.—Average densities for adult shortnose sturgeon populations from rivers in eastern North America.

System	Boundary: Lower	Boundary: Upper	Surface area (ha)	Adult population estimate $\bar{N}$	Density SNS/ha
Saint John R., N.B.	Reversing Falls	Fredericton	5.0×10^4	18,000	0.36
Kennebec R., Maine	Popham Beach	Augusta	1.1×10^4	10,000	0.90
Holyoke Pool, Connecticut R., Mass.	Holyoke Dam	Turner's Falls	1.6×10^3	400	0.25
Lower Connecticut R., Conn.	Enfield Dam	Holyoke Dam	0.8×10^3	186	0.23
	Long Island Sound	Holyoke Dam	3.6×10^3	800	0.22
Hudson R., N.Y.	Battery	Troy Dam	2.9×10^5	27,000	0.93
Delaware R., N.J.	Cape May	Scudders Falls	1.9×10^5	10,000	0.05
	C & D Canal	Lambertville	2.4×10^4	10,000	0.42

gill net if such a fishery was permitted in the Saint John River, Canada.

4.4 Mortality and morbidity

4.41 Mortality rates

Mortality rate has been determined for the Saint John River, Canada, population (Dadswell 1979), the Holyoke Pool population (Taubert 1980b), and the Pee Dee-Winyah population (Marchette and Smiley 1982 see Table 2, footnote 24). In all studies catches were adjusted for gill net selectivity and effort. Total instantaneous mortality rate (Z) for ages 14 through 55 was 0.12 for 1974 and 0.15 for 1975 in the Saint John River (Fig. 41). Mortality was relatively high among younger shortnose sturgeon but declined with age (Dadswell 1979). In the Holyoke Pool, Z was 0.12 for adjusted catches and 0.14 for all catches (Taubert 1980b). Marchette and Smiley (1982 see Table 2, footnote 24) estimated an instantaneous mortality in the Pee Dee-Winyah between 0.08 and 0.12.

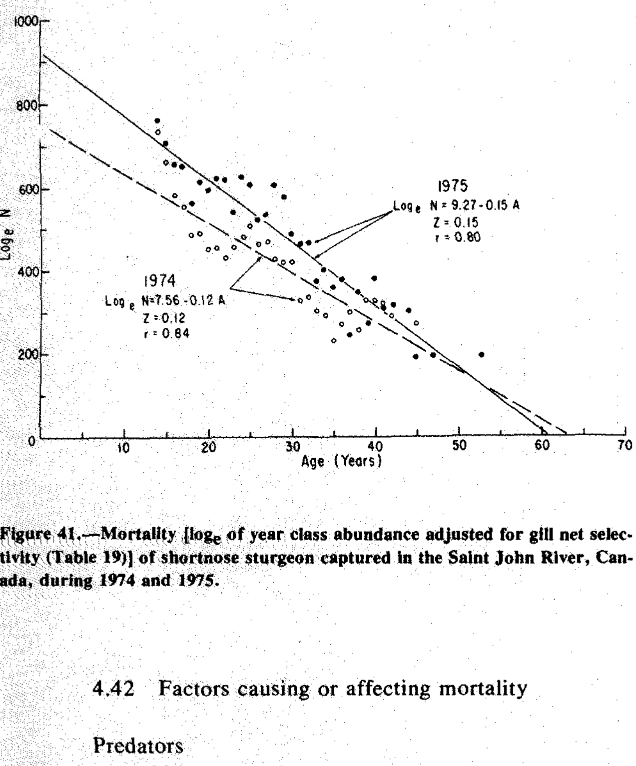

Figure 41.—Mortality [loge of year class abundance adjusted for gill net selectivity (Table 19)] of shortnose sturgeon captured in the Saint John River, Canada, during 1974 and 1975.

4.42 Factors causing or affecting mortality

Predators

See sections 3.34 and 3.35. Young are known to be eaten by yellow perch and adults may possibly be attacked by seals, sharks, gar, or alligators.

Physical factors

Dadswell (pers. obs.) observed a small kill of shortnose sturgeon during the first week of August 1974. The sturgeon were found dying or dead (four specimens) in an intensely eutrophic region of the Saint John estuary that was choked with vegetation. It was assumed that the heavy plant concentration caused an oxygen depletion in the area during the night. Other species of fish (suckers, perch) were killed at the same time.

Dovel (1981 see Table 2, footnote 15) observed that 78% of adult shortnose sturgeon in the Hudson River were affected by fin rot. Whether this has contributed to mortality is unknown.

Impingement of shortnose sturgeon on intake screens of power stations may result in some mortality, but the cause of impingement may be from events or injury elsewhere (netting, natural death). Hoff et al. (1977 see Table 2, footnote 12) reported that three shortnose sturgeon were found dead on the intake screens of Indian Point Power Plant, Hudson River, during 1978 and W. Kirk[19] stated mortalities of two, two, and one shortnose sturgeon were recorded at Indian Point in 1972, 1973, and 1979, respectively. Hoff and Klauda (1979 see Table 1, footnote 1) reported 39 shortnose sturgeon impinged on intake screens of power plants along the Hudson River between 1969 and 1979. Three shortnose sturgeon were impinged on the intake screens of the Salem Nuclear Station on the Delaware River in 1978 (Masnick and Wilson 1980), one in 1981 (Brundage[20]), and one at the Delaware Station in Philadelphia in 1975 (Brundage and Meadows 1982). Two shortnose sturgeon have been impinged at the Connecticut Yankee Nuclear Power Station. The most recent was in 1979 (Klattenberg[21]). Two shortnose sturgeon recovered dead were impinged on the trash racks of the Maine Yankee Nuclear Power Plant in 1980 (Squiers[22]).

Fishing

Besides natural mortality, fishing mortality caused by incidental catch in nets set for other species (mainly shad) is probably the main cause of mortality of shortnose sturgeon. Dadswell (1979) estimated the annual fishing mortality for shortnose sturgeon in the Saint John River as 1% or approximately 200 adult sturgeon a year. Many fishermen return sturgeon to the water alive but others do not. Either they are killed and discarded as a nuisance (Leland 1968; Cobb 1900) or they are marketed locally (Bean 1893; McCabe 1942). Incidental fishing mortality may be a major reason for the disappearance of this species from the shallow estuaries of Chesapeake Bay (Shortnose Sturgeon Recovery Team[23]) and is a suspected major factor of mortality in South Carolina (Marchette[24]).

4.5 Dynamics of population (as a whole)

No studies on shortnose sturgeon population dynamics have been done to date.

4.6 The population in the community and the ecosystem

4.61 Physical features of the biotype of the community

The shortnose sturgeon inhabits riverine, estuarine, and nearshore marine waters. It is most commonly found in productive

[19]W. Kirk, Research Scientist, Texas Instruments Inc., P.O. Box 237, Buchanan, NY 10511, pers. commun. March 1979.

[20]H. M. Brundage III, Ichthyological Associates Inc., 100 South Cass Street, Middleton, DE 19709, pers. commun. April 1983.

[21]R. Klattenberg, Northeast Utilities, P.O. Box 270, Hartford, Conn., 06101, pers. commun. July 1981.

[22]T. S. Squiers, Fisheries Biologist, Maine Department of Marine Resources, Augusta, ME 04333, pers. commun. June 1981.

[23]Shortnose sturgeon recovery team, National Marine Fisheries Service, State Pier, Gloucester, MA 01930, pers. commun. March 1978.

[24]D. E. Marchette, Fisheries Biologist, South Carolina Wildlife and Marine Resources, Charleston, SC 29412, pers. commun. August 1982.

mesohaline environments with salinities between 1 and 20 ‰, usually in and around the salt-wedge portion of estuaries (Squiers and Smith footnote 7; Dadswell 1979; Marchette and Smiley 1982 see Table 2, footnote 24). Freshwater habitats are characterized as deep river channels or in shallow regions with soft bottoms and abundant macrophytes. Habitats in higher salinity are usually over sand-mud bottoms in and around the *Mya-Macoma* zone. Populations may require access to a gravel-boulder section of riverine habitat for spawning (Taubert 1980b; Buckley 1982). The habitat of the shortnose sturgeon while in nearshore marine situations is undescribed, but shortnose sturgeon may occur in shallow water a few miles from shore associated with mixed sediments containing *Mya arenaria*, *Corbicula manilensis*, or other similar molluscs.

4.62 Species composition of the community

Juvenile shortnose sturgeon share the deep river channels with few other species. In the Saint John River only juvenile Atlantic sturgeon and ling, *Lota lota*, occur in this habitat. Adult shortnose sturgeon in the Saint John River were found in company with American eels, *Anguilla rostrata*; ling, *Lota lota*; suckers (*Catostomus* spp.); and whitefish, *Coregonus clupeiformis*, in freshwater and Atlantic sturgeon, *A. oxyrhynchus*; flounders (*Pseudopleuronectes americanus*); hake, *Urophycis tenuis*; and tomcod, *Microgadus tomcod*; in saline water (Dadswell, pers. obs.). In the Connecticut River, adult shortnose sturgeon associated with channel catfish, *Ictalurus punctatus*, walleye, *Stizostedion vitreum*, carp, *Cyprinus carpio*, and northern pike, *Esox lucius* (Taubert, pers. obs.; Buckley, pers. obs.).

Community relationships of shortnose sturgeon populations in other rivers are undescribed at present.

4.63 Interrelations within the community

Dadswell (1976) considered shortnose sturgeon and Atlantic sturgeon to competitively exclude each other depending on the salinity of the habitat. In the Saint John River, Canada, shortnose sturgeon compete with flounder and whitefish for the same food resource (see section 3.33).

5. EXPLOITATION

5.1 Fishing equipment

Shortnose sturgeon were captured with gill nets and traps. Gill nets were either drifted or fixed (Ryder 1890; Greeley 1937; McCabe 1942). Most shortnose sturgeon were (Meehan 1910; Greeley 1937), and are presently caught in shad drift and set gill nets (Dovel 1979, see Fig. 4 legend; Dadswell 1979; Shortnose Sturgeon Recovery Team footnote 23). In the Saint John River, Canada, many shortnose sturgeon are captured in commercial alewife trapnets. Some of these shortnose sturgeon are processed along with the alewife into fish meal. A few shortnose sturgeon are captured by ocean trawlers (Brundage and Meadows 1982).

5.2 Fishing areas

Commercial shortnose sturgeon fishing areas were typically the middle and upper reaches of the estuaries of large rivers. McCabe (1942) described a sturgeon fishery below the Holyoke Dam in the Connecticut River that may have principally utilized shortnose sturgeon.

5.21 General geographic distribution

Throughout its range shortnose sturgeon have entered the commercial fishery (see section 2.1) (Bean 1893; Greeley 1937). Caviar from this species formerly commanded a higher price than Atlantic sturgeon caviar (Vladykov and Greeley 1963).

5.22 Geographic ranges

See section 2.1.

5.23 Depth ranges

Adult shortnose sturgeon are usually captured in shallow water. Depth of capture seldom exceeds 10 m but this is mainly because of the commercial fishing gear used.

5.3 Fishing seasons

5.31 General pattern of seasons

Since the shortnose sturgeon is listed as endangered in the United States, there is no open season for this species. Formerly, a few fishermen in the Delaware and Hudson Rivers set nets for the purpose of capturing this species during the few weeks (late April) before the shad season (Greeley 1937).

In the Saint John River, Canada, the sturgeon season is open all year except the month of June, but sturgeon are actively sought only during July-August. If a season for shortnose sturgeon were established in the Saint John River, Dadswell (1975) recommended it be confined to winter and early spring (January-April). This would provide caviar in peak condition and flesh untainted by a muddy flavor which becomes prevalent in late summer in this river.

5.32 Dates of beginning, peak and end of season

See section 5.31.

5.33 Variation in date or duration of season

See section 5.31.

5.4 Fishing operations and results

5.41 Effort

At present there is no directed effort for shortnose sturgeon in the United States because of its endangered status. Effort for sturgeon in the Saint John River, Canada, amounts to 1 or 2 mo of gillnetting per year, depending on the market. About 5% of the sturgeon catch in the Saint John River is shortnose sturgeon (Dadswell, unpubl. data).

5.42 Selectivity

Figure 39 illustrates the indirect and direct selectivity of various size monofilament gill nets for shortnose sturgeon. Each direct selectivity mode has a broad plateau because of the multiple ways a shortnose sturgeon can mesh (Dadswell 1979). Larger mesh sizes are more efficient in capturing shortnose sturgeon than small mesh sizes. Dadswell (unpubl. data) found that monofilament nets were about twice as efficient as multifilament nets unless multifilament twine size was very fine. The direct selectivity relationship for the commercial, multifilament nylon, shad gill net (5 in or 12.7 cm stretched mesh) is illustrated in Figure 42. Confidence limits of the selectivity curve indicate 95% of incidental shortnose sturgeon catch is concentrated between 57 and 90 cm fork length ($\bar{X}$ = 73.6, SE = 8.1) which is the size range of adult shortnose sturgeon in most U.S. rivers.

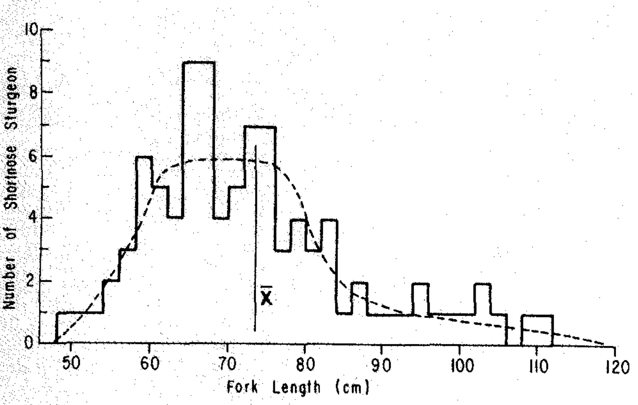

Figure 42.—Direct selectivity of 15.2 cm (5 in) stretched mesh, 210/3 multifilament nylon, commercial shad net for shortnose sturgeon in the Saint John River, Canada. Data from tag returns of shortnose sturgeon captured by commercial fishermen.

5.43 Catches

Total annual yield

The annual, incidental, shortnose sturgeon catch in most U.S. rivers, except perhaps the Hudson, may not exceed 10 or 20 fish per river (Shortnose Sturgeon Recovery Team shad fishery bycatch survey). Annual yield of shortnose sturgeon before the advent of endangered species status is unknown since fishery statistics data were listed as "sturgeon" only, thereby combining the two Atlantic coast species (Hoff 1979). For landing statistics of "sturgeon" on the east coast of the United States see Murawski and Pacheco (1977).

In the Saint John River, Canada, about three or four legal size shortnose sturgeon (total length 4 ft [122 cm TL] or more) are captured each year (Gorham[25]). As many as 200 sublegal shortnose sturgeon may be harvested each year as a bycatch from the shad gill net or alewife trapnet fisheries as determined by limited local markets (Dadswell, pers. obs.). Additionally, an unknown amount of shortnose sturgeon captured with alewives in the trapnet fishery become fish meal (Dadswell, unpubl. data). Dadswell (1975) used a yield/recruit model based on a 20 cm gill net catch curve (Fig. 43) to estimate a sustainable annual yield of approximately 2,000 kg or 350 adult shortnose sturgeon/yr could be removed from the Saint John River, Canada, over and above the present incidental catch.

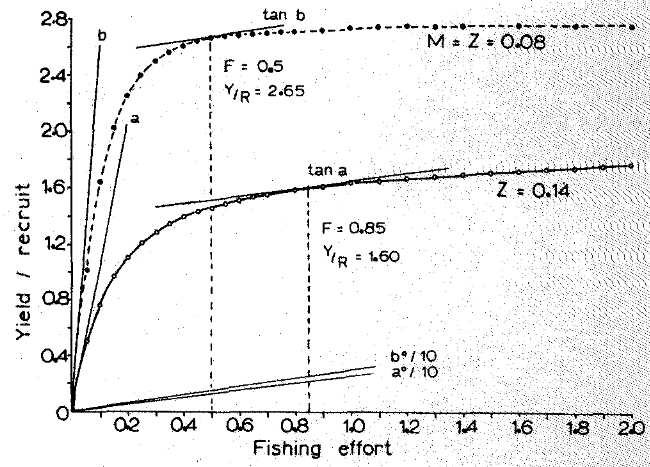

Figure 43.—Theoretical yield/recruit relationship for a 20 cm (8 in) stretched mesh gill net fishery for the shortnose sturgeon population in the Saint John River, Canada, at two levels of instantaneous total mortality.

6. PROTECTION AND MANAGEMENT

6.1 Regulatory (legislative) measures

6.11 Limitation or reduction of total catch

Since passage of the Endangered Species Act of 1973, as amended, it has been unlawful to "take" (hunt, harass, capture, or kill) shortnose sturgeon in the United States.

6.12 Protection of portions of population

At present all portions of the shortnose sturgeon population in the United States are protected. In Canada, all sturgeon under 122 cm (4 ft) total length are protected.

6.2 Control or alteration of the physical features of the environment

Not presently used for promotion of shortnose sturgeon stocks but some alterations of fish-lift schemes or bypass systems are now under consideration to assist natural populations (Klattenberg[26]). However, any other proposed alteration of the environment that may adversely affect shortnose sturgeon populations is closely reviewed in the United States under the Endangered Species Act. Any proposed action that might jeopardize the continued existence of a population will be modified to reduce these adverse effects.

6.3 Control or alteration of the chemical features of the environment

None used for the promotion of shortnose sturgeon stocks. See section 6.2 for proposed alterations.

[25]S. W. Gorham, Curator of vertebrates, New Brunswick Museum, Saint John, N.B., pers. commun. August 1975.

[26]R. Klattenberg, Northeast Utilities, P.O. Box 270, Hartford, Conn. 06101, pers. commun. March 1981.

6.4 Control or alteration of the biological features of the environment

None used for the promotion of shortnose sturgeon.

6.5 Artificial stocking

6.51 Maintenance stocking

None has been attempted.

6.52 Transplantation, introduction

None has been attempted.

7. POND FISH CULTURE

Shortnose sturgeon have never been cultured. Meehan (1910) described one successful and one unsuccessful attempt to overwinter shortnose sturgeon in catfish ponds near Philadelphia. These fish were kept for the purpose of stripping eggs and milt when ripe and not for growth experiments. Marchette (footnote 24) kept 12 shortnose sturgeon in hatchery ponds in South Carolina for over a year, and work is now underway in South Carolina to culture this species.

7.1 Procurement of stocks

Stocks appear to be available if enhancement or reintroduction is attempted.

7.2 *Genetic selection of stocks*

None attempted to date.

7.3 Spawning

Artificial spawning has been successful for this species (Anonymous 1980 see Table 2, footnote 2; Buckley and Kynard 1981; Dovel 1981 see Table 2, footnote 15), but only from naturally ripe specimens. Hormonal inducement has been unsuccessful so far (Pottle and Dadswell 1979 see Table 2, footnote 1; Anonymous 1980 see Table 2, footnote 2).

7.4 Rearing

Artificially spawned shortnose sturgeon have been reared only to an age of 40-60 d (Anonymous 1980 see Table 2, footnote 2; Buckley and Kynard 1981). Most larvae in hatchery conditions have died just after yolk sac absorption, probably because offered natural or artificial diets were not correct.

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