GEHitachiUELAPEm Resource

From: Ridge, Christianne
Sent: Wednesday, August 05, 2009 4:44 PM
To: Avci, Halil I.
Cc: Fischer, Karl W.; vinikour@anl.gov; Yilma, Haimanot; Shroff, Behram
Subject: GLE: Consultation Reply from NOAA Fisheries - Protected Species Information
Attachments: ESA-Listed Spp. North Carolina.pdf; Moser & Ross 1995 Habitat use & mvmt of sturgs C Fear NC.pdf; Moser et al. 2000 electrofishing & SNS habitat Cp Fear drai.pdf; Moser et al. 2000 sturgeon sampling protocol.pdf; BA GUIDE-INITGUIDE COMBO_April 23, 2007.pdf

Halil,
Please see the reply (below) from NOAA Fisheries. The NOAA Fisheries representative indicated to me by phone that we should consider this email to be their reply to our consultation letter.
Thanks.

-----Original Message-----
From: GLE_EIS Resource
Sent: Wednesday, August 05, 2009 4:10 PM
To: Ridge, Christianne
Subject: FW: NOAA Fisheries Protected Species Information

-----Original Message-----
From: Andrew.Herndon [mailto:Andrew.Herndon@noaa.gov]
Sent: Monday, August 03, 2009 8:33 AM
To: GLE_EIS Resource
Subject: NOAA Fisheries Protected Species Information

To Whom it May Concern,

Per your request, attached and included here is information on the protected species under NOAA Fisheries' purview that may by affected by the proposed project.

Attachment 1: List of all Endangered Species Act (ESA)-listed species known to occur off North Carolina.
Attachment 2-4: Information on Shortnose Sturgeon. Additional information on shortnose sturgeon can be found in its recovery plan at:
http://www.nmfs.noaa.gov/pr/pdfs/recovery/sturgeon_shortnose.pdf
Attachment 5: A guide to how best analyze potential impacts to ESA-listed species.

Below are links to information on the species of sea turtles that may be affected by the project. The first link to the NOAA Fisheries-Protected Resources webpage for each species, the second link is to the most recent version of the recovery plan for each species. Please note links to other useful documents may be available on each species' webpage.

Loggerhead:
http://www.nmfs.noaa.gov/pr/species/turtles/loggerhead.htm;
http://www.nmfs.noaa.gov/pr/pdfs/recovery/turtle_loggerhead_atlantic.pdf
Leatherback:
http://www.nmfs.noaa.gov/pr/species/turtles/leatherback.htm;
http://www.nmfs.noaa.gov/pr/pdfs/recovery/turtle_leatherback_atlantic.pdf
Hawksbill: http://www.nmfs.noaa.gov/pr/species/turtles/hawksbill.htm;
http://www.nmfs.noaa.gov/pr/pdfs/recovery/turtle_hawksbill_atlantic.pdf
Green: http://www.nmfs.noaa.gov/pr/species/turtles/green.htm;

http://www.nmfs.noaa.gov/pr/pdfs/recovery/turtle_green_atlantic.pdf
Kemp's ridley:
http://www.nmfs.noaa.gov/pr/species/turtles/kempsridley.htm;
http://www.nmfs.noaa.gov/pr/species/turtles/kempsridley.htm

Please remember that providing your determination of why an ESA-listed species may or may not be affected by the proposed action with your request for consultation will increase the speed with which it can be processed.

Feel free to contact this office at any time if you have additional questions.

Andy

Hearing Identifier: GEHitachiUE_LicenseApplication_Public
Email Number: 197

Mail Envelope Properties (Christianne.Ridge@nrc.gov20090805164400)

Subject: GLE: Consultation Reply from NOAA Fisheries - Protected Species Information
Sent Date: 8/5/2009 4:44:17 PM
Received Date: 8/5/2009 4:44:00 PM
From: Ridge, Christianne

Created By: Christianne.Ridge@nrc.gov

Recipients:
"Fischer, Karl W." <kfischer@anl.gov>
Tracking Status: None
"vinikour@anl.gov" <vinikour@anl.gov>
Tracking Status: None
"Yilma, Haimanot" <Haimanot.Yilma@nrc.gov>
Tracking Status: None
"Shroff, Behram" <Behram.Shroff@nrc.gov>
Tracking Status: None
"Avci, Halil I." <avci@anl.gov>
Tracking Status: None

Post Office:

Files	**Size**	**Date & Time**
MESSAGE	2585	8/5/2009 4:44:00 PM
ESA-Listed Spp. North Carolina.pdf	33413	
Moser & Ross 1995 Habitat use & mvmt of sturgs C Fear NC.pdf	904880	
Moser et al. 2000 electrofishing & SNS habitat Cp Fear drai.pdf	1860813	
Moser et al. 2000 sturgeon sampling protocol.pdf	389852	
BA GUIDE-INITGUIDE COMBO_April 23, 2007.pdf	66824	

Options
Priority: Standard
Return Notification: No
Reply Requested: No
Sensitivity: Normal
Expiration Date:
Recipients Received:

Endangered and Threatened Species and Critical Habitats
under the Jurisdiction of the NOAA Fisheries Service

North Carolina

Listed Species	Scientific Name	Status	Date Listed
Marine Mammals			
blue whale	*Balaenoptera musculus*	Endangered	12/02/70
finback whale	*Balaenoptera physalus*	Endangered	12/02/70
humpback whale	*Megaptera novaeangliae*	Endangered	12/02/70
North Atlantic right whale	*Eubalaena glacialis*	Endangered	12/02/70
sei whale	*Balaenoptera borealis*	Endangered	12/02/70
sperm whale	*Physeter macrocephalus*	Endangered	12/02/70
Turtles			
green sea turtle	*Chelonia mydas*	Threatened[1]	07/28/78
hawksbill sea turtle	*Eretmochelys imbricata*	Endangered	06/02/70
Kemp's ridley sea turtle	*Lepidochelys kempii*	Endangered	12/02/70
leatherback sea turtle	*Dermochelys coriacea*	Endangered	06/02/70
loggerhead sea turtle	*Caretta caretta*	Threatened	07/28/78
Fish			
shortnose sturgeon	*Acipenser brevirostrum*	Endangered	03/11/67

Designated Critical Habitat
None

Species Proposed for Listing
None

Proposed Critical Habitat
None

[1] Green turtles are listed as threatened, except for breeding populations of green turtles in Florida and on the Pacific Coast of Mexico, which are listed as endangered

North Carolina

Candidate Species[2]	Scientific Name
None	

Species of Concern[3]	Scientific Name
Fish	
Atlantic sturgeon	*Acipenser oxyrhynchus oxyrhynchus*
barndoor skate	*Raja laevis*
dusky shark	*Carcharhinus obscurus*
night shark	*Carcharinus signatus*
sand tiger shark	*Carcharias taurus*
speckled hind	*Epinephelus drummondhayi*
Warsaw grouper	*Epinephelus nigritus*
Invertebrates	
ivory tree coral	*Oculina varicosa*

[2] The Candidate Species List has been renamed the Species of Concern List. The term “candidate species” is limited to species that are the subject of a petition to list and for which NOAA Fisheries Service has determined that listing may be warranted (69 FR 19975).

[3] Species of Concern are not protected under the Endangered Species Act, but concerns about their status indicate that they may warrant listing in the future. Federal agencies and the public are encouraged to consider these species during project planning so that future listings may be avoided.

Transactions of the American Fisheries Society 124:225–234, 1995
American Fisheries Society

Habitat Use and Movements of Shortnose and Atlantic Sturgeons in the Lower Cape Fear River, North Carolina

MARY L. MOSER[1]

North Carolina Cooperative Fish and Wildlife Research Unit, North Carolina State University Campus Box 7617, Raleigh, North Carolina 27695-7617, USA

STEVE W. ROSS

North Carolina National Estuarine Research Reserve, Center for Marine Science Research 7205 Wrightsville Avenue, Wilmington, North Carolina 28403, USA

Abstract.—We conducted a gill-net survey and used sonic tracking to document the distribution and movements of adult shortnose sturgeons *Acipenser brevirostrum* and juvenile Atlantic sturgeons *Acipenser oxyrhynchus* in the lower Cape Fear River, North Carolina. Shortnose sturgeons were rare; only eight fish were captured from 1990 to 1993. The five fish we tracked occupied river kilometer 16–96 from early January to May. The presence of gravid females and the rapid (11.5–27.0 km/d), directed upstream migrations we observed provided evidence that shortnose sturgeons may attempt to reproduce in this drainage. We also documented the disruption of spawning migrations by dams and incidental gill-net capture, which may prevent these fish from ever reaching their spawning grounds. Atlantic sturgeon juveniles were relatively common and preferred deep areas (>10 m) in the vicinity of the saltwater–freshwater interface (km 46). In summer they held position for extended periods and apparently fasted, but were more active (1.3 km/d) and ranged over a greater area during cooler water temperatures in fall, winter, and spring. Both species occupied regularly dredged areas and were present during dredging operations in the Wilmington Harbor.

Shortnose sturgeon *Acipenser brevirostrum* and Atlantic sturgeon *Acipenser oxyrhynchus* co-occur throughout most of their ranges (southeastern Canada to Florida). The shortnose sturgeon is found primarily in riverine and estuarine areas, whereas the Atlantic sturgeon occupies these habitats but also makes extensive coastal migrations (Gilbert 1989). Sturgeons historically supported a valuable commercial fishery in North Carolina. In the late 1800s the largest landings in the southeastern USA were recorded from the Cape Fear River (McDonald 1887). It is impossible to track landings of each species separately because their catch records were combined (Smith 1985). By the early 1900s the sturgeon fishery had declined dramatically in North Carolina (Smith 1907). Now the shortnose sturgeon is a federally listed endangered species, and the Atlantic sturgeon is considered threatened in North Carolina (Ross et al. 1988). Consequently, both recreational and commercial sturgeon fishing was banned in the state, starting in 1991.

Both sturgeon species have been extensively studied in the northern part of their range (Brundage and Meadows 1982; Dadswell et al. 1984; Lazzari et al. 1986; Kieffer and Kynard 1993; O'Herron et al. 1993) but very few studies have documented sturgeon habits in the southeastern USA (Dadswell et al. 1984; Hall et al. 1991). It was unclear that shortnose sturgeons even occurred in North Carolina until 1987, when a gravid adult was captured in the Brunswick River, a relatively undisturbed tributary of the lower Cape Fear River (Ross et al. 1988). Although Atlantic sturgeons are regularly caught in North Carolina, details of their distribution patterns and habitat preferences are unknown (Ross et al. 1988). Whether or not sturgeons are affected by dredging operations, low-elevation dams, and incidental capture is also unknown. In this study we documented the relative abundance, seasonal occurrence, habitat use, and movements of adult shortnose sturgeons and juvenile Atlantic sturgeons in the lower Cape Fear River. We also compared the two species' use of both routinely dredged and undisturbed areas, and noted the effects of a low-elevation dam and gill-net capture on migrating shortnose sturgeons.

Study Area

The Cape Fear River estuary is a drowned river valley, characterized by tidally driven currents,

[1] Present address: Center for Marine Science Research, 7205 Wrightsville Avenue, Wilmington, North Carolina 28403, USA.

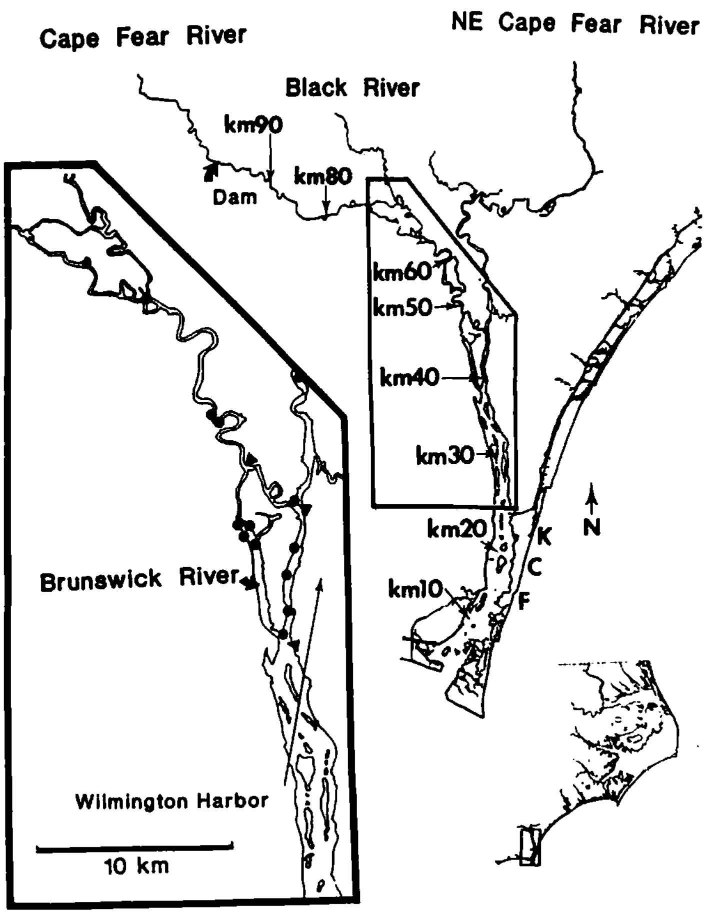


FIGURE 1.—Study area in the lower Cape Fear River, North Carolina, with the region from km 20 to 75 expanded (boxed area) and the North Carolina coastline in lower right corner. Remote receiving stations at km 37, 44, and 49 are indicated by triangles, and gill-net stations are shown with circles. The ocean beaches where Atlantic sturgeon were recaptured, Carolina, Kure, and Ft. Fisher, are denoted by C, K, and F, respectively.

high turbidity, and vertical salinity stratification. Sediment ranges from soft mud to sand. Mean bottom salinity at river km 21 in the lower estuary generally ranges from 9 to 25‰, varying with seasonal changes in river discharge (50–900 m^3/s). The Cape Fear River is influenced by diurnal tides within the entire study area (Figure 1), but tidal range decreases from 1.2 m at km 49 to 0.3 m at km 96. Profiles of vertical current velocity in the study area are typically uniform with depth to within 1.5–3.0 m of the bottom (Giese et al. 1979). The Brunswick River runs parallel to the main stem of the Cape Fear River from km 37 to 46 and has not been extensively dredged since the 1940s. In contrast, the Cape Fear River from km 37 to 46 (Wilmington Harbor) is dredged annually so that a depth of 12 m is maintained. The main stem of the Cape Fear River in the study area above km 49 is dredged to an average depth of 4 m, but there are numerous deep holes (>10 m) throughout. Lock and Dam 1, one of three navigational locks and dams built between 1915 and 1934, defines the upper limit of our study area (km 96). The maximum height of this dam is 4 m.

Methods

Gill-net survey.—We conducted a gill-net survey from May 1990 to May 1992. All sinking gill nets were 50 m long and 3.5 m deep. We used two sizes of monofilament mesh gill nets: 14-cm stretched mesh (year-round) and 5.1-cm stretched mesh (April–November). One trammel net (inside panel, 7.6-cm stretched mesh; outside panels, 20.3-cm stretched mesh) was also operated year-round. The gill nets were set perpendicular to the current, from 2 to 20 m deep. The trammel net was always set approximately 5 m deep and parallel to the current, due to the increased drag created by this gear.

We set gill-nets in three general areas (Figure 1): the Brunswick River (year-round), the Wilmington Harbor from km 37 to 46 (December–May), and the Cape Fear River from km 46 to 66 (April–November). Samples were taken weekly from December to May and every 2 weeks during the rest of the year. In each sampling week the nets were deployed for three days and two nights and checked daily. When water temperature exceeded 28°C, the nets were checked twice daily to reduce fish mortality. Surface and bottom salinity and temperature were recorded at each set on each sampling day.

Weights (nearest 25 g) and fork (FL) and total (TL) lengths (nearest mm) of all sturgeons were recorded. Catch per unit effort (CPUE) was defined as the number of fish caught in one 50-m net fished for 24 h (a net-day). Both Atlantic and shortnose sturgeons were tagged externally with Petersen disc tags (Floy model FTF-69) through the dorsal caudal fin. Stomachs of dead sturgeons were removed, wrapped in cheesecloth, and preserved in 10% formalin for later analysis. Stomach contents were identified to the lowest possible taxon, and frequency of occurrence of each item (number of fish with item/total number of fish) was calculated.

We also recorded commercial captures of shortnose sturgeons made in the study area that were voluntarily reported by 5–10 shad and striped bass fishermen. The commercial gill nets were all 50–100 m long with 13.3–14.0-cm stretched monofilament mesh. They were operated daily from late November to late May as both stationary and drifting nets set perpendicular to the current.

Sonic tracking.—Sturgeons in excellent condition were selected for sonic tagging and placed in a 1 × 1.5 × 1-m floating net pen. Large fish (>800 mm TL) were fitted with high-power transmitters (18 × 100 mm, 12 g in air) having an 18-month battery life (Sonotronics CHP-87-L). Sturgeons smaller than 800 mm TL received smaller high-power transmitters (18 × 65 mm, 8 g in air) having a 7-month battery life (Sonotronics CHP-87-S). Transmitters were usually attached externally (Buckley and Kynard 1985) and were surgically implanted only when water temperature was less than 28°C to minimize handling stress. For internal implantation, the sturgeons were lightly anesthetized with MS-222 (50 mg/L). The transmitter and surgical instruments were disinfected with chlorhexidine diacetate and rinsed with 0.9% sodium chloride. A 3-cm incision was made laterally through the body wall just above the fifth ventral scute. After the transmitter was inserted posterior to the incision, we closed the incision with five to six individual knotted sutures of 2-0 coated Vicryl (Ethicon). The entire operation took no longer than 10 min. Sterile technique was used throughout the procedure, and implanted fish received a 30-min prophylactic treatment of 0.2 g nitrofurazone/L (9.2%).

All transmitters used in this study were uniquely coded by frequency (68–80 kHz) and pulse interval so that individual fish could be identified. Sonically tagged fish were released at the site of capture and tracked continuously for at least 6 h immediately after release. Transmitter signals were located by a portable digital-readout receiver (Sonotronics USR-5B) and a directional hydrophone (Sonotronics DH-2). During periods of continuous tracking, fish positions (±20 m) were determined by a combination of triangulation and signal strength at least every 15 min. Current velocity (±1 cm/s) at 1-m depth was measured (Marsh–McBirney 201) at least every 30 min during continuous tracking, and surface and bottom temperatures and salinities were recorded frequently.

After the release date, sonically tagged fish were relocated during daily surveys with the portable receiver or whenever they passed one of three remote receiving stations (Sonotronics USR-90) at km 37, 44, and 49 (Figure 1). The remote receivers operated around the clock and provided a record of diel activity. Each passage event was defined by the median time of passage (halfway between the time of first and last recorded presence). We analyzed only cases in which fish passed the receiver in less than 30 min to eliminate cases when a fish was not actively moving. Individual passage events for the same fish were included if they were separated by at least 30 min. To determine whether or not Atlantic sturgeons exhibit diel activity patterns, we compared the frequency of passage events during six 4-h time periods using the χ^2 test (Zar 1984). Only fish that passed the monitors at least 24 different times were included in this analysis to assess individual variation and ensure a minimum expected frequency of four in each time period (Zar 1984).

Depth, temperature, and salinity were recorded at each relocation. We documented the depth distribution of juvenile Atlantic sturgeons by comparing depths at daily relocations to available depths using χ^2 analysis (White and Garrott 1990). Recent (1991) bathymetry maps were available for

TABLE 1.—Release date, fish size, duration of tracking, and gross travel rate (total distance travelled/total time tracked) of shortnose and Atlantic sturgeons. Transmitter placement (I = surgically implanted, E = externally attached) and approximate dates of tag loss (if known) are also given.

Fish number	Release date	Size (mm TL)	Days tracked (number of observations)	Gross travel rate (km/d)	Tag placement	Tag loss date
			Shortnose sturgeon			
1	16 Feb 1989	942	14.7 (20)	1.0	E	
2	9 Jan 1990	900	2.3 (13)	10.8	E	
3	4 May 1991	715	88.0 (112)	2.6	E	31 Jul 1991
4	14 Feb 1992	812	4.2 (47)	14.9	I	
5	26 Feb 1992	753	21.4 (87)	14.1	E	
			Atlantic sturgeon			
1	3 Jul 1990	910	2.1 (3)		I	
2	19 Oct 1990	760	15.2 (42)	2.4	I	3 Nov 1990
3	14 Dec 1990	1,220	229.0 (98)	0.5	E	31 Jul 1991
4	8 Jan 1991	752	364.0 (31)	0.3	I	
5	27 Jun 1991	716	93.1 (85)	1.7	E	27 Sep 1991
6	10 Jul 1991	705	72.0 (38)	0.5	E	20 Sep 1991
7	23 Jul 1991	689	87.2 (42)	0.2	E	18 Oct 1991
8	8 Aug 1991	723	71.0 (11)	0.2	E	18 Oct 1991
9	15 Aug 1991	735	36.0 (62)	1.1	E	20 Sep 1991
10	3 Sep 1991	1,202	34.2 (17)	0.4	E	
11	3 Sep 1991	838	90.1 (76)	0.8	E	2 Dec 1991
12	3 Dec 1991	719	222.0 (67)	1.1	I	
13	24 Mar 1992	746	161.0 (127)	1.7	I	
14	9 Apr 1992	833	156.3 (150)	1.8	I	

only km 46–59 of our study area in the Cape Fear River (Cape Fear Community College, unpublished data), so only sturgeons that were relocated in this mapped area were included in the analysis. The mapped area was divided into three depth zones: less than 5 m, from 5 to 10 m, and greater than 10 m. The proportional area of each depth zone was determined by the map-weighing method (White and Garrott 1990).

Gross travel rate (km/d) was defined as the total distance a fish traveled divided by the total time over which that fish was tracked or relocated. Percent holding time was defined as the number of days that a fish was relocated in the same position (± 1 km) divided by the total number of days the fish was tracked or relocated. For observations made during periods of continuous tracking, we estimated fishes' swimming speed in body lengths per second (BL/s) by subtracting speed of the current from fish ground speeds.

Results

Shortnose Sturgeon

Despite intensive gill-net sampling (893 net-days), we caught only three shortnose sturgeons in the lower Cape Fear River drainage during 1990–1992. One of these, a gravid female (870 mm FL, 990 mm TL), died during capture in the Brunswick River on 6 February 1991. Gut contents of this fish included two slender isopods (*Cyathura polita*), detritus, and sand grains. Five shortnose sturgeons were also caught and voluntarily reported by commercial fishermen from 1989 to 1993. Two of these five fish were captured in 1993 after our field work had ended and thus were not sonically tagged. The first (525 mm FL, 623 mm TL, 1,725 g) was captured on 1 February at Cape Fear River km 90 in a stationary gill net. The second fish (568 mm FL, 643 mm TL, 1,450 g) was captured in the same net on 4 February. This fish was recaptured and released at km 92 on 11 February 1993 by the same fisherman.

Five shortnose sturgeons were tagged with sonic transmitters and tracked for up to 3 months following their release (Table 1). Shortnose sturgeons 1, 2, and 4 were captured and released in the Brunswick River in January and February. Shortnose sturgeon 3 was captured and released at the mouth of the Black River in May and a fifth fish was captured at km 90 and released at km 92 in late February. Shortnose sturgeons 1 and 2 were obviously gravid females, but the sex of the other three fish is unknown. The fish occupied the entire study area from km 16 to 96 (Lock and Dam 1) from January to mid-July and moved through both the undredged Brunswick River and the regularly dredged Wilmington Harbor during dredging operations.

Shortnose sturgeons tended to move downstream in response to excessive handling or recapture. Fish 2 and 5 that were captured by commercial fishermen and subjected to increased handling both moved rapidly downstream at rates of 8.5–36.0 km/d after release. Shortnose sturgeon 1 was originally captured by a commercial fisherman and then recaptured twice in a stationary gill net in the Brunswick River. This fish moved rapidly downstream after the second recapture and did not move back upstream while we were monitoring its movements. Shortnose sturgeon 5 was also recaptured twice in the upper 2 m of drift nets set at km 62 and 63. We were tracking the fish as it moved upstream just before these captures, and in both cases it was released unharmed. Nevertheless, this fish moved downstream immediately after the second release and did not resume upstream movements while we tracked it. In contrast, shortnose sturgeons 3 and 4, which we captured, received minimal handling and both moved rapidly upstream following release.

We tracked shortnose sturgeons during rapid and directed upstream movements which were apparently obstructed by Lock and Dam 1. Shortnose sturgeons 3, 4, and 5 remained in midchannel while moving upstream and stemmed strong ebbing currents of up to 40 cm/s. Their mean estimated swimming speeds during continuous tracking ranged from 0.78 to 1.07 BL/s, and they maintained average ground speeds of 11.5–27.0 km/d. Both fish 3 and 5 exhibited rapid and directed upstream migration from the point of release to the dam base. Upon reaching the dam, they milled about at its base for 24 h and then moved back downstream. Shortnose sturgeon 3 did not resume upstream movement and was relocated periodically in the area km 37–79 during the next 2 months. Shortnose sturgeon 5 resumed upstream migration after falling 78 km downstream from the dam but was then recaptured in a drift net as described earlier. We tracked fish 4 to within 8 km of the dam, but the next day an anonymous caller reported that it had been captured and probably killed, so it is unclear whether or not upstream movement of this fish was affected by the dam.

Atlantic Sturgeon

We captured 100 juvenile Atlantic sturgeons. The highest CPUEs occurred in the Brunswick River from June through September when water temperatures were greater than 25°C (Figure 2). This area was near the head of the salt wedge where salinity did not exceed 10‰ (Figure 2). Brunswick River fish were generally captured over shoals (<7 m), even though the nets extended into deeper channel areas. In contrast, fish caught in the upper Cape Fear River were always in deep water (>10 m), away from the shoreline and low in the net webbing. In Wilmington Harbor, Atlantic sturgeons were caught primarily at stations located near the mouth of the Brunswick River (Figure 1) and in depths less than 7 m. Atlantic sturgeons ranged from 340 to 1,240 mm TL, but most were 600–800 mm TL (overall mean, 708 mm TL) due to the size selectivity of our gear.

Gill-net mortalities (N = 24) occurred from June through September when water temperatures exceeded 28°C (Figure 2), even though the nets were often checked after less than 4 h. Gut content analysis of these 24 dead fish plus one donated by a fisherman revealed that 12 had empty stomachs. There was generally very little food present in any of the other 13 fishes' stomachs, but the food items in highest frequency of occurrence were polychaete worms (fragments, 32%), slender isopods (*Cyathura polita,* 28%), and molluscs (shell fragments, 12%).

Seven Atlantic sturgeons had severe wounds or abnormalities. Four had large dorsal wounds consisting of a 10–15-cm-long gash, usually just anterior to the dorsal fin. These wounds were up to 3 cm deep and in all cases had healed, resulting in loss of two to four dorsal scutes. Otherwise these fish appeared to be healthy. Abnormalities exhibited by the other three fish included a deformed mouth, lesions of the buccal region, lesions around the eye, or some combination thereof. These fish were in poor condition, and two did not survive capture.

Seventy-seven Atlantic sturgeons were conventionally tagged and released. We recaptured 12 fish (16%), and commercial fishermen recaptured 5 (6%). The fish we recaptured were at large for varying periods during the summer (June to early September) and were recaptured within 1 km of their release sites in the Brunswick River (Table 2). These fish did not increase in TL or weight, and the weight of fish number 8760 decreased from 2,500 g to 2,300 g. Commercial gill-net fishermen recaptured fish in spring and fall but did not measure them, so we could not calculate growth rates for these fish. Four fish moved from the river into the ocean and were caught in gill nets set from shore at Carolina Beach (8788), Kure Beach (8793), and Ft. Fisher (8794, 8932) (Figure 1).

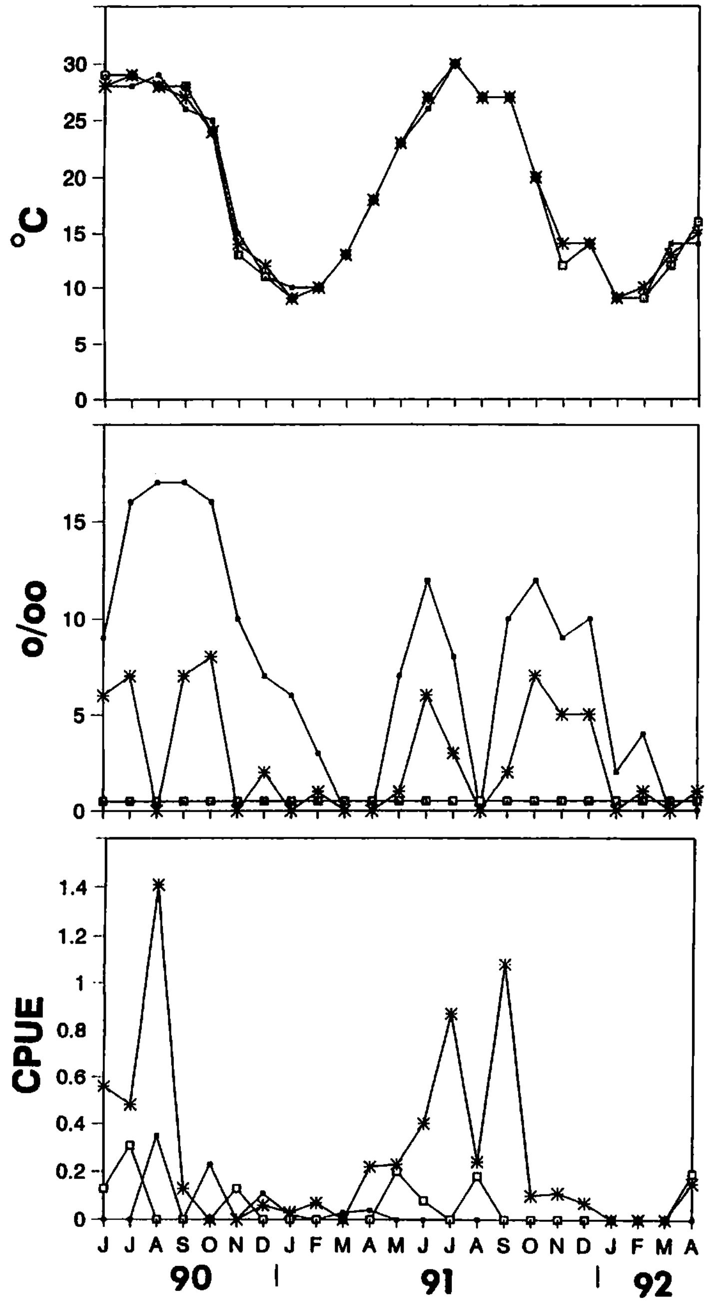


FIGURE 2.—Monthly mean bottom temperature (°C), salinity (‰), and CPUE (number of fish per net-day) at the gill net stations in the Brunswick River (stars), Wilmington Harbor (dots), and upper Cape Fear River (open squares).

Atlantic sturgeons did not retain sonic tags well. We tracked 14 juveniles (705–1,220 mm TL) between September 1990 and April 1992 using both externally attached and surgically implanted sonic transmitters (Table 1). The first fish in which we surgically implanted a tag was captured when water temperature exceeded 30°C, and it died within 2 d of release. Thereafter, all sturgeons captured in water temperature exceeding 28°C (fish 5–11) were tagged externally. In all but two cases (fish

TABLE 2.—Recaptures of Atlantic sturgeon tagged with Petersen discs, including days at large and distance between release and recapture sites (BR = Brunswick River km, CF = Cape Fear River km). Nine fish were recaptured within 48 h of the release date and were not included here.

Tag number	Fish size (mm TL)	Release date	Recapture date	Days at large	Release site	Recapture site	Distance (km)
8748	580	5 Jun 1990	12 Jun 1990	7	BR44.5	BR44.5	0.0
8759	750	6 Jun 1990	13 Jun 1990	7	BR45.5	BR44.5	1.0
8760	686	26 Jun 1991	3 Sep 1991	69	BR45.4	BR45.4	0.0
8788	719	3 Dec 1991	?? May 1992	>148	BR45.4	Ocean	75.0
8789	497	15 Jan 1991	2 Feb 1991	18	CF44.4	BR45.5	12.9
8793	840	6 Mar 1991	1 Oct 1991	209	CF42.0	Ocean	68.9
8794	698	26 Jul 1990	5 Apr 1992	618	BR44.5	Ocean	62.3
8932	817	16 Apr 1992	11 May 1992	26	CF61.1	Ocean	78.9

10 and 11, both very large individuals), the transmitters fell off within 3 months of the fishes' release, primarily during September and October. Two surgically implanted transmitters were also apparently expelled by the sturgeons, as was found by Kieffer and Kynard (1993). Retention of surgically implanted tags was improved when the transmitters were coated with a biologically inert polymer, Dupont Sylastic (fish 12–14, Table 1).

All of the Atlantic sturgeons released between June and September (fish 5–11) behaved similarly. Movements during this period were very slow (mean gross travel rate, 0.7 km/d, Table 1). The fish occupied both the Cape Fear and Brunswick rivers from km 35 to 61 (*N*, 180 observations; mean, km 46; SD, 5.4 km). During daily relocations these fish were found within 1 km of their previous location 80% of the time and often were found in exactly the same spot for several days (mean duration of holding, 12.1 d; SD, 5.5 d).

TABLE 3.—Depth ranges of relocated juvenile Atlantic sturgeons in the Cape Fear River, km 46–59. Availability of each depth range, in parentheses, is expressed as a percent of the mapped area (km 46–59). Significant χ^2 test results ($P < 0.05$) are marked with an asterisk and indicate sturgeons that showed a depth bias. "Warm" indicates sturgeons that were tracked between June and September when water temperature was greater than 25°C. "Cool" indicates sturgeons tracked in water temperatures less than 25°C.

Sturgeon number	Water temperature	Number of observations			χ^2
		<5 m (34%)	5–10 m (55%)	>10 m (11%)	
2	Cool	0	2	3	11.48*
3	Cool	0	3	8	43.73*
4	Cool	0	1	3	18.95*
5	Warm	1	3	4	12.21*
6	Warm	0	0	5	36.67*
7	Warm	1	3	12	65.20*
8	Warm	0	2	1	2.73
11	Warm	1	2	1	1.03
12	Cool	0	2	0	1.64
13	Warm	0	0	2	18.00*
14	Warm	0	3	0	2.52
Total		3	21	39	214.16*

Holding areas were all deep (>10 m) and were often used by several different individuals; however, we never found more than one sonically tagged sturgeon in any site at the same time. The majority of the area from km 46 to 59 of the Cape Fear River was less than 10 m deep (Table 3). Seven fish tracked in this area during the day were found in deeper areas than expected on the basis of depth availability (Table 3). We pooled the results of the χ^2 analysis and found that as a group Atlantic sturgeon occupied depths greater than 10 m (Table 3). We compared the depth distributions of sturgeon tracked when temperature exceeded 25°C (warm) to those tracked during the rest of the year (cool), and found that sturgeons occupied deeper depths in both temperature regimes (warm: χ^2 = 138.3, df = 14; cool: χ^2 = 75.8, df = 8; both $P < 0.05$).

The Atlantic sturgeons we released in fall, winter, and spring (2, 3, 4, 12, 13, and 14, Table 1) were more active than those released in summer (mean gross travel rate, 1.3 km/d). During movements their mean estimated swimming speed was 0.44 BL/s (SD, 0.21). The center of Atlantic sturgeon distribution from October to May was the same as in summer, but a variance ratio test (Zar 1984) indicated that the fishes' range was significantly larger in winter (*N*, 215 observations, mean, km 46, SD, 10.5). Atlantic sturgeons 13 and 14 were both released in the Brunswick River in spring, immediately moved downstream to km 38 in Wilmington Harbor, and resided between km 36 and 41 for the month following release. Twice during this time, sturgeon 13 was tracked as it moved within 100 m of a hydraulic pipeline dredge operating at km 40, but there was no evidence that

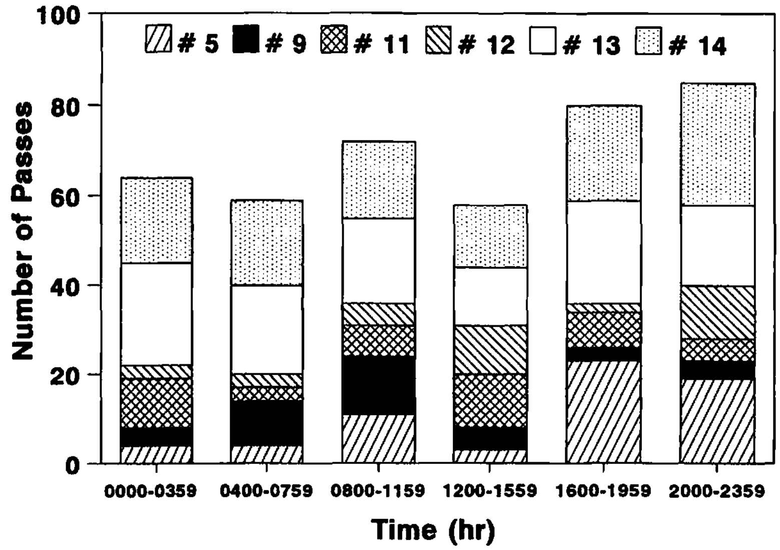


FIGURE 3.—Number of times individual Atlantic sturgeons (5, 9, 11, 12, 13, and 14) passed the remote receiving stations during different times of day.

the fish was affected by the dredge on either occasion. In late April, sturgeon 13 migrated steadily (1.1 km/h) upstream into the Northeast Cape Fear River and stayed between km 47 and 50 until 30 May. Atlantic sturgeon 14 moved up the Brunswick River on 21 May at a rate of 0.6 km/d and was relocated between km 37 and 54 until mid-September. Both fish were relocated in deep holes (>10 m) throughout the summer until tracking was terminated.

Six Atlantic sturgeons (5, 9, 11, 12, 13, 14) passed the remote receivers more than 24 times and were analyzed for diel activity patterns. Atlantic sturgeon 9 passed the monitor significantly (χ^2 = 12.54, df = 5, $P < 0.05$) more often than expected during the morning (0400–1200 hours) and sturgeon 12 passed the monitors significantly (χ^2 = 16.01, df = 5, $P < 0.05$) more often than expected in early afternoon (1200–1600 hours) and evening (2000–2400). The remaining four fish showed no significant diel activity pattern. We pooled the data for all fish and found that the observed times of passage occurred evenly throughout the day and night and were not significantly different from expected frequencies (χ^2 = 1.9, df = 25, $P > 0.05$; Figure 3).

Discussion

Shortnose sturgeons are very rare in the Cape Fear River drainage and are extremely susceptible to both set and drifting gill nets that target striped bass *Morone saxatilis* and American shad *Alosa sapidissima*. Several commercial fishermen reported capturing shortnose sturgeons regularly in the past, but always in small numbers. Some of these fishermen may have captured and released the same fish on several occasions, as occurred twice during this study. To reduce fishing mortality, a state law was passed in 1991 prohibiting the possession of any sturgeon in North Carolina. However, shortnose sturgeons may still suffer significant mortality from incidental capture.

Our gill-net sampling and sonic tracking data indicated a much wider distribution of shortnose sturgeon in the Cape Fear River basin than previously documented (Ross et al. 1988). Although previous captures were from only the Brunswick River in January, we found that shortnose sturgeons also occupied the main stem of the Cape Fear River from the lower estuary (km 16) to Lock and Dam 1 (km 96) and were caught from early January to early May. This corresponds with the timing of spawning migrations observed in other southeastern U.S. rivers (Dadswell et al. 1984; Hall et al. 1991). We observed directed upstream movements at rates similar to those reported for prespawning shortnose sturgeon in other systems (Buckley and Kynard 1985; Hall et al. 1991), indicating that shortnose sturgeons in the Cape Fear River drainage participate in spawning migrations. Moreover, both Cape Fear River specimens deposited at the North Carolina State Museum of Natural Sciences (NCSM 13827 and 17539) were gravid females, and two of the fish used for sonic tracking appeared to be gravid.

Our data suggested that the combined obstacles of high fishing pressure and dams may prevent shortnose sturgeons from reaching spawning areas, which, in other rivers, are 100–300 km upstream (Dadswell et al. 1984; Hall et al. 1991; O'Herron et al. 1993). Upstream migration of at least two of the shortnose sturgeons we tracked was apparently blocked by Lock and Dam 1. In addition, repeated capture or excessive handling of shortnose sturgeons by commercial fishermen appeared to interrupt or abort the spawning migration of four of the five fish we tracked. No juvenile shortnose sturgeons have been caught in this drainage, further indicating that the species may not be spawning successfully here.

Our data indicated that Atlantic sturgeons reproduce in the Cape Fear River drainage. Compared to shortnose sturgeons, Atlantic sturgeon juveniles were abundant. Historical records also indicate that Atlantic sturgeons occur regularly in the Cape Fear River drainage (McDonald 1887; Schwartz et al. 1981). Our CPUE of Atlantic sturgeon juveniles was most comparable to that of the Delaware River and estuary (Brundage and Meadows 1982; Lazzari et al. 1986). Based on age-to-fork-length relationships (Smith 1985; Lazzari et al. 1986), we estimated that most of the Atlantic sturgeons we caught were 3–7 years old, although the smallest individuals may have been 2-year-olds.

The center of juvenile Atlantic sturgeon distribution in the Cape Fear River was near the saltwater–freshwater interface, as in other southern rivers (Hall et al. 1991; G. Rogers, Georgia Department of Natural Resources, personal communication). In contrast, juvenile Atlantic sturgeons in northern rivers favor more saline areas (Kieffer and Kynard 1993). The fish we tracked occupied depths greater than 10 m year-round and in summer they moved infrequently and appeared to fast. These observations suggest that Atlantic sturgeons in the southern part of their range may be confined to a relatively small number of deep, freshwater holes which serve as thermal refuges. Mason and Clugston (1993) reported a similar pattern of reduced summer and fall feeding by Gulf sturgeons *Acipenser oxyrhynchus desotoi* in the Suwannee River, Florida, with increased feeding at estuarine overwintering sites. Some of the winter holding sites favored by the sturgeons we tracked in the lower Cape Fear River estuary also support very high levels of benthic infauna (M. Posey, University of North Carolina at Wilmington, personal communication) and may be important feeding stations.

We frequently caught deformed and previously injured Atlantic sturgeons in the Brunswick River. Common defects in the buccal region, like those we observed, have also been noted in shortnose sturgeons (Dadswell et al. 1984). Oral, buccal, and ventral lesions or ulcerations, often signs of poor water quality, were observed on several sturgeons and ictalurids we captured. Because sturgeons often move in the upper water column, the dorsal gashes we observed could have been caused by boat propellers. Further study is needed to determine the causes of such abnormalities and injuries and to what extent they affect these fishes.

Atlantic and shortnose sturgeons occupied both relatively undisturbed and regularly dredged areas and were tracked through the Wilmington Harbor during dredging operations. These fish appear to seek out deep areas and stay in midchannel, behaviors that would put them in the proximity of dredges. However, as did McCleave et al. (1977), we found some evidence that shortnose sturgeons remain within 2 m of the surface while moving, which would limit their entrainment in dredges. Although we obtained no evidence that dredges affected sturgeons, our results clearly indicated that both species are incidentally taken in commercial gill nets and that shortnose sturgeons may abort spawning migrations as a result of capture and release. Of even more concern is the observation that even low-elevation dams, such as Lock and Dam 1, block upstream migration of this endangered species.

Acknowledgments

We thank P. D. Manders, C. Jensen, H. L. Early, J. E. Melson, and many volunteers for their help in tracking fish movements. Thanks also to Cape Fear Community College, Carolina Power and Light Brunswick Steam Electric Plant Biology Laboratory, the North Carolina Eastern Municipal Power Agency, and the University of North Carolina–Wilmington Center for Marine Science Research for boat dockage, storage space and office support. F. C. Rohde and the North Carolina Division of Marine Fisheries provided help with fish tagging and supplied the conventional fish tags. Gold Bond Building Products, CSX Railroad, and Cape Fear Community College kindly provided space for the remote monitoring stations. This project was funded by the U.S. Army Corps of Engineers (Wilmington District).

References

Brundage, H. M., III, and R. E. Meadows. 1982. The Atlantic sturgeon, *Acipenser oxyrhynchus*, in the Delaware River estuary. U.S. National Marine Fisheries Service Fisheries Bulletin 80:337–343.

Buckley, J., and B. Kynard. 1985. Yearly movements of shortnose sturgeons in the Connecticut River. Transactions of the American Fisheries Society 114: 813–820.

Dadswell, M. J., B. D. Taubert, T. S. Squiers, D. Marchette, and J. Buckley. 1984. Synopsis of biological data on shortnose sturgeon, *Acipenser brevirostrum* Lesueur 1818. FAO (Food and Agricultural Organization of the United Nations) Fisheries Synopsis 140.

Giese, G. L., H. B. Wilder, and G. G. Parker, Jr. 1979. Hydrology of major estuaries and sounds of North Carolina. U.S. Geological Survey, Water Resources Investigations 79-46, Raleigh, North Carolina.

Gilbert, C. R. 1989. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Mid-Atlantic Bight)—Atlantic and shortnose sturgeons. U.S. Fish and Wildlife Service Biological Report 82.

Hall, J. W., T. I. J. Smith, and S. D. Lamprecht. 1991. Movements and habitats of shortnose sturgeon, *Acipenser brevirostrum*, in the Savannah River. Copeia 1991:695–702.

Kieffer, M. C., and B. Kynard. 1993. Annual movements of shortnose and Atlantic sturgeons in the Merrimack River, Massachusetts. Transactions of the American Fisheries Society 122:1088–1103.

Lazzari, M. A., J. C. O'Herron II, and R. W. Hastings. 1986. Occurrence of juvenile Atlantic sturgeon, *Acipenser oxyrhynchus*, in the upper tidal Delaware River. Estuaries 9:356–361.

Mason, W. T., and J. P. Clugston. 1993. Foods of the Gulf sturgeon in the Suwannee River, Florida. Transactions of the American Fisheries Society 122: 378–385.

McCleave, J. D., S. M. Fried, and A. K. Towt. 1977. Daily movements of shortnose sturgeon, *Acipenser brevirostrum*, in a Maine estuary. Copeia 1977:149–157.

McDonald, M. 1887. The rivers and sounds of North Carolina. Pages 625–637 *in* G. B. Goode, editor. The fisheries and fishery industries of the United States, section 5, volume 1. United States Commission on Fish and Fisheries, Washington, D.C.

O'Herron, J. C., II, K. W. Able, and R. W. Hastings. 1993. Movements of shortnose sturgeon, *Acipenser brevirostrum*, in the tidal Delaware River. Estuaries 16:235–240.

Ross, S. W., F. C. Rohde, and D. G. Lindquist. 1988. Endangered, threatened, and rare fauna of North Carolina, part 2. A re-evaluation of the marine and estuarine fishes. North Carolina Biological Survey, Occasional Papers 1988-7 Raleigh, North Carolina.

Schwartz, F. J., W. T. Hogarth, and M. P. Weinstein. 1981. Marine and freshwater fishes of the Cape Fear estuary, North Carolina, and their distribution in relation to environmental factors. Brimleyana 7:17–37.

Smith, H. M. 1907. The fishes of North Carolina. North Carolina Geological and Economic Survey 2:1–453.

Smith, T. I. J. 1985. The fishery, biology, and management of Atlantic sturgeon, *Acipenser oxyrhynchus*, in North America. Developments in Environmental Biology of Fishes 6:61–72.

White, G. C., and R. A. Garrott. 1990. Analysis of wildlife radio-tracking data. Academic Press, New York.

Zar, J. H. 1984. Biostatistical analysis. Prentice Hall, Englewood Cliffs, New Jersey.

Received May 6, 1994
Accepted October 5, 1994

99-EP-06

99-EP-06

J. Robin Hall

Effects of recreational electrofishing on sturgeon habitat in the Cape Fear River drainage.

Mary.L.Moser, Jean Conway, and Teresa Thorpe
Center for Marine Science Research.
7205 Wrightsville Avenue
Wilmington, NC 28403

and

J. Robin Hall
68 Flowers Settlemeyer Road
Riegelwood, NC 28456

Final Report to:
North Carolina Sea Grant
Fishery Resource Grant Program

January 2000

INTRODUCTION

The shortnose sturgeon (*Acipenser brevirostrum*) is a federally-listed endangered species. This fish was reportedly abundant in North Carolina waters in the early 1900s, but due to overfishing and habitat degradation it now occurs only rarely in the Cape Fear River and Albemarle Sound drainages and has apparently been extirpated from other state waters (Ross et al. 1984, NMFS 1998). In spite of Endangered Species Act (1973) protections and a moratorium on Atlantic sturgeon (*A. oxyrinchus*) harvest in North Carolina (1991), shortnose sturgeon are still very rare in state waters. Consequently, concerns about habitat quality and the possible need for enhancement with cultured fish are current shortnose sturgeon management issues in North Carolina.

The Shortnose Sturgeon Recovery Plan (NMFS 1998) outlines priority tasks for recovery of each shortnose sturgeon population segment. In addition, it provides general guidelines for conditions that must be met for stock enhancement or restoration using cultured shortnose sturgeon. Among these recommendations for the Cape Fear River population is the need to assess sturgeon bycatch in other fisheries and the impacts of non-indigenous species. Enhancement or restoration of shortnose sturgeon populations cannot be considered until it has been established that essential habitats are available to sustain the species, and that mortalities from bycatch or from predation by non-indigenous fishes are not a significant threat to these efforts (NMFS 1998).

The 1966 introduction of flathead catfish (*Pylodictis olivaris*) and blue catfish (*Ictalurus furcatus*) into the Cape Fear River (Moser and Roberts in press) had several potentially significant repercussions for already rare sturgeon populations. Both catfish species attain very large sizes and occur in shortnose sturgeon spawning and nursery habitats. The flathead catfish is piscivorous and is known to feed on other demersal species (particularly other catfishes). The blue catfish is omnivorous and could act as both a potential predator on and/or a competitor for food of the shortnose sturgeon juveniles. The rapid expansion of these non-indigenous catfishes heralded the demise of native icatlurids in the upper Cape Fear River and the 1981 establishment of a novel recreational electrofishing fishery to target non-native catfish (Moser and Roberts 1999).

Sturgeon, like catfish, possess exceptional electro-sensory capabilities. Consequently, they are likely to be significantly impacted by electrofishing developed to target catfish (Morris and Novak 1968). Avoidance of electroshocking and the results of being shocked could reduce feeding or alter spawning behavior and subsequently reduce sturgeon fitness. In this study, we examined both the effects of catfish predation on shortnose sturgeon and the potential impact of recreational electrofishing, which is prosecuted intensively in the Cape Fear River main stem from the mouth of the Black River to Lock and Dam #3 (Figure 1).

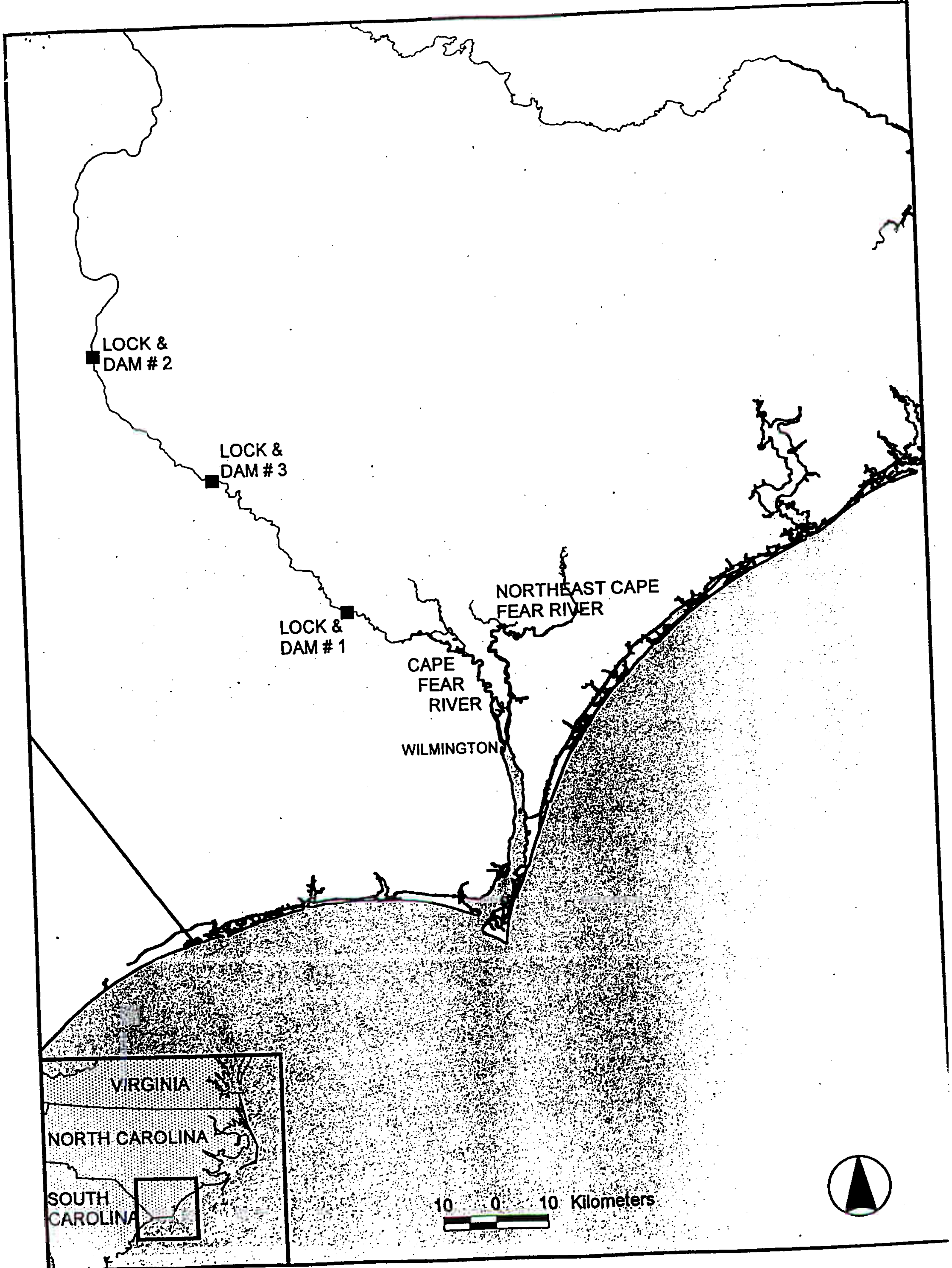


Figure 1. Lower Cape Fear River drainage, North Carolina.

MATERIALS AND METHODS

Electrofishing

Juvenile hatchery-reared shortnose sturgeon and channel catfish were exposed to simulated electrofishing conditions while being held in ambient Cape Fear River water. The electrofishing device was a hand-cranked "telephone" generator supplied by a local recreational fisherman. It consisted of a 5-bar telephone generator wired to a capacitor. A pulley connected the generator to a bicycle wheel that permitted hand-cranking at approximately 80 revolutions per minute during a one minute treatment. This use of the gear was consistent with that of local electrofishers. Two insulated wires were connected to the capacitor and acted as electrodes, which were positioned along the bottom of the treatment area in each experiment. We also observed behavioral responses of fish when they were subjected to a variety of DC frequencies and pulse widths by using a commercially available back-pack electroshocker (Smith Root Model 12A). This enabled us to empirically determine the frequency and pulse width that elicited the same response as that produced by the hand-cranked generator.

Shortnose sturgeon juveniles were obtained from the U.S. Fish and Wildlife Service fish hatcheries at Warm Springs, Georgia and Bear's Bluff , South Carolina. Blue catfish juveniles were obtained from Southeastern Pond Stocking and Aquatic Maintenance. Fish were maintained in aerated 8, 800 gallon tanks with water circulated from the Cape Fear River for over eight months prior to testing, to allow adequate acclimation to their new setting and for water quality to approximate conditions when electrofishing is prosecuted most intensely. Unfortunately, during this period an electrical storm caused a power outage and the backup generation system for tanks housing the sturgeon failed, resulting in mass mortality. Consequently, scaled down experiments were conducted with a small number of fish held in a backup facility (Cape Fear Community College). The experiments were conducted in two, 800 gal tanks: one treatment and one control tank. Fish were fed ad libitum (approximately 72 g) on Hi-Pro #3 every evening. Salinity, conductivity, dissolved oxygen and water temperature were recorded prior to each electroshocking test and these parameters were also recorded continuously in the control tank using a data logger (Yellow Springs Instruments 6600).

On the first day of electroshock experiments, all fish were weighed and measured. The tank containing the experimental fish was lined with a seine net, which, when raised, allowed us to observe fish behaviors. These fish were then exposed to the output from the "telephone" generator four to five times a day for two weeks. During the one minute exposure, the following behaviors were recorded, the second at which it occurred, how long it lasted and the recovery time:

- Twitching – rapid twitching/swimming usually accompanied by heightened operculation.
- Lateral roll – fish rolls over to one side. This behavior was often preceded by a period of rigor when the fish would form a rigid "S" shaped curve and remains motionless.
- Belly up – fish completely rolls upside-down.
- Avoidance.

Fish in the control tank were not exposed to the output from the "telephone" generator, but were regularly disturbed to replicate activities associated with the electroshocking treatment. After two weeks, all fish were again weighed and measured. The electroshock experiment was conducted a second time; however, the seine net was removed and no observations were made during shocking. This test was conducted to insure that disturbance associated with making the observations was not confounding the results. After two weeks, the fish were again weighed and measured. All electroshock experiments were conducted in October and November 1999. Weights and total-lengths of experimental and control fish were compared before and after the electroshock experiments to determine any deleterious effects of electroshocking on shortnose sturgeon. The instantaneous growth rate (G) was computed as: $G = (\ln W_t - \ln W_0)t^{-1}$ where W_t was the mean weight at the end of the experiment, W_0 was the mean weight at the start of the experiment, and t was the length of the experiment in days.

Catfish predation

Large adult flathead catfish (> 3000 g) were collected from the Cape Fear River using gillnets (Mallin et al. 1999). They were held in the River in floating net pens and were not fed for one week prior to experimentation. Hatchery-reared shortnose sturgeon, channel catfish (*Ictalurus punctatus*) and striped bass (*Morone saxatilis*) juveniles were held in aerated 800 gal tanks with flow-through Cape Fear River water for over three months prior to experimentation and were fed ad libitum during this period. Temperature, salinity and dissolved oxygen were recorded daily.

To initiate experiments, one flathead catfish was moved to an empty aerated 800 gallon tank with water circulated from the Cape Fear River and allowed to acclimate to the tank for 24 h. Then, ten each of shortnose sturgeon, channel catfish and striped bass were placed in fish cages and lowered into the tank containing the flathead catfish. They remained in the cage for 24 hours to acclimate and were then released. Every day for a period of two weeks, the fish were counted in order to determine consumption rates and preferential prey species of the flathead catfish. After two weeks, the flathead catfish was returned to the Cape Fear River and replaced with a new one. This experiment was repeated four times; however, in the last three replicates striped bass were not available. The first three replicates were conducted between February 17th and April 19th 1999, the fourth from November 30th to December 14th 1999.

Moser
206-860-3351
who was technician?

RESULTS

Electrofishing

Water quality in the control and experimental tanks was very similar (Figure 2 and 3). The temperature ranged from 14.5 – 18.1 ^{0}C. Dissolved oxygen was also within a narrow range. At the end of November, the salinity began to rise from 0.00 ‰ to a maximum of 4.1 ‰ in the control tank and 3.4 ‰ in the experimental tank. Thus conductivity increased from an average of 101.8 μmols/cm in the control tank and 95.4 μmols/cm in the experimental tank when salinity was 0.00, to a maximum of 5057 and 5042.5 μmols/cm respectively.

Average lengths and weights of fish used were similar in the control and experimental tanks, although shortnose sturgeon were larger and heavier than channel catfish (Figure 4 and 5). Both species increased in length and weight over the four week experimental period. Instantaneous daily growth rates for shortnose sturgeon in the first replicate were lower (0.013 d^{-1}) for fish exposed to electroshocking and .0214 d^{-1} for controls. In contrast, electroshocked sturgeon in the second replicate grew faster (0.024 d^{-1} than controls (0.022 d^{-1}). As for sturgeon, electroshocked catfish in the first replicate grew more slowly (0.003 d^{-1}) than controls (0.016 d^{-1}), but in the second replicate, the shocked catfish grew faster (0.034 d^{-1}) than controls (0.007 d^{-1}). Consequently, there were similar growth rates observed between treatments when the growth rate was calculated over the entire four week time period for each species (Figure 4 and 5).

Using the back-pack electroshocker, we were able to elicit the same type of sturgeon and catfish responses as obtained with the hand cranked generator when 100 volt output was produced at 10 Hz and 10 pulses/second (as in Quinn 1986). Sturgeon were initially more responsive to the electroshocking treatment than catfish; however, they recovered quickly and moved to avoid the stimulus (Figure 6). More sturgeon than catfish rolled onto their side or completely rolled upside-down within the first 15 seconds. They also exhibited more twitching, rigor and avoidance behaviors than did catfish (Table 1). But, sturgeon generally recovered immediately after the experiment. Over 75% of the sturgeon recovered immediately, with maximum recovery times of 5 minutes. In contrast, catfish tended to display electronarcosis and as the shocking continued, more catfish lost equilibrium. Catfish also took longer to recover than sturgeon, sometimes up to 8 minutes after the experiment had ended (Figure 6). The average recovery time for catfish was 3.5 min and only 7 fish recovered immediately.

Figure 2. Water quality in control tanks during electroshocking experiments.

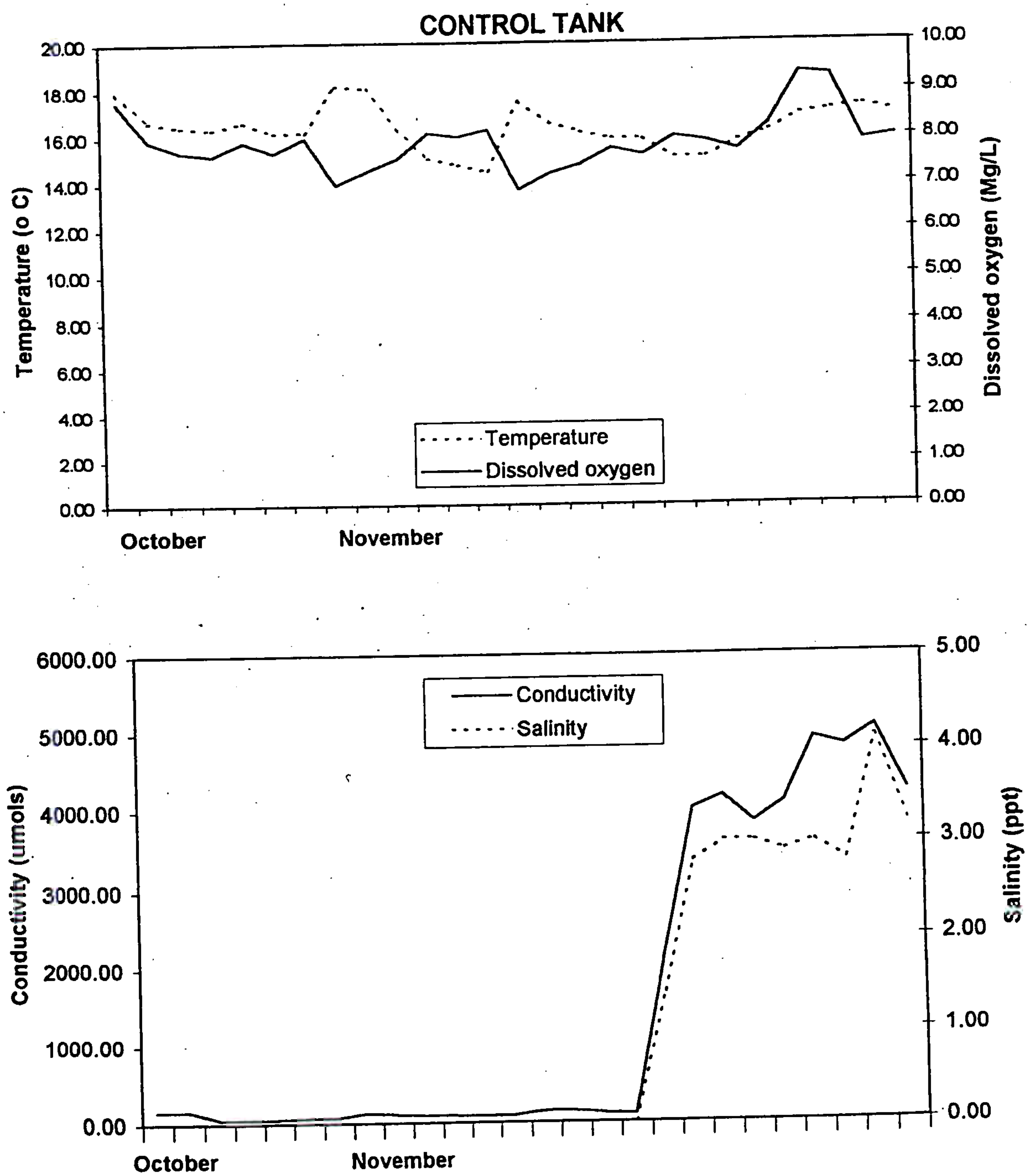


Figure 3. Water quality in experimental tanks during electroshocking experiments.

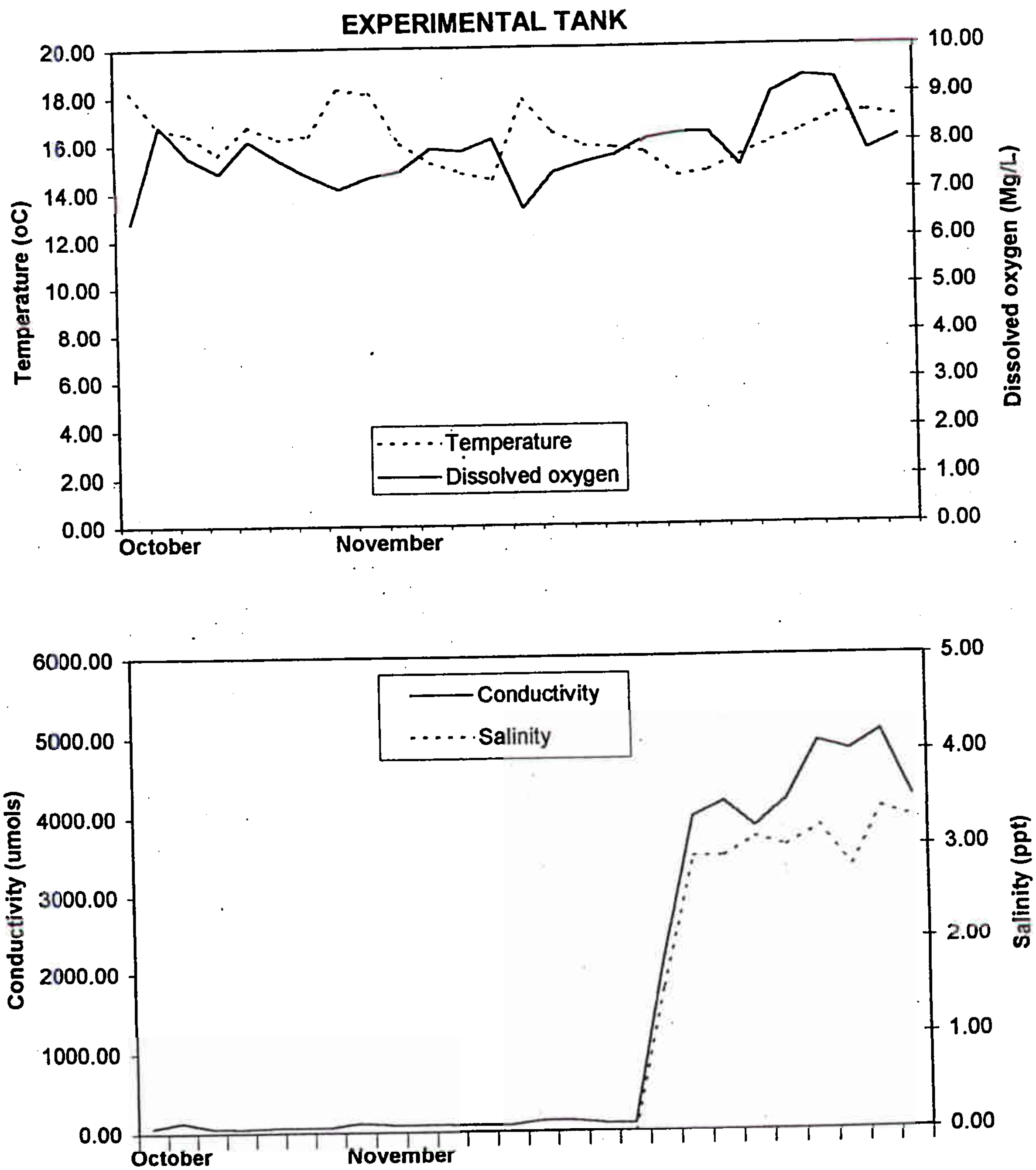


Figure 4. Mean total length (mm) and weight (g) of shortnose sturgeon in control (upper panel) and electroshocking treatments (bottom panel) conducted over the 32 day period from 10/22/99 – 11/23/99.

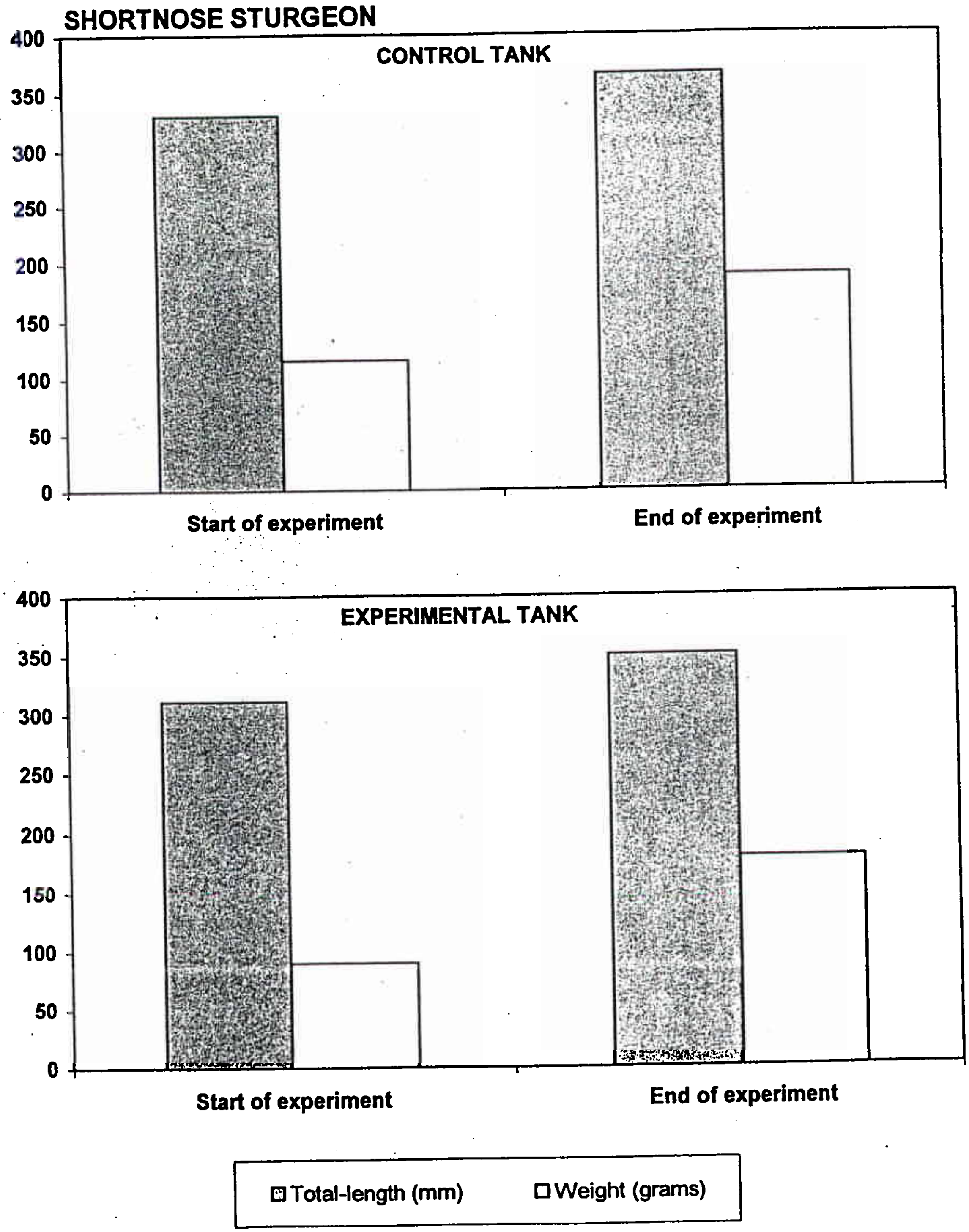


Figure 5. Mean total length (mm) and weight (g) of channel catfish sturgeon in control (upper panel) and electroshocking treatments (bottom panel) conducted over the 32 day period from 10/22/99 – 11/23/99.

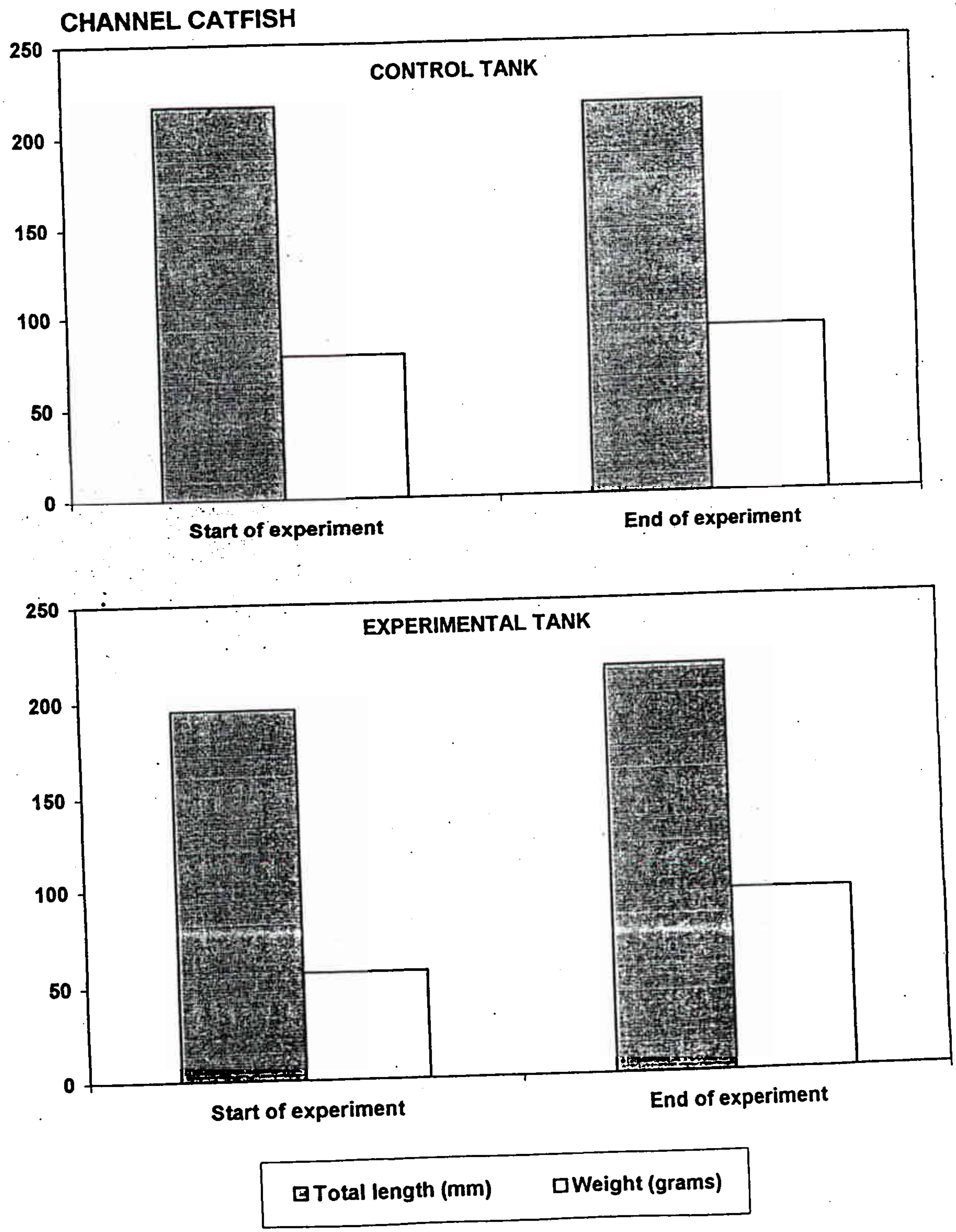


Figure 6. Total number of shortnose sturgeon (top panel) and channel catfish (bottom panel) that exhibited either a lateral roll (dark bars) or complete loss of equilibrium (open bars) during 28 observation periods of 60 seconds each.

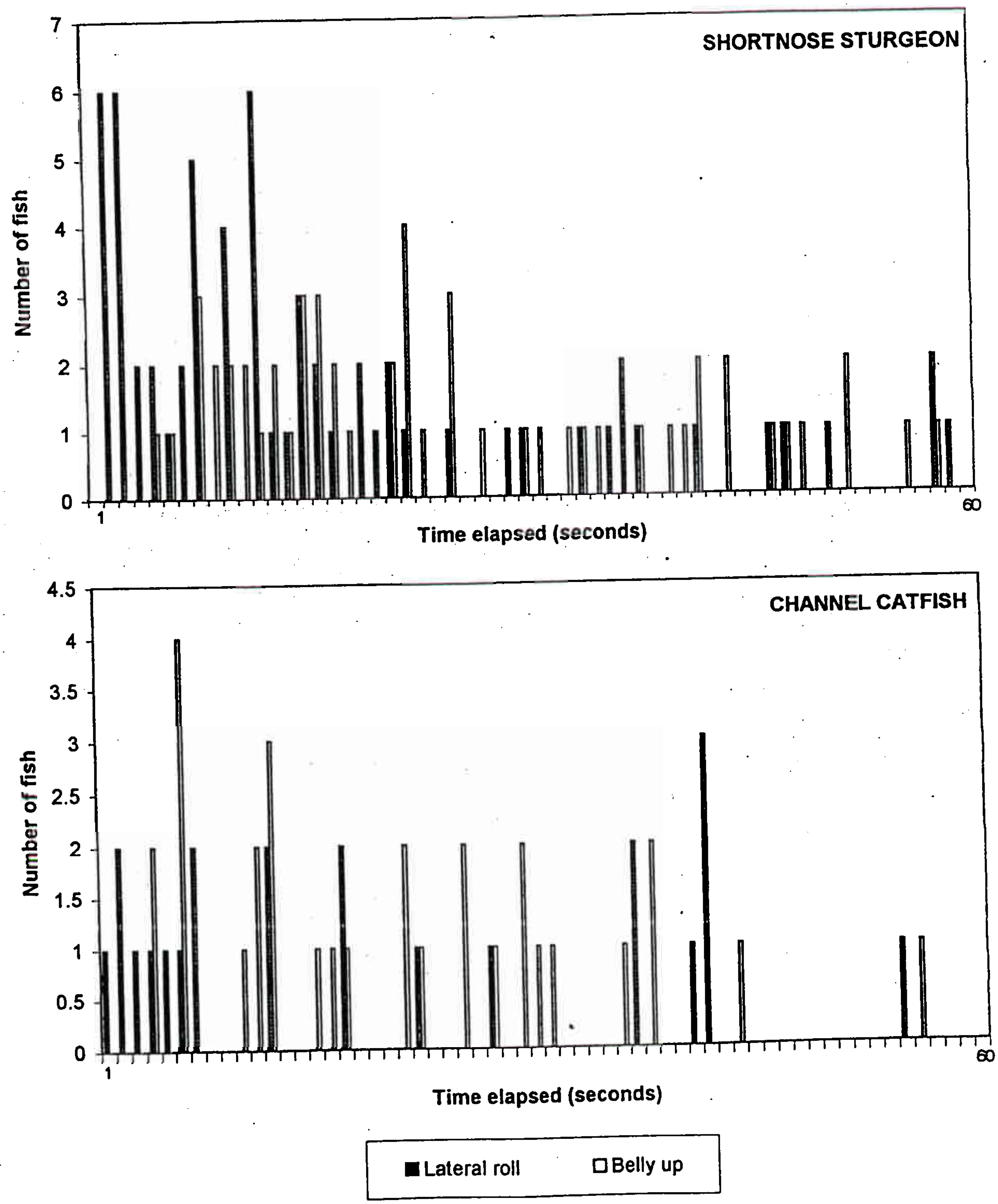


Table 1. Percent of all shortnose sturgeon and channel catfish that exhibited twitching, partial (roll) or complete (belly up) loss of equilibrium or avoidance in response to electroshocking during the first two week experiment (n=8 fish of each species observed during 48 electroshocking bouts).

	Twitch	Roll	Belly up	Avoidance
Sturgeon	12.5	16.1	17.1	10.0
Channel catfish	8.3	6.0	8.8	5.5

Catfish predation.

Salinity and temperature were the most variable water quality parameters during the catfish predation study (Figure 7). The temperature during experiment three was higher than in experiments one and two, although the temperature dropped below 10 ^{0}C only during experiment one. Salinity was generally lower during experiment three, and was elevated at the start of experiment two, peaking at 9.9 ‰ (Figure 7).

Size ranges of prey used in catfish predation studies differed among experiments due to availability of each size class (Table 2). Although sturgeon were longer than catfish in experiments 2-4, they were similar in weight and girth due to their long heterocercal tails. When striped bass were available, these were eaten first (Table 3). In experiment two, when striped bass were removed, channel catfish were missing from the tank. Flathead catfish did not eat any of the shortnose sturgeon in our experiments.

Figure 7. Water quality conditions during the four flathead catfish predation experiments: temperature °C (light line), salinity ppt (heavy line), and dissolved oxygen mg/L (dotted line).

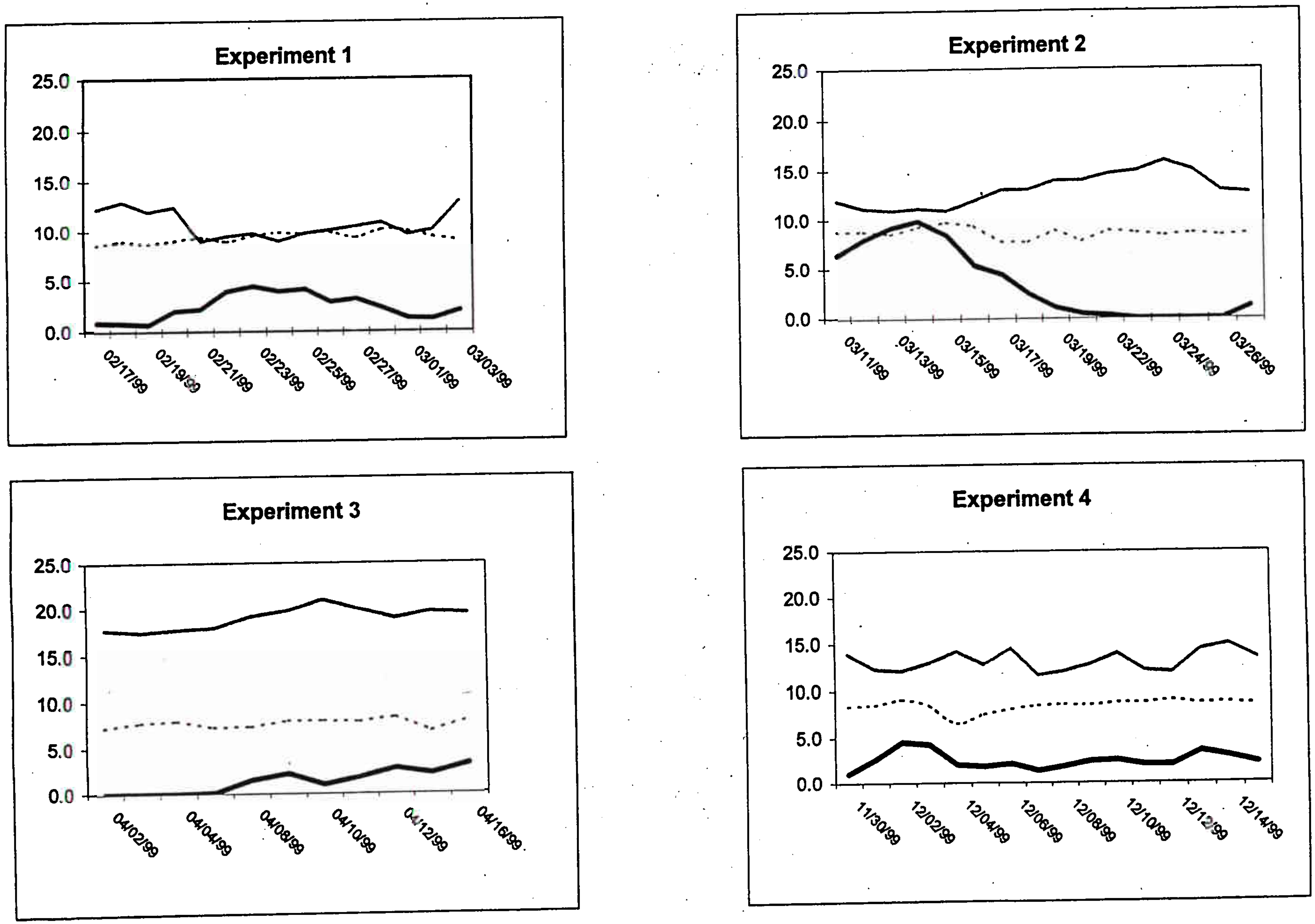


Table 2. Size ranges of fish used in flathead catfish predation study (total-length, mm).

	Striped bass	Channel catfish	Shortnose sturgeon	Flathead Catfish
Experiment 1	136-154	140-160	168-199	698
Experiment 2	-	98-124	172-199	640
Experiment 3	-	80-120	141-213	697
Experiment 4	-	181-258	298-355	695

- striped bass not used

Table 3. Number of each prey species consumed by flathead catfish in each experiment.

	Striped bass	Channel catfish	Shortnose sturgeon
Experiment 1	2	0	0
Experiment 2	-	3	0
Experiment 3	-	0	0
Experiment 4	-	0	0

DISCUSSION

Shortnose sturgeon are very sensitive to electrical currents produced by hand-held generators used for recreational electrofishing. We documented a variety of behaviors that sturgeon exhibited more frequently than did catfish (the species targeted by this gear) including: avoidance, twitching, rigor, and loss of equilibrium. However, the sturgeon recovered very rapidly during the one minute treatments they were exposed to in our experiments. The one minute treatments are conservative in that it is unlikely that the fish would be exposed to shocking of this duration during normal electrofishing. Moreover, it is unlikely that sturgeon would ever be subjected to four-five electroshocking events on a single day, even during periods of intensive fishing pressure. The fact that both experimental and control sturgeon exhibited similar positive growth rates indicates that sturgeon are able to recover from even excessive amounts of electroshocking of this type and are able to feed normally. However, subtle changes in feeding behavior would not have been detected in our tank experiments. Sturgeon were fed ad libitum and had to expend very little effort to feed; whereas in natural conditions a relatively short period of inactivity due to shocking could result in missed feeding opportunities. Moreover, behavior associated with courtship and spawning could easily be disrupted by electroshocking, as evidenced by the sensitivity of sturgeon to very low level electrical output.

We found no evidence that flathead catfish fed preferentially on shortnose sturgeon juveniles. The flathead catfish in our experiments seemed to feed most readily on striped bass, with channel catfish preferred over sturgeon when the bass were not available. A number of studies have documented predation of flathead catfish on other ictalurids, which has led to extirpation of native catfishes in rivers where flathead catfish have been introduced (reviewed in Moser and Roberts in press). While we found no evidence that flathead catfish fed as readily on sturgeon as on other catfish, we were also disappointed that so few prey were taken by the flathead catfish in our experiments. The flathead catfish were starved prior to experimentation and were allowed extended periods to recover from gillnetting and to acclimate to experimental tanks. One possible reason for the low feeding rates of our predators may have been the relatively low water temperatures during experimental periods. Yet, feeding was observed during the periods of lowest temperature, and no feeding occurred during experiment 3, which had the highest temperature (Figure 7). Future experiments could limit food choices to only sturgeon to determine whether flathead catfish will take them if nothing else is available. Moreover, the ability of flathead catfish to feed on sturgeon of a variety of sizes should be examined to insure that they are not able to target a size range of sturgeon juveniles that was not available in our experiments.

In summary, we found that the direct effects of electroshocking are more likely to negatively impact shortnose sturgeon than the indirect effect of removing potential flathead catfish predators. Unfortunately, due to unavoidable reductions in the number of fish available for the experiments and the time periods when they could be conducted (due to hurricanes), these experiments represent a pilot effort. Nevertheless, they clearly indicated that extensive periods of electroshocking could negatively effect shortnose sturgeon, particularly during critical, easily disrupted behaviors, such as courtship and spawning. Moreover, the energy expended to avoid shocking in summer could depress fitness of sturgeon already stressed by low oxygen and high temperature conditions. Further research to assess these issues should be conducted before restoration of shortnose sturgeon in the Cape Fear River drainage is considered.

ACKNOWLEDGEMENTS

We thank the U.S. Army Corps of Engineers for supplying the sturgeon and striped bass used in our experiments. The personnel of Warm Springs, Bears Bluff and Edenton fish hatcheries accommodated our needs for fish and Southeastern Pond Stocking and Aquatic Maintenance delivered them in fine condition. Special thanks to Cape Fear Community College for making space, and their expertise, available throughout the study. Without their help, this work would have ended with the deaths of fish at our primary fish holding facility. Michael Williams was instrumental in providing catfish for the predation study and the North Carolina National Estuarine Research Reserve kindly provided office support. This project was funded by a North Carolina Sea Grant, Fishery Resource Grant.

LITERATURE CITED

Mallin, M.A., M.H. Posey, M.L. Moser, L.A. Leonard, T.D. Alphin, S.H.Ensign, M.R. McIver, G.C.Shank, and J.F. Merritt. 1999. Environmental assessment of the lower Cape Fear River system, 1998-1999. Center for Marine Science Research, UNC-Wilmington, Wilmington, North Carolina.

Morris, L.A., and P.F. Novak. 1968. The telephone generator as an electrofishing tool. Progressive Fish Culturist. 30:110-112.

Moser, M.L., and S.B. Roberts. in press. Effects of non-indigenous ictalurid introductions and recreational electrofishing on catfishes of the Cape Fear River drainage, North Carolina. First International Ictalurid Symposium, American Fisheries Society Special Publication.

National Marine Fisheries Service. 1998. Recovery Plan for the Shortnose Sturgeon (*Acipenser brevirostrum*). Prepared by the Shortnose Sturgeon Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland.

Quinn, S.P. 1986. Effectiveness of an electrofishing system for collecting flathead catfish. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 40:85-1.

Ross, S.W., F.C. Rohde, and D.G. Lindquist. 1988. Endangered, threatened, and rare fauna of North Carolina, part 2. A re-evaluation of the marine and estuarine fishes. Occassional Papers of the North Carolina Biological Survey 1988-7, Raleigh, North Carolina.

I have permission from Mr. Ashley to give you a copy of his report and would appreciate it if you would put it in with my final report. I think the information Mr. Ashley has obtained is also beneficial.

Thank you,

Robin

32/894 0033

NORTH CAROLINA WILDLIFE RESOURCES COMMISSION

Division of Boating and Inland Fisheries

Final Report

Determination of Current Food Habits of Flathead Catfish in the Cape Fear River

Project Type: Survey

Period Covered: April 1986 - December 1986

Keith W. Ashley

Bobby Buff

Raleigh, North Carolina

December 1986

19 pf

Abstract: Current food habits of flathead catfish in the Cape Fear River were determined through analysis of 184 stomachs collected during the spring and summer of 1986. Fish were collected with a 5-bar, hand-cranked telephone generator (magneto). The objective was to determine if frequency of occurrence and percent by numbers of individual food items in the diet of flathead catfish changed significantly between 1979 and 1986. Current data indicates ictalurids, clupeids and centrarchids remain the primary food items in the diet of Cape Fear River flatheads; however, a shift from ictalurids to clupeids as the primary food item occurred between 1979 and 1986. Centrarchids occurred with equal frequency in flathead stomachs during 1979 and 1986 but were less numerous in the 1986 samples. There is no evidence to support anglers claims that flatheads may be responsible for the reputed decline in sunfish populations within the river. Decapods were more abundant in flathead stomachs in 1986 while frequency of occurrence remained unchanged. Pelecypods were less abundant in the 1986 samples but occurred with significantly higher frequency.

Flathead catfish (*Pylodictis olivaris*) are native to the New and French Broad Rivers of western North Carolina and were once common to the Nolichucky River. It is a solitary species preferring medium to large rivers with deep holes and abundant drift piles, sunken logs, log jams and standing timber (Minckley and Deacon 1959, Cross 1967, Morris et al. 1968, Pflieger 1975 and Glodek 1979). The Cape Fear River was stocked with flathead catfish in 1966 when 11 adults weighing 107.0 kg were released near Fayetteville, North Carolina by North Carolina Wildlife Resources

Commission personnel. This is the only known introduction of flathead catfish into the Cape Fear system. Guier and Nichols (1977) documented the establishment of a reproducing flathead population in 1976 with the collection of 5 specimens representing several age groups. Fourteen additional specimens, ranging in size from 10.0 g to 22.7 kg, were collected during 1977 providing further evidence of flathead reproduction within the Cape Fear River (Guier et al. 1980). Since its initial introduction the flathead population has expanded to inhabit 201 km of the mainstream Cape Fear and is considered the top level predator within the system (Guier et al. 1980).

The highly predatory feeding habits of flathead catfish were suspected of having adverse effects on the native fish species of the Cape Fear River. As early as 1970 NCWRC fisheries biologists received reports from local fishermen that native bullhead populations were declining. The fishermen attributed this decline to flathead predation. Apparently, rapid expansion of the flathead population during the mid 1970s resulted in a tremendous reduction in the bullhead population. This study was initiated in response to complaints from local fishermen concerning a perceived decline in sunfish populations within the river. The objective of this study was to determine if frequency of occurrence and percent by numbers of individual food items of flathead catfish in the Cape Fear River have changed significantly since 1979.

We wish to thank Mr. and Mrs. Earl Russell and Mr. James D. Davis for their assistance with data collection. This study was funded in part

through Dingell-Johnson Federal Aid in Fish Restoration, Project F-22, North Carolina.

METHODS

The Cape Fear River forms at the confluence of the Deep and Haw Rivers in piedmont North Carolina and flows southeasterly for approximately 274 km where it discharges into the Atlantic Ocean at Cape Fear near Southport (Louder 1963). Ninety percent of the drainage basin lies within the Coastal Plain and encompasses an area of approximately 1,916,600 ha (7,400 mi^2). Below river km 219 the river is regulated during low and moderate stages by 3 federal navigation locks and dams. The lunar tidal influence extends from the mouth of the river upstream to Lock and Dam #1, a distance of approximately 113 km.

Flathead catfish were collected from 1 April 1986 through 30 September 1986 from the mainstream Cape Fear River at Fayetteville, Tarheel/Elizabethtown, Elwell's Ferry and Riegelwood. All flathead catfish collected during this study were taken with a 5-bar, hand-cranked telephone generator as described by Morris and Novak (1968). Morris and Novak reported flathead catfish are particularly susceptible to capture using this device. The collecting operation was conducted using a shocking boat and a pickup or chase boat. Areas shocked included drift piles, log jams, sunken logs and standing timber located in the deeper pool areas along both banks.

Stomach contents were collected from all flathead catfish exceeding 1.0 kg in weight using the pulsed gastric lavage technique described by Foster (1977). Approximately 25.0 % of all fish were sacrificed to verify the effectiveness of the pulsed gastric lavage technique. All flatheads were weighed (kg) and measured (cm) prior to removal of the stomach contents. Individual food items were identified (if possible), sorted, counted and weighed.

Food habit data (frequency of occurrence, percent by numbers) collected during this study were statistically compared ($\alpha = 0.05$) with food habit data collected by Guier et al. (1980) using the following statistical test for comparing the equality of 2 percentages (Sokal and Rohlf 1969):

$$t_s = \frac{\arcsin\sqrt{p_1} - \arcsin\sqrt{p_2}}{\sqrt{820.8\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

where: p_1 = the proportion of food item 1 in the 1979 samples

p_2 = the proportion of food item 1 in the 1986 samples

n_1 = sample size for 1979

n_2 = sample size for 1986

820.8 = a constant representing the parametric variance of a distribution of arcsine transformations of proportions or percentages.

RESULTS

Examination of stomachs from sacrificed fish indicated pulsed gastric lavage removed approximately 100.0 % of all material present. Occasionally, a large particle would become lodged in the esophagus and require removal with forceps. It is an excellent technique for collecting stomach contents without injury to the fish.

Contents from 184 flathead catfish stomachs were examined and analyzed (Table 1). Fifty-five percent (102) of the stomachs were empty. Fish were the dominant food item in the diet of Cape Fear River flathead catfish during 1986 by frequency of occurrence, percent by numbers and percent by weight (Table 1). Fish accounted for 65.5 % by number and 97.0 % by weight of all food items consumed by flatheads during 1986. Unidentified fish remains occurred in 28.0 % of the stomachs.

Clupeids (12.1 % by number; 57.1 % by weight) were the most dominant food item group comprising the diet of Cape Fear River flathead catfish (Table 1). They occurred in approximately 18.0 % of the stomachs containing food (Table 2). White shad (*Alosa sapidissima*) accounted for approximately 51.0 % by weight of the diet during 1986; however, they occurred in stomachs collected during April and May suggesting their consumption may be related to seasonal influences (distribution and abundance). It is interesting to note the occurrence of white shad weighing 1.1 kg and 1.5 kg in the stomachs of flathead catfish weighing 6.5 kg and 17.2 kg, respectively. Gizzard shad (*Dorosoma cepedianum*) represented an additional 7.5 % by number and 6.4 % by weight of the diet.

Ictalurids, most notably white catfish (*Ictalurus catus*), blue catfish (*Ictalurus furcatus*), channel catfish (*Ictalurus punctatus*) and flathead catfish (*Pylodictis olivaris*), were the second most preferred forage items consumed by flatheads. They occurred in approximately 20.0 % of the stomachs containing food (Table 2). Two specimens of snail bullhead (*Ictalurus brunneus*), representing 1.2 % by number and 1.3 % by weight of the diet, accounted for the only other ictalurid comprising the food habits of Cape Fear River flatheads.

Centrarchids occurred in only 8.5 % of the stomachs containing food (Table 2) and accounted for only 4.6 % by number and 3.5 % by weight of the diet. Largemouth bass (*Micropterus salmoides*) were not found in any of the 82 stomachs containing food.

Cyprinids represented 16.1 % by number but less than 1.0 % by weight of the flathead diet during 1986. Longnose gar (*Lepisosteus osseus*) and yellow perch (*Perca flavescens*) accounted for an additional 4.6 % by number and 1.1 % by weight of all food items consumed (Table 1). The occurrence of 1 southern flounder (*Paralicthys lethostigma*), 2 spot (*Leiostomus xanthurus*) and 3 crabs (Brachyura) in stomachs of fish collected at the Riegelwood station is a reflection of saltwater intrusion resulting from the extensive and prolonged drought which occurred during the summer of 1986.

Decapods (crayfish) accounted for 11.5 % by number but only 1.2 % by weight of the flathead diet and occurred in 12.0 % of the stomachs containing food (Tables 1 and 2). Pelecypods (freshwater clams) represented an even higher percentage of the diet by percent number (18.4 %) but less than 1.0 % by weight and occurred relatively infrequently in the diet (8.5 % of the stomachs).

DISCUSSION

Food habit data collected by Guier et al. (1980) included data collected from flathead catfish taken near Lillington, NC; however, since there was no comparable station during this study the Lillington data was not included in the data analysis. In addition, individual weights for the food items examined and analyzed by Guier et al. (1980) could not be located making it impossible to compare the data from both studies on a percent by weight basis. Figures 1 and 2 compare the frequency of occurrence and percent total numbers, respectively, of individual food items comprising the diet of flathead catfish collected from the Cape Fear River during 1979 and 1986.

Flathead catfish exceeding 300 mm feed primarily on fish (Minckley and Deacon 1959, Turner and Summerfelt 1970, Pflieger 1975 and Borawa 1982). In an earlier study, in which they examined and analyzed the stomach contents of 105 Cape Fear River flathead catfish, Guier et al. (1980) reported they fed predominantly on ictalurids (39.0 %), clupeids (12.0 %) and centrarchids (10.0 %) during 1979 (Figure 1). Data collected during the present study indicates flatheads are still utilizing these forage items heavily; however, there was a significantly higher proportion, both in frequency of occurrence and percent by numbers, of clupeid food items in the 1986 samples. This coincides with a significant reduction, again, both in frequency of occurrence and percent by numbers, of ictalurid food items indicating a shift in food habits from ictalurids to clupeids between 1979 and 1986.

Shad availability is dependent upon the annual shad run up the river which normally occurs between March 15 and May 1 in any given year. Guier et al. (1980) conducted their sampling in May and June and August and September of 1979 while sampling was conducted from April through September during the present study. The shift in food habits from ictalurids to clupeids could be the result of the temporal difference in sampling schedules between the 2 studies. By beginning their sampling in May Guier et al. (1980) may have missed the majority of the shad run up the river in 1979 and therefore their food habit data would not adequately reflect the true percentage of shad (especially white shad) in the flathead diet for 1979. In addition, the shad forage base (especially white shad) available to flathead catfish in 1986 could have been much larger than that available in 1979 and could be another explanation for the shift in food habits. According to Mr. Earl Russell (personal communication), more white shad were observed coming back down the river in 1986 than in the past 5 to 6 years. Furthermore, the majority of adult white shad returning down river die and sink to the bottom becoming easy prey for flathead catfish.

Edmundson (1974) reported sunfish were the dominant forage consumed by flathead catfish in Bluestone Reservoir, West Virginia and they occurred in approximately 23.0 % of the flathead stomachs examined by Guier et al. (1980). However, there was no significant difference in the frequency of occurrence of centrarchid food items in the flathead diet between 1979 and 1986 (Figure 1). There was a significantly lower number of sunfish food items in the 1986 diet indicating sunfish were not as heavily foraged upon in 1986 (Figure 2). A decline in the available sunfish forage base between 1979 and 1986 could explain the lower number of sunfish in the 1986 diet; however, there is no data to support anglers' claims that flatheads are responsible for the reputed decline in sunfish populations within the Cape Fear River.

Ictalurids and cyprinids were the principal food items consumed by flathead catfish in a riverine system (Morris et al. 1968). There was a significantly higher proportion (both in frequency of occurrence and percent total numbers) of cyprinid food items in the 1986 diet; however, since they accounted for less than 1.0 % by weight of the food items consumed (Table 1), their occurrence would be considered insignificant.

According to Hackney (1965), flathead catfish selected centrarchids and ictalurids over cyprinids in experiments conducted in plastic-lined pools and earthen ponds. There was no significant difference in the proportion of unidentified fish remains comprising the diet between 1979 and 1986.

Previous studies (Morris et al. 1968, Edmundson 1974 and Pflieger 1975) have indicated crayfish can serve as a major food item in the diet of flathead catfish. The number of decapods consumed in 1986 was significantly higher than the number consumed during 1979 (Figure 2) but frequency of occurrence remained the same indicating more crayfish may have been available for consumption during 1986. Frequency of occurrence of pelecypods was significantly higher in the 1986 samples while the percent total numbers was significantly lower. This may indicate either preference for clams by flathead catfish increased during 1986 or that there may have been fewer clams available for consumption.

In summary, the diet of flathead catfish in the Cape Fear River between 1979 and 1986 remained fairly constant regarding the consumption of primary food items (ictaluirds, clupeids and centrarchids). A shift in food habits from catfish to shad as the primary food item occurred between 1979 and 1986 and was probably the result of temporal differences between sampling schedules between 1979 and 1986 or the result of a larger shad forage base in 1986 or both. Sunfish were consumed with equal frequency in 1979 and 1986 but occurred in fewer numbers in the 1986 samples indicating a possible decline in the sunfish forage base since 1979. There is no data to support anglers claims that flatheads are responsible for the reputed decline in sunfish populations within the Cape Fear River. Crayfish were more abundant in flathead stomachs during 1986 while frequency of occurrence remained unchanged. Finally, freshwater clams were less abundant in flathead stomachs in 1986 but occurred with significantly higher frequency.

RECOMMENDATIONS

1. Flathead catfish should not be stocked in any system dominated by ictalurids and clupeids unless it is to be used as a predator to control these species.
2. Food habits of flathead catfish in the Cape Fear River should be examined in the near future (within the next 5 - 10 years) to determine if dietary preference has changed or has stablilized.

LITERATURE CITED

Borawa, J.C. 1982. Biological evaluation of the effects of flathead catfish on native catfish populations in the Northeast Cape Fear River. Final Report, F-22. N.C. Wildl. Resour. Comm. Raleigh. 12pp.

Cross, F.B. 1967. Handbook of fishes of Kansas. Mus. of Nat. Hist., Misc. Publ. Univ. of Kan. Lawence, Kan. 45, 357pp.

Edmundson, J.P., Jr. 1974. Food habits, age and growth of flathead catfish, *Pylodictis olivaris* (Rafinesque) in Bluestone Reservoir, West Virginia. W.Va. Dep. of Nat. Resour. 78pp.

Foster, J.R. 1977. Pulsed gastric lavage: An efficient method of removing the stomach contents of live fish. Prog. Fish-Cult. 39(4):166-169.

Glodek, G.S. 1979. *Pylodictis olivaris* (Rafinesque), Flathead catfish. Page 422 *in* D.S. Lee et al. (eds.) N.C. State Mus. Nat. Hist., Raleigh, N.C.

Guier, C.R. and L.E. Nichols. 1977. A preliminary survey to determine the current status of largemouth bass in the Cape Fear River. N.C. Wildl. Resour. Comm. Unpubl. Rep., 26pp.

______, L.E. Nichols and R.T. Rachels. 1980. Biological investigation of flathead catfish in the Cape Fear River. N.C. Wildl. Resour. Comm. Final Rep., F-22-4, 43pp.

Hackney, P.A. 1965. Predator-prey relationships of the flathead catfish in ponds under selected forage fish conditions. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 19:217-222.

Louder, D.E. 1963. Survey and classification of the Cape Fear River and tributaries, North Carolina. N.C. Wildl. Resour. Comm. Final Rep., F-14-R, Job I-G. 15pp. and appendices.

Minckley, W.L. and J.E. Deacon. 1959. Biology of the flathead catfish in Kansas. Trans. Am. Fish. Soc. 88:344-355.

Morris, L.A. and P.F. Novak. 1968. The telephone generator as an electrofishing tool. Prog. Fish-Cult. 30:110-112.

_____, R.N. Langemeier and A. Witt, Jr. 1968. The flathead catfish in unchannelized and channelized Missouri River, Nebraska. Neb. Game and Parks Comm. Lincoln, Neb. 34pp.

Pflieger, W.L. 1975. The fishes of Missouri. Mo. Dep. of Conserv., Jefferson City, Mo. 343pp.

Sokal, R.R. and F.J. Rohlf. 1969. Biometry. W.H. Freeman and Company, San Francisco, Calif. 776pp.

Turner, R.P. and R.C. Summerfelt. 1970. Food habits of adult flathead catfish (*Pylodictis olivaris*) in Oklahoma reservoirs. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 24:387-401.

Table 1. Numbers, weights and percent composition of food items in stomachs of flathead catfish collected from the Cape Fear River, North Carolina during 1986. (n = 82)

Food Item	Number	Weight (g)	% No.	% Wt.
Crustecea				
Decapoda				
Astacidae	15.0	65.1	8.62	1.19
Palaemonidae	5.0	1.5	2.87	0.03
Pelecypoda	32.0	22.5	18.39	0.41
Gastropoda	1.0	4.0	0.57	0.07
Brachyura	3.0	66.0	1.72	1.21
Insecta				
Terrestrial insects	3.0	1.5	1.72	0.03
Tricoptera	1.0	1.0	0.57	0.02
Osteichthyes				
Seminonotiformes				
Lepisosteidae				
Lepisosteus osseus	7.0	38.0	4.02	0.70
Clupeiformes				
Clupeidae				
Alosa sapidissima	8.0	2,763.0	4.60	50.70
Dorosoma cepedianum	13.0	348.0	7.47	6.39
Cypriniformes				
Cyprinidae				
Notropis spp.	28.0	30.5	16.09	0.56
Siluriformes				
Ictaluridae				
Ictalurus brunneus	2.0	72.0	1.15	1.32
Ictalurus catus	5.0	13.0	2.87	0.24
Ictalurus furcatus	5.0	1,096.0	2.87	20.11
Ictalurus punctatus	5.0	368.0	2.87	6.75
Pylodictis olivaris	1.0	10.0	0.57	0.18
Perciformes				
Centrarchidae				

Table 1. Cont.

Food Item	Number	Weight (g)	% No.	% Wt.
Lepomis macrochirus	6.0	172.0	3.45	3.16
Lepomis microlophus	2.0	16.0	1.15	0.29
Percidae				
Perca flavescens	1.0	23.0	0.57	0.42
Sciaenidae				
Leiostomus xanthurus	2.0	93.0	1.15	1.71
Pleuronectiformes				
Bothidae				
Paralicthyes lethostigma	1.0	12.0	0.57	0.22
Unidentified fish remains	28.0	234.0	16.09	4.29
Totals	174.0	5,450.1	99.95	100.00

Table 2. Frequency of occurrence of food items in flathead catfish stomachs collected from the Cape Fear River, North Carolina during 1979 and 1986.

	Year			
	1979		1986	
Food Item	Number	Percent	Number	Percent
Clupeidae	11.0	16.7	15.0	18.0
Ictaluridae	22.0	33.4	16.0	20.0
Centrarchidae	15.0	22.7	7.0	8.5
Percidae	0.0	0.0	1.0	1.0
Cyprinidae	1.0	1.5	10.0	12.0
Lepisosteidae	1.0	1.5	4.0	5.0
Sciaenidae	0.0	0.0	2.0	2.0
Bothidae	0.0	0.0	1.0	1.0
Fish Remains	26.0	39.4	23.0	28.0
Decapoda	7.0	10.6	10.0	12.0
Pelecypoda	2.0	3.0	7.0	8.5
Gastropoda	2.0	3.0	1.0	1.0
Brachyura	0.0	0.0	3.0	4.0
Insecta	19.0	28.8	4.0	5.0
Totals	106.0		174.0	

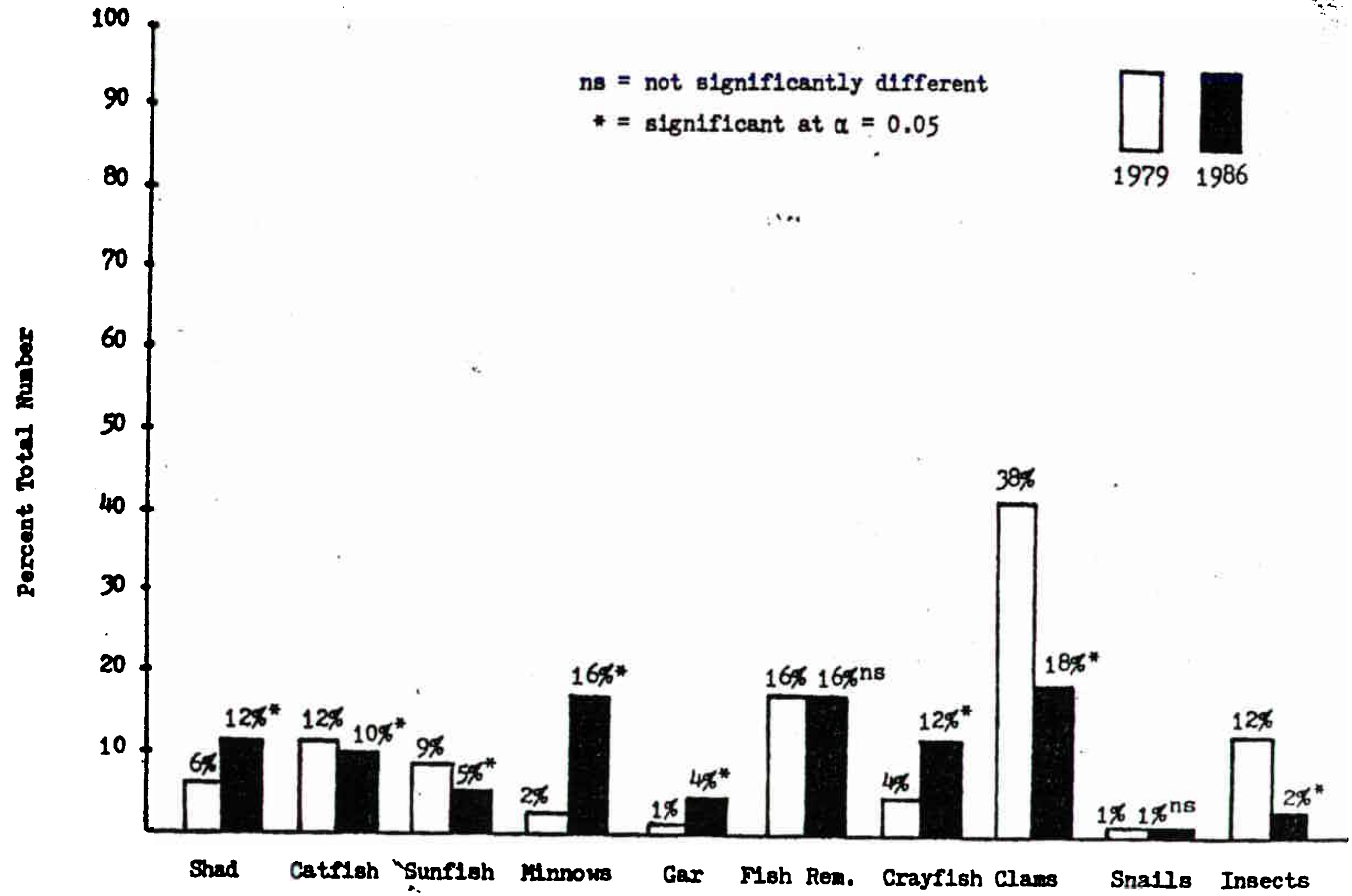


Figure 2. Percent total numbers of food items occurring in flathead catfish stomachs collected from the Cape Fear River, North Carolina during 1979 and 1986.

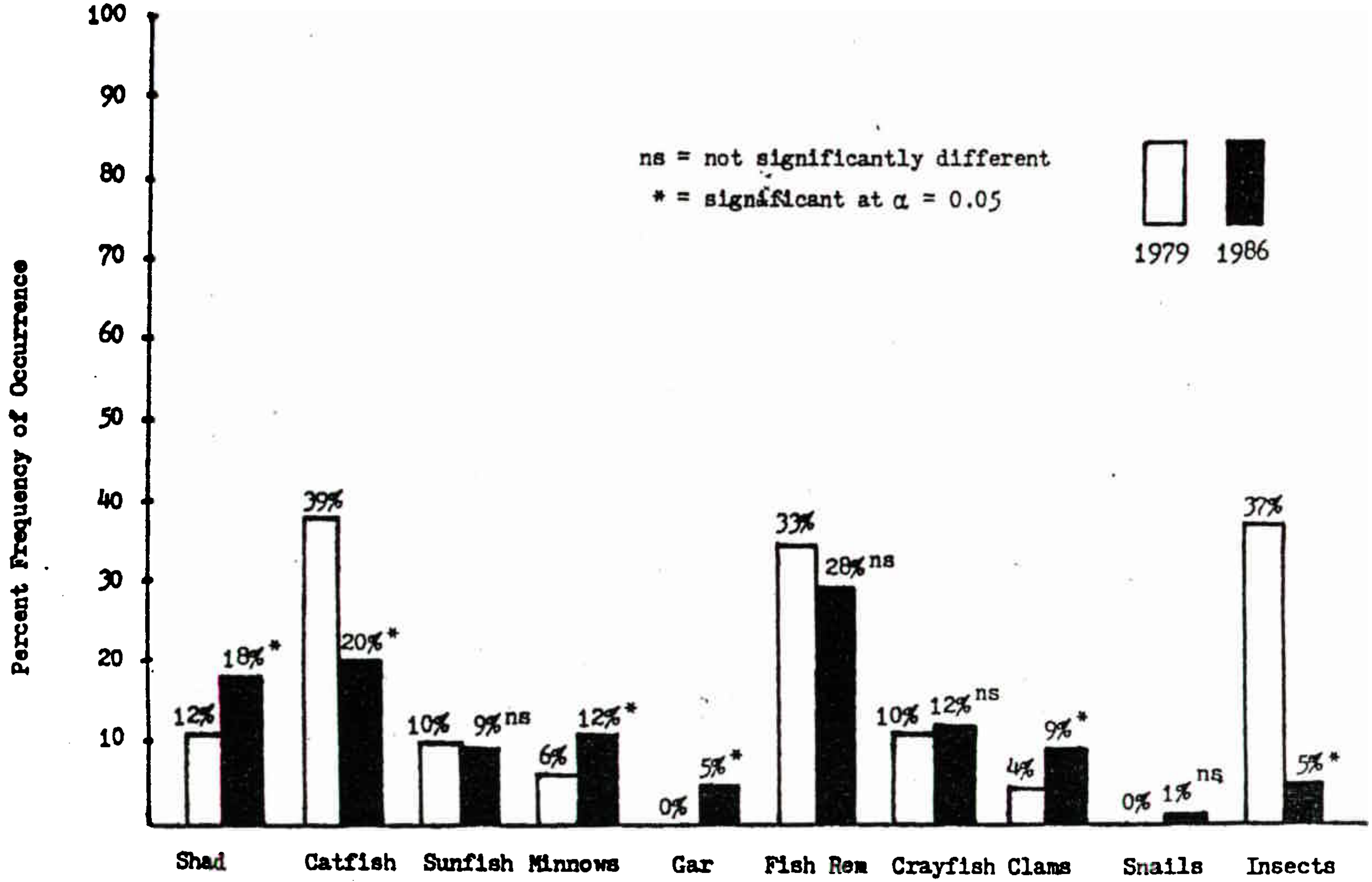
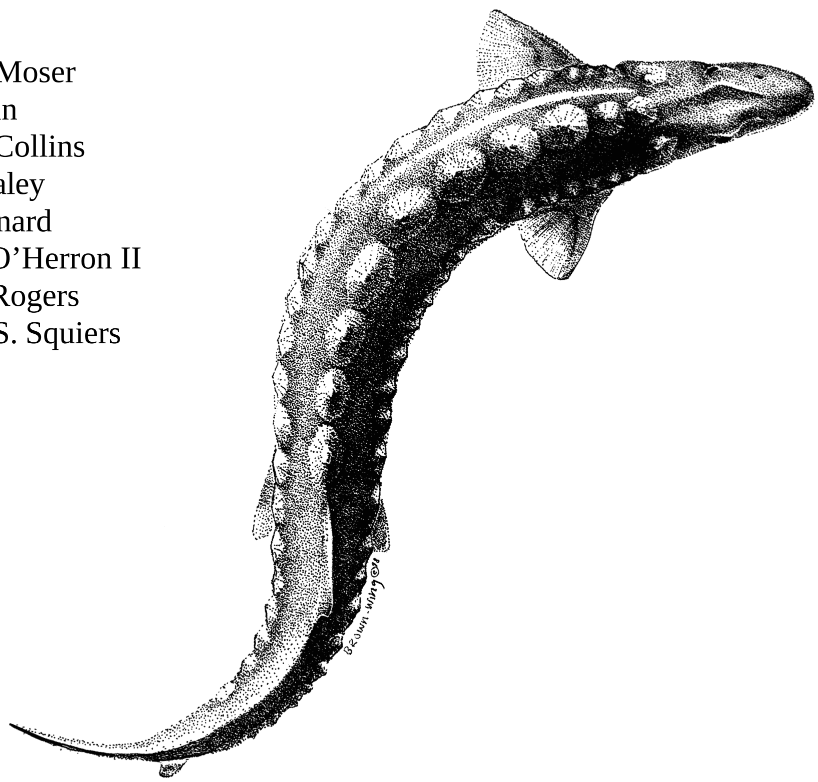


Figure 1. Percent frequency of occurrence of food items occurring in flathead catfish stomachs collected from the Cape Fear River, North Carolina during 1979 and 1986.

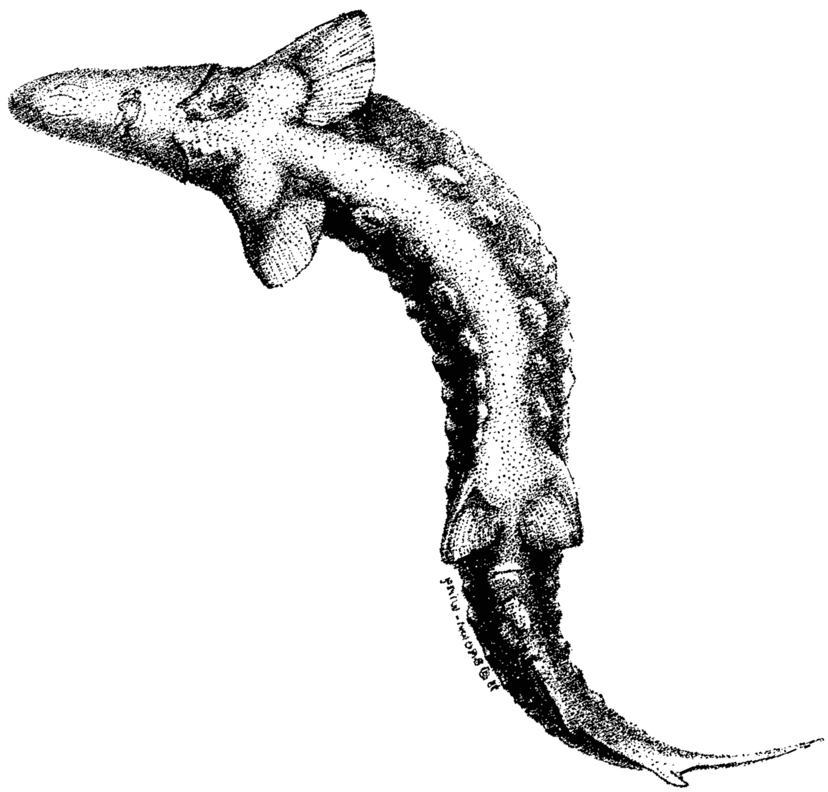
A Protocol for Use of Shortnose and Atlantic Sturgeons

Mary L. Moser
Mark Bain
Mark R. Collins
Nancy Haley
Boyd Kynard
John C. O'Herron II
Gordon Rogers
Thomas S. Squiers



U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

NOAA Technical Memorandum NMFS-OPR-18
May 2000



A copy of this report may be obtained from:

NMFS Office of Protected Resources
1315 East-West Highway
Silver Spring, MD 20910

or on the interet at:
http://www.nmfs.gov/prot_res/prot_res.html

A Protocol for Use of Shortnose and Atlantic Sturgeons

Mary L. Moser
Center for Marine Science Research
Univ. of North Carolina-Wilmington
7205 Wrightsville Avenue
Wilmington, NC 28403

Mark Bain
New York Cooperative
Fish and Wildlife Research Unit
Fernow Hall,Cornell University
Ithaca, NY 14853-3001

Mark R. Collins
S.C. Dept of Natural Resources
P.O. Box 12559
Charleston, SC, 29422-2559

Nancy Haley
National Marine Fisheries Service
212 Rogers Avenue
Milford, CT 06460

Boyd Kynard
Conte Anadromous Fish Research Lab
USGS/BRD 1 Migratory Way
Turners Falls, MA 01376

John C. O'Herron II
O'Herron Biological and
Environmental Consulting
220 Washington Street
Mount Holly, NJ 08060

Gordon Rogers
Satilla Management Associates/
Southern Resources and Environ. Serv.
Route 2, Box 7A-1
Waynesville, GA 31566

Thomas S. Squiers
Maine Dept. of Marine Resources
State House, Station Number 21
Augusta, ME 04333

NOAA Technical Memorandum
NMFS-OPR-18
May 2000

U.S. Department of Commerce
William M. Daley, Secretary

National Oceanic and Atmospheric Administration
D. James Baker, Under Secretary for Oceans and Atmosphere

National Marine Fisheries Service
Penelope D. Dalton, Assistant Administrator for Fisheries

Abstract

Guidelines for handling and sampling of Atlantic coast sturgeons are needed to protect these fishes and to facilitate standardization of methodologies used by sturgeon researchers. The shortnose sturgeon, *Acipenser brevirostrum*, is a federally listed endangered species and the Atlantic sturgeon, *Acipenser oxyrinchus oxyrinchus*, is considered a species of special concern. Consequently, special techniques have been developed to reduce stress and mortality resulting from sampling and handling these species. In this document we review the most acceptable methods for short-term holding, identification and measurement, tagging, tissue sampling, gastric lavage, and collection using a variety of gear types. In addition, we provide a protocol for sampling to establish whether shortnose sturgeon are present in systems where their status is unknown.

Introduction

In recent years, a need has developed for standardization of sampling and handling methods for Atlantic coast sturgeons: shortnose (*Acipenser brevirostrum*) and Atlantic (*A. oxyrinchus oxyrinchus*). The shortnose sturgeon has been federally-listed as an endangered species since the Endangered Species Act of 1973. In the past few years the Atlantic sturgeon has been petitioned for listing and has been designated as a candidate species. Because the shortnose sturgeon has been listed for so long, it has been the subject of a relatively large number of research projects; however, this research has been conducted by only a handful of individuals. The Shortnose Sturgeon Recovery Plan (National Marine Fisheries Service 1998) specified the need for a sampling and handling protocol because of: 1) the likely increases in research on sturgeon in future years by a larger number of scientists and the concomitant need for standardization of methods, 2) the need for guidance in permitting research activities that may harm sturgeon, and 3) the need for minimum sampling requirements to determine that sturgeon are extant in a given system.

Sturgeon present some unique challenges for development of standardized methods. Both shortnose and Atlantic sturgeon may occur in a variety of habitats in Atlantic drainages from southern Canada (Saint John River) to northern Florida (St. Johns River). The differences in habitat both within and among river systems, and latitudinal differences in temperature and sturgeon life history, have resulted in sampling methods that are often specific to a given region or time of year. To make this document as comprehensive as possible, we have incorporated methodologies from research conducted across the entire range of habitats where these sturgeons occur and for the all sturgeon life stages that have been studied in the wild. We make no attempt here to suggest methodology for culture or long-term maintenance of sturgeon. In reviewing the literature and incorporating our own experiences in this protocol, we noted that innovations in research occur rapidly. Consequently, we emphasize that this protocol should be a living document that incorporates new techniques as they are developed and perfected. This protocol represents many years of collective experience in sampling and handling sturgeons and should provide useful guidelines for future research. Our intent is not to discourage development of new techniques or to limit or restrict sturgeon research.

Handling Methodologies

Both shortnose and Atlantic sturgeons are very hardy species. The ability of sturgeon to survive under extremely stressful conditions is well established and was exploited during early fisheries for their flesh and roe. The sturgeon's hardy nature also permits the use of research practices that stress these fish, potentially resulting in negative, but sub-lethal, impacts. For example, excessive handling of pre-spawning adults during their migration can result in interruption or even abandonment of upstream migration (Moser and Ross 1995). Moreover, sturgeon are very sensitive to handling during periods of high water temperature or low dissolved oxygen, and sturgeon can be lethally stressed in a short time if handled improperly during these conditions. The following handling protocol therefore includes guidelines for a variety of conditions.

Short-term holding

It is frequently necessary to hold sturgeon for short periods while fishing nets, tagging or collecting tissue samples. If possible, sturgeon should be held in floating net pens or live cars during processing. When fish are held on board the research vessel, they should be placed in flow-through tanks that allow total replacement of the water volume every 15 - 20 min. While total water volume in the tanks is not critical, adequate control of temperature and oxygen levels is absolutely essential. Fish should not be held on board for longer than 2 h when water temperatures are equal to or less than 27°C. If water temperature exceeds 27°C, sturgeon should never be held on board for longer than 30 min. Dissolved oxygen levels below 3 ppm are also stressful to sturgeon (Jenkins et al. 1993). Therefore, oxygenation of the water in holding tanks may be necessary during periods of high temperature or low dissolved oxygen and handling should be minimized. The use of an electrolyte bath (such as Stress Coat, marketed by aquaculture suppliers) can also help to reduce stress and restore the slime coat when fish are collected in fresh water. Sturgeon are very sensitive to chlorine; so, very thorough flushing is required if holding tanks are sterilized with bleach between sampling periods.

Sturgeon are physostomous and tend to inflate their swim bladder when stressed and in air. If this occurs, efforts should be made to return the fish to neutral buoyancy prior to or during release. This can often be achieved by propelling the fish rapidly downward during release. If the fish still has air in its bladder it will float and be susceptible to sunburn or bird attacks. Often the remaining air can be released by gently applying ventral pressure in a posterior to anterior direction.

Identification and measurement

Identification of sturgeon to species, sex and reproductive condition may involve use of both external and internal morphology. Juvenile Atlantic sturgeon and juvenile or adult shortnose sturgeon are easily confused and care should be taken in use of morphological characters for identification. The most consistently accurate external character is the ratio of bony inter-orbital width to mouth width (Moser et al. 1998). Use of other characters such as snout length and scute patterns can be misleading. For weight measurements, sturgeon should be supported using a sling or net and handling should be minimized throughout processing. Use of smooth rubber gloves is recommended to reduce abrasion of skin and removal of mucus.

Neither sturgeon species can be sexed on the basis of external morphology. A close magnifier at the end of a light beam (Bioscope) can be used to distinguish sexes and even to stage eggs without surgery. This instrument is gently inserted through the genital opening and rotated to view the gonads internally. This technique is quick, far less intrusive than surgical procedures, and with experience its use will allow differentiation of females that will spawn during the next spawning period from immature and post-spawned females. However, it cannot provide maturity stage data for males, nor differentiate between males and immature females.

Tagging

The life history, morphology, behavior, and physiology of sturgeons present a plethora of challenges for tagging studies. Sturgeon are long-lived; so, for many studies it is essential that tags be retained for extended periods. In addition, they exhibit very rapid juvenile growth rates and, in the case of Atlantic sturgeon, can achieve very large sizes (> 3 m). Therefore, tags must be retained even as the tag placement area changes size and shape. Moreover, sturgeon are adept at rubbing off external tags and can actually extrude internal tags through the body wall to rid themselves of tags placed in the body cavity (Kynard and Kieffer 1994). Our collective experiences with a variety of tagging methods and materials, in addition to laboratory studies of tag retention, were drawn upon to provide the following recommendations for tagging.

External tags generally have lower retention rates than internal tags, but are often needed in studies that require participation of people other than the researcher (such as tag-recapture studies that rely on tag returns from fishermen). A variety of external tag designs and placement sites have been used on both Atlantic and shortnose sturgeon. The first laboratory studies of tag retention by shortnose sturgeon indicated that Carlin tags placed just below the dorsal fin and internal anchor tags inserted laterally into the abdomen had the highest retention rates of the tags tested (Smith et al. 1990). More than 50 shortnose sturgeon marked with Carlin tags in the Hudson River from 1979-80 were recovered in recent research, indicating that these tags can have long retention times. About half of the tag disks were clearly legible and provided valuable data on fish at large for over 15 years. However, Carlin tag retention in both the Connecticut River and Delaware River has been poor when compared to passive integrated transponding (PIT) and anchor tags, respectively. Anchor tags placed at the base of the dorsal fin in 1981-87 are now being recovered in the Delaware River over a decade later. Collins et al. (1994) tested a variety of external tag designs in the laboratory and found that a T-anchor tag inserted into the lateral abdominal wall provided the greatest retention. However, it was noted that healing of the insertion wound was slow (or did not occur) for all tags that protruded through the skin. While external tags clearly have lower retention than internal tags, anchor tags in the dorsal musculature show the most promise for greatest longevity with least impact to the fish.

A number of sturgeon studies use PIT tags in addition to an external tag. These tags are injected just below the skin along the dorsal mid-line anywhere from the posterior edge of the fourth dorsal scute to the posterior edge of the dorsal fin. Due to the lack of standardization in placement of PIT tags, we recommend that the entire dorsal surface of each fish be scanned with a waterproof PIT tag reader to insure detection of fish tagged in other studies. We note that juvenile Atlantic sturgeon may grow around the PIT tag, making it difficult to get close enough to read the tag in later years. For this reason, the largest (highest power) PIT tags should be used for both sturgeon species, and tags should be placed posterior to the dorsal fin, where tissue growth is least. PIT tags far out perform external tags. However, laboratory studies indicate that sturgeon smaller than 200 mm TL shed PIT tags at a rate of over 50%, due to the lack of musculature at this size. The likelihood of high PIT tag loss should therefore be considered when marking sub-yearling sturgeon.

A variety of methods have been used to outfit sturgeon with sonic or radio transmitters. Due to their large body size, sturgeon can carry large transmitters having extended battery life. Consequently, it is important that these tags be retained for as long as possible. External attachment of the transmitters is the least intrusive method; however, a number of field studies have indicated that both sonic and radio tags are shed at rates of 15 - 60% within the first 4 – 6 mo. of external attachment (Smith 1988, Moser and Ross 1993, Kieffer and Kynard 1993, Rogers and Weber 1995). In a tank study using cultured shortnose sturgeon, externally-attached transmitter loss began on day 2, and 100% were lost by day 60. It was obvious that the sturgeon actively rubbed the transmitters on any available surface.

In spite of the problems with tag loss, only external attachment of transmitters should be used for pre-spawning fish in spring or those on the spawning ground. In addition, surgical implants should not be attempted when water temperature exceeds 27°C (to reduce handling stress) or is less than 7°C (incisions do not heal rapidly in low temperatures). External transmitters are retained longest when they are as small as possible and are attached through the dorsal fin using monofilament line or stainless steel leader and a PVC backing plate (Rogers and Weber 1995). The addition of a neoprene pad between the fish's body and the transmitter or backing plate helps to protect the fish.

Internal implantation of radio or sonic transmitters provides greater retention than external attachment. Radio range is maximized with a trailing antenna, however, there is less chance of infection if the antenna is also implanted internally. In a recent tank study, radio transmitters were surgically implanted in cultured shortnose sturgeon, but the antennas were externally trailing. After 90 days, all of the fish had openings around the antenna exit area and were still bleeding or obviously infected. In some cases the antenna had cut large wounds through the abdominal wall and the transmitter and internal organs were visible. Field trials using this method of attachment indicated less significant impacts to wild shortnose sturgeon in the upper Connecticut River. Eight fish tagged internally with transmitters having a trailing radio antenna were recaptured after 12 months at large. While the tissue at the antenna exit area was darkened, there was no sign of infection or of abrasion to the fins on any of these fish (Kynard et al. 1999). We conclude that radio transmitter antennas should be internally implanted whenever possible to minimize injury to the fish. However, when it is absolutely necessary to obtain maximal signal range (aerial surveys, passage studies around dams, etc.), trailing antennas may be used with caution. This method should not be used when tagging a significant percentage of a given population.

Surgery to implant transmitters should only be attempted when fish are in excellent condition. Methods of Summerfelt and Smith (1990) should be used as general guidelines for sturgeon anesthesia using tricaine methane sulfonate (MS-222); however, the dose should be reduced to only that needed to immobilize the fish during surgery, if at all. Placing fish upside down in a cradle or trough during surgery is often sufficient to immobilize them. Also, sturgeon may be safely immobilized using galvanonarcosis (low voltage DC). The transmitters and internally implanted coiled antennas can be coated with an inert elastomer (Silastic MDX4.4210) to reduce tissue irritation and subsequent tag rejection. However, some transmitter coatings are quite inert and do not need this treatment, and some transmitter models coated with Silastic have been expelled by cultured shortnose sturgeon in tank studies. Also, transmitters with externally trailing antennas should not be coated to allow sturgeon tissue to adhere to the tag and hold it in place in the body cavity (Kynard et al. 1999).

The transmitter and all surgical instruments should be sterilized immediately prior to use. A lateral incision approximately 30 mm long should be made 40 - 60 mm anterior to the pelvic fin and about 10 - 20 mm above the ventral row of scutes (although the specific location will vary with fish size). This location reduces abrasion of the transmitter on the incision. However, lateral muscle tissue in large adults may be quite thick, so a ventral incision is recommended for them. The incision should be closed with either absorbable or non-absorbable suture material (absorbable material is superior for tying knots but there has been no documented differences in healing of wounds with either suture type) and a large cutting needle. Individual sutures should be closed with separate, double, square knots so that the muscle tissue firmly touches but is not drawn tightly. After surgery the fish should be released as soon as it recovers from the anesthesia.

Tissue sampling

Tissue sampling is required for genetic evaluation, studies of contaminant loading, assays of physiological condition, and ageing. A 1 cm^2 pelvic fin clip is recommended for genetic analysis. Muscle samples for contaminant analysis or energetic evaluation should be taken from the thickest dorsal musculature using a mammalian tissue punch. First, a v-shaped flap of skin should be peeled back using a sterilized scalpel. The punch is then used to cut a small core of tissue, which may be removed with cutting pliers. The flap of skin should then be replaced and two sutures used to close the wound. Blood samples may be taken from the ventral caudal peduncle. Egg samples may also be removed using a large gauge hypodermic needle (as used for PIT tag insertion). The needle is inserted through a small ventral incision in the abdomen and a small number of eggs drawn out, if the female has ovulated (i.e., eggs are loose in the abdomen). A gonad biopsy for histological analysis can be obtained from either sex at any point in the reproductive cycle by making a small incision and inserting an Eppendorfer biopsy punch. These techniques should not be used in systems having small populations and should be limited to only a few individuals.

The removal of pectoral fin rays for ageing studies is controversial. Concerns raised include potential impacts to fish swimming performance in high current velocity areas and the equivocal data that may be obtained from these structures. In tank tests, ray regeneration was rapid and sturgeon swimming performance was unaffected (Collins and Smith 1996). Continued study of the impacts of ray removal on sturgeon performance, validation of annuli, and investigations into alternative methods of ageing are sorely needed.

Gastric lavage

A safe and effective technique for flushing food items from the stomach of live sturgeons has recently been developed (Haley 1998). Due to the morphology of the gut tract and the physostomous swim bladder, gastric lavage of sturgeons was previously considered a risky procedure. Consequently, diet information was only available from fish that had been killed. The new lavage method requires the careful use of a flexible, small diameter tubing (intramedic polyethylene, 1.57-mm inner diameter and 2.08 mm outer diameter). The fish is lightly anesthetized using MS-222 and the tube is directed past the pneumatic duct and into the alimentary canal until it can be felt on the ventral surface of the fish. Water is slowly injected into the tubing to flush the stomach. After lavage the fish are allowed to recover and are immediately released. This method is not recommended when water temperature exceeds 27°C and extreme caution should be taken to avoid damage to the swim bladder, which can result in mortality.

Sampling Methodologies

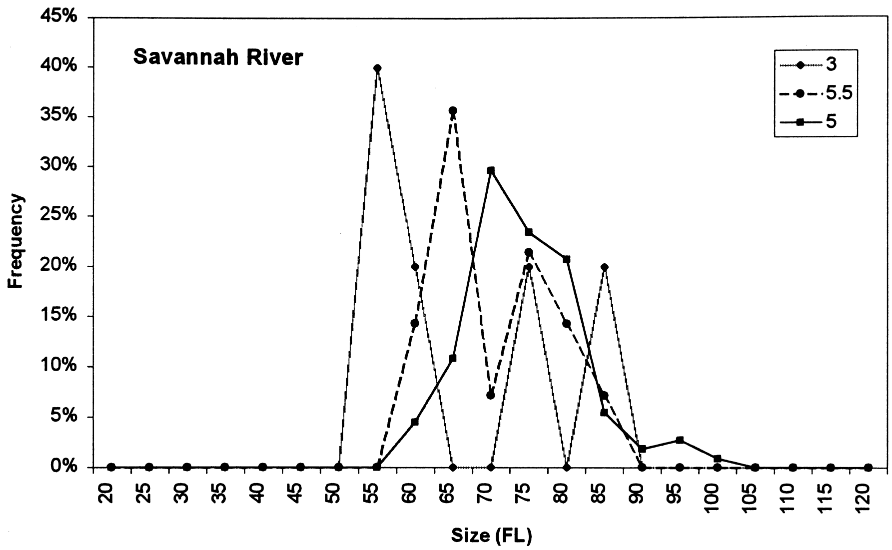
Preferred sampling methods for sturgeon are dictated by the habitat where they occur, season of capture, and life stage. In general, large juvenile and adult sturgeon are efficiently captured in stationary or drifting gillnets or trammel nets (Buckley and Kynard 1985, Hoff et al. 1988, Dovel et al. 1992, Geoghegan 1992, Kieffer and Kynard 1993, Moser and Ross 1995, Collins et al. 1996). Trawl sampling is also an effective means of capturing sturgeon, but much of the time this gear is not feasible for use, due to the rapid current conditions and excessive amount of bottom structure in riverine or estuarine sturgeon habitat. Sturgeon are also susceptible to pound nets, but this gear has not been used for research purposes, other than to assess commercial capture rates. Similarly, sturgeon are occasionally captured on hook and line (usually baited trotlines or via snagging); however, this gear has not been employed for research sampling. Baited trotlines are a safe and effective method for capturing white sturgeon (*A. transmontanus*), and this method probably has potential for shortnose and Atlantic sturgeon research as well (Elliott and Beamesderfer 1990).

Very small juveniles (larvae and young-of-the-year) are rarely captured in traditional survey sampling. Young sturgeon seek cover in gravel crevices and amongst structure for about 9 d after hatching and then the larvae move downstream. Sturgeon eggs and/or larvae have successfully been collected in some rivers using D-shaped drift nets (Kynard et al. 1999), epibenthic sleds, and textured pads to which the eggs adhere. Recent studies have been conducted to confirm that light traps are not effective for capture of sturgeon larvae.

Electrofishing has not proven to be an effective method for capture of sturgeon in most systems because the fish tend to sink immediately upon being stunned. This is unfortunate, because many resource agencies conduct regular survey sampling with this gear. In very shallow areas with clear water it may be possible to retrieve stunned sturgeon from the bottom with a long handled dipnet. The more widespread use of sophisticated electrofishing equipment that allows control of amperage, voltage, and waveform may result in development of electrofishing methods that are specific to sturgeon (such as those for specific collection of catfish). Moreover, Aadland and Cook (1992) have developed an electric trawl for use in sampling benthic river fishes that may be very useful for collecting sturgeon. Studies to examine the efficacy of electrofishing gear should be undertaken using hatchery fish.

Gillnets and trammel nets

Both shortnose and Atlantic sturgeon are very susceptible to gillnets and trammel nets as adults or large juveniles. These gears (especially gillnets) are size selective and therefore should be used with caution when determining sturgeon size or age distributions. However, length frequencies from studies using gillnets having different mesh sizes indicate that there is considerable overlap between size distributions of sturgeon collected with different mesh sizes (Figure 1). Sub-yearling sturgeon (200 –300 mm FL) have been captured using 5 cm (2”) stretched mesh nets in the Hudson, Cape Fear, Edisto and Savannah rivers but in all cases the catch rates were low. This was probably due to low abundance of



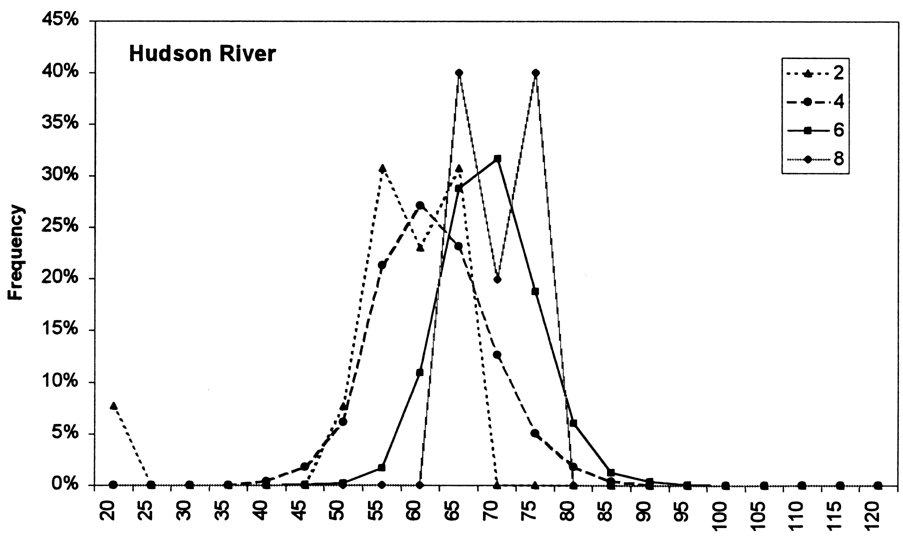
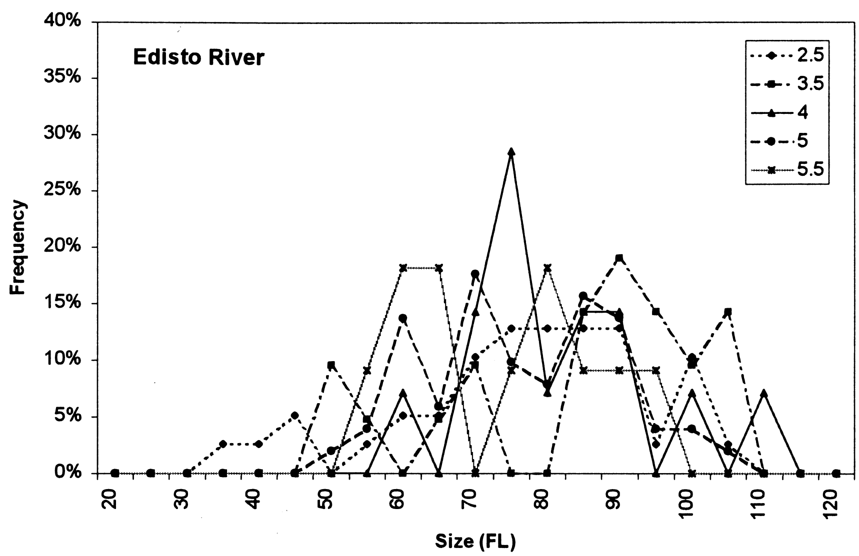
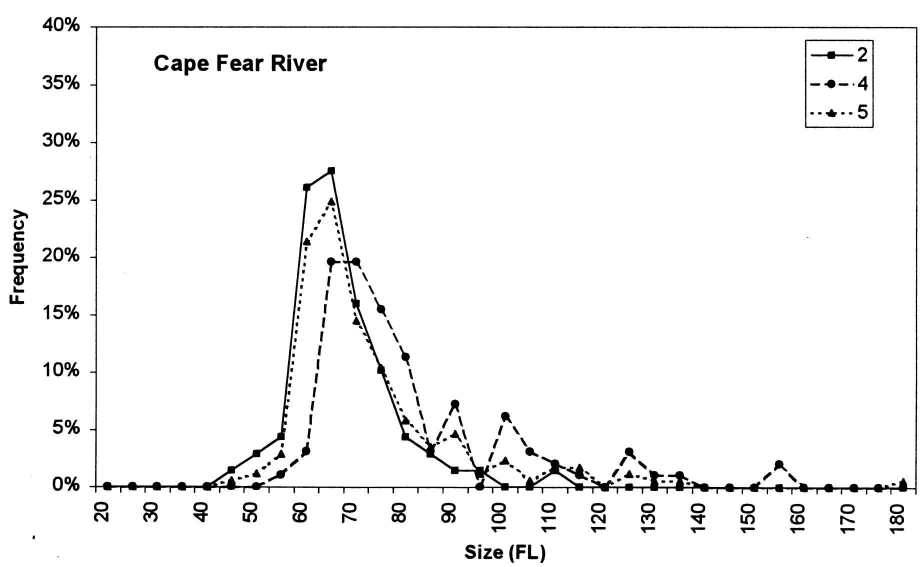


Figure 1. (Above and facing page) Size frequencies (in cm fork length) of shortnose and Atlantic sturgeon captured using various gillnet mesh sizes (in inches stretched mesh): 2 (5.1 cm), 2.5 (6.4 cm), 3 (7.6 cm), 3.5 (8.9 cm), 4 (10.2 cm), 5 (12.7 cm), 5.5 (14.0 cm), 6 (15.2 cm), and 8 (20.3 cm). Data from the Savannah River, S.C. and the Hudson River, N.Y. are for shortnose sturgeon captured in stationary gillnets. Data from the Edisto River, S.C. (J. McCord, S.C. Department of Natural Resources, unpubl. data) are for shortnose sturgeon caught in drifting gillnets. Data from the Cape Fear River, N.C. are for Atlantic sturgeon caught in stationary gillnets.

small size classes in these rivers, rather than gear selectivity. For post-yearlings, all mesh sizes greater than 6.4 cm (2.5") stretched mesh result in similar length frequencies (Figure 1). Trammel nets collect a wider size distribution than gillnets and are often less stressful than gillnets because the fish are frequently entangled rather than gilled.

Both monofilament and braided nylon mesh are effective for capture of sturgeon; however, twine size should be increased if large fish are targeted. Although fish are captured more effectively with light twine, sturgeon can easily break through webbing that is too light. Also, light twine is more likely to cut into the fish and cause injury. When targeting adults, heavy multifilament nylon (size 208 – 233) with 15 cm (6") stretched mesh can be used to reduce sturgeon injury.





Sturgeon are benthivores and generally are captured near the bottom unless they are actively migrating (McCleave et al. 1977, Moser and Ross 1995). Therefore stationary gillnets or trammel nets should be heavily weighted and allowed to contact the bottom. In low velocity areas, nets should be set perpendicular to the current. However, in areas of high velocity or having heavy debris loading, this is not feasible. In this case, nets should be set in back eddies, on the downstream side of islands, or parallel to the current in mid-channel (Buckley and Kynard 1985, Kieffer and Kynard 1993, Moser and Ross 1993, Kynard et al. 1999). In many southern rivers, trammel nets are set during slack tide periods only, to reduce stress on fish and debris loads.

Drifting gillnets can be used very effectively to capture sturgeon by drifting through relatively snag-free areas while dragging near or on the bottom (O'Herron and Able 1990, McCord 1998). Often this method results in lower debris loading because the nets drift along with the debris and do not intercept it. Generally, the short soak times and reduced pressure on driftnets also result in less injury to captured fish. This method can be used through upriver runs and pools without large entanglements by using very light leadline (just enough to take the net to the bottom). The net should be buoyed at the ends with large floats (8-15 L displacement) to facilitate operating the net and to avoid snags. In tidal areas, buoyancy should be reduced and the net dragged along the bottom wherever possible (McCord 1998).

Entanglement in gillnets or trammel nets can result in sturgeon mortalities (Kieffer and Kynard 1993, Moser and Ross 1993*,* Collins et al. 1996, Kynard et al. 1999). To reduce the risk of mortality, precautions should be taken to reduce stress to fish during netting. Gillnets and trammel net soak times should never exceed 2 hrs in water temperatures > 27°C. During lower water temperatures, soak times up to 24 h are acceptable, but soak times should be reduced as much as possible as temperature rises. Sturgeon should also not be exposed to air temperatures below 0°C for more than a few minutes. In these conditions, fish should be processed while held underwater to reduce the risk of freezing tissue. Every effort should be made to reduce stress during removal of fish from nets and net meshes should be cut to facilitate rapid removal of fish.

Trawls

Where conditions permit the use of trawls, this gear can be effective for the capture of sturgeon. Collins et al. (1996) found that 39% of all juvenile Atlantic sturgeon and 8% of the adult shortnose sturgeon tag returns from fish tagged in the Altamaha River, Georgia were from the commercial trawl fishery. Sampling of shortnose and Atlantic sturgeon was conducted in the tidal portion of the Hudson River from 1975 - 80 using a 6.4 m and 10.7 m semi-balloon otter trawl having mesh sizes of 1.3 – 6.5 cm (Dovel and Berggren 1983, Dovel et al. 1992). Fish >200-mm total length were regularly caught, with most fish around 500 mm. These trawls were fished for variable lengths of time (up to 50 min) at tow speeds of 4-km h^{-1} (2.2 knots). The Hudson River Utilities Monitoring Program has also conducted a standardized trawling survey since 1985 using a 3 m beam trawl with 1.3 - 3.8 cm mesh. This gear is towed for 5 min against the current and adult shortnose sturgeon (500 - 1000 mm fork length) are caught regularly. This sampling indicates that even a small trawl effectively captures sturgeon.

Drift nets

D-shaped or rectangular drift nets have been used effectively to catch shortnose sturgeon eggs and larvae in both northern (Kynard et al. 1999) and southern (Smith et al. 1993) rivers. Mesh sizes of 2 mm^2 trap sturgeon eggs and larvae while letting some debris pass through. The net is attached to a weighted and floated, 1 m diameter steel ring that has been flattened to maximize contact with the substrate (D-shaped, Kynard et al. 1999). A 1m square or 2 m 1m Neuston net can also be used. The net is attached to a Danforth or grapnel-type anchor via a short bridle. This arrangement allows the net to stand upright in currents of up to 1.0 m s^{-1}. Depending on the current velocity and amount of debris accumulation, such gear should be fished for 10 min – 1 h in areas of suspected spawning. A flow meter should be positioned in the mouth of the net to allow calculation of egg or larval densities per volume of water sieved. Such studies are best conducted with the aid of telemetry data from pre-spawning adults to identify likely spawning locations (Collins and Smith 1993, Kynard et al. 1999). Little to no mortality occurs with this gear type if the samples are processed in the field . The D-shaped nets have been used to capture eggs of Chinese sturgeon in the Yangtze River for four years. Tens of thousands of eggs have been captured when the nets have been set in areas occupied by telemetered fish. These eggs are reared to juvenile stages and released into the river (Wei and Kynard 1996). Egg samples can also be collected using artificial substrates to which they adhere (anchored buffer pads, Moser et al. 1998).

Minimum Sampling Required to Confirm Presence of Shortnose Sturgeon

Guidelines for minimum sampling necessary to confirm that shortnose sturgeon still exist in a system are desperately needed for management of this species. Shortnose sturgeon are no longer extant in many rivers where they historically occurred (Dadswell et al. 1984). However, the Shortnose Sturgeon Recovery Plan (NMFS 1998) stipulates that restoration efforts (stocking of cultured fish) should not be undertaken until it is confirmed that wild fish have been extirpated. In addition, sampling for the presence of shortnose sturgeon is often required when activities that jeopardize the existence of this fish are proposed in an area where their status is unknown. Consequently, the National Marine Fisheries Service and other regulatory agencies require guidelines for sampling efforts that are adequate to address such questions.

Unfortunately, it is impossible to absolutely confirm that shortnose sturgeon no longer exist in a given system due to their life history and problems associated with sampling them. Shortnose sturgeon are long-lived (over 30 yrs) and do not spawn every year (Dadswell et al. 1984). Therefore, sampling over multiple years is needed to insure that a strong year class has not been missed. Moreover, sturgeon are rarely captured using traditional survey sampling, so specialized sampling methods in specific habitats are needed, particularly in systems where sturgeon are very rare. Even studies specifically designed to capture sturgeon can only confirm their presence, as negative data does not necessarily indicate that the fish are extirpated. However, given adequate sampling, an acceptable degree of confidence that the fish are extirpated (or functionally extirpated) can be gained. Based on the types and amounts of effort conducted in other systems to date, we developed the following sampling guidelines as the best available approach to assessing shortnose sturgeon presence in areas where they historically occurred.

Research Survey

The first step in any system is to conduct a literature survey and to contact people who currently or historically fished in the area using gear that captures sturgeon. Often museum records, archeological remains (scutes in middens), or patterns in historical collections can provide vital clues to appropriate areas and times to sample for shortnose sturgeon. Personal contact with local fishers is also essential. They can provide detailed information on exact sampling locations that were historically productive, tricks to effective use of gear, and observations on the timing of sturgeon movements. In addition, people currently fishing in the system may have recently captured shortnose sturgeon as bycatch and be willing to provide anecdotal information on these captures or actual specimens (Collins and Smith 1993, Moser and Ross 1993, Collins et al. 1996, Moser et al. 1998). The U.S. Fish and Wildlife Service has successfully obtained shortnose sturgeon specimens by offering monetary rewards for live fish in Chesapeake Bay (J. Skejeveland, Maryland Fisheries Resources, personal communication). While this technique may put more fish at risk or result in targeted fishing for sturgeon, the ability to enlist the help of commercial fishers greatly increases the chances of documenting the presence of fish in areas where they are thought to be extirpated.

Finally, prior to any fieldwork, literature from neighboring systems should be reviewed. Patterns of sturgeon habitat use and movements are similar over small spatial scales (Dadswell et al. 1984). By mapping suspected aggregation areas (spawning grounds, wintering areas, summering sites) from adjoining systems, sites to sample in the study area can be more accurately identified. Any available maps of water quality or bottom substrate in the study area should be collected to help identify likely spawning sites and aggregation areas.

Patterns of habitat use and movements of shortnose sturgeon vary latitudinally. Therefore, our recommendations for minimum sampling are divided into two main groups: 1) northern rivers where < 7°C water temperature regularly occurs in winter and temperatures occasionally reach >27°C in summer (Chesapeake drainages north), and 2) southern rivers where >27°C occurs regularly in summer and temperatures seldom drop below 7°C in winter (south of Chesapeake drainages).

Minimum Sampling Requirements in Northern Rivers

Northern rivers having sturgeon habitat can be subdivided into two groups: northerly (systems in Maine and Canada), and north central (Chesapeake drainages to Massachusetts). It is necessary to subdivide the northern region because sturgeon in the most northerly rivers exhibit a greater degree of anadromy, venturing into high salinity regions. Shortnose sturgeon in north central rivers spend more time in freshwater and make only short forays into relatively low salinity areas to feed (Dadswell et al. 1984, Kynard 1997).

Sampling in northerly rivers (Maine and Canada) should be conducted for a minimum of two years. Attempts should first be made to capture pre-spawning adult shortnose sturgeon at the base of the first dam or falls that they would encounter. This sampling should be conducted weekly for 8 - 10 weeks during early spring when water temperatures range from 8 – 18°C. Four to six, 100 m, 15.2 cm (6”) stretched mesh, stationary sinking gillnets should be set as recommended in the sampling protocol for at least two days each week and checked at least every 24 h (minimum sampling effort = 128, 100 m net days). In the event that no fish are captured in the first spring, sampling should be conducted in the estuary (1 – 12 ppt) along marsh edges and in tidal creeks that summer and the following summer. This sampling should occur weekly with four to six, 100 m, 15.2 cm (6”) stretched mesh sinking gillnets (2 - 3 day/week) in June – August (8 - 10 weeks) when water temperatures range from 20 – 25°C (minimum sampling effort = 128, 100 m net days). Telemetry studies are recommended so that any fish captured in the estuary can be tracked to their river of origin.

Sampling in north central rivers (Chesapeake drainages to Merrimack River) should initially concentrate on capture of pre-spawning adults with gillnets at the base of the first dam or falls (protocol as described for northerly rivers) for two years (minimum sampling effort = 128, 100 m net days). If no fish are collected in the first spring, sampling efforts should be directed to likely aggregation areas that summer. Areas targeted should be between the saltwater/freshwater interface and the first dam or falls. Habitats sampled should include the deepest part of the water body in every curve and around each island (Kynard et al. in press). Sampling should continue weekly through two summers (June – October) using four to six, 100 m, 15.2 cm (6”) stretched mesh sinking gillnets set for at least 3 days each week (soak times should be 24 h unless water temperature exceeds 27°C, see previous section on gillnet methodology).

Minimum Sampling Requirements in Southern Rivers

Adult and juvenile shortnose sturgeon in southern rivers aggregate in deep areas near the saltwater/freshwater interface in summer (Hall et al. 1990, Weber 1996, Moser and Ross 1995, Collins et al. in press). Sampling for shortnose sturgeon should initially be focused in these summer aggregation areas, but extreme caution must be exercised to avoid killing any fish captured during high water temperatures. Sampling should begin in summer when temperature exceeds 27°C (July in most southern rivers) and continue until the temperature drops below 27°C (October in most southern rivers).

Three sinking gillnets of 13 –14 cm stretched mesh (5 – 5.5 in) or trammel nets with 5 – 8 cm (2 – 3 in) stretched mesh inner panels and 35 cm (14 in) stretched mesh outer panels should be set as specified in this sampling protocol. Nets should be 100 m long, or else shorter nets with the equivalent combined length of 300 m should be used (e.g., six, 50 m nets). All nets should be set for 2 h during the slack tide (neap tides are preferred) in the deepest part of the water body near the upper extent of the salt wedge (0 - 3 ppt) or up to 2 km above the saltwater-freshwater interface. In deltaic systems there may be more than one area that fits this definition. In this case all candidate sites should be sampled in random order during the summer. Sampling should be conducted 3 times per week for 8 - 10 weeks (minimum sampling effort = 288 net hours).

If no shortnose sturgeon are collected in the first summer of sampling at the saltwater/freshwater interface, sampling for pre-spawning adults should be initiated at the base of the first dam or falls in January – April. Some rivers on the coastal plain do not present such obstacles to migration and possible aggregation areas are unknown. In such cases, likely spawning habitats based on research in other southern rivers (as identified in Hall et al. 1993) should be identified and sampled. Three, 100 m sinking gillnets of 13 –14 cm stretched mesh (5 – 5.5 cm) or 100 m trammel nets with 5 – 8 cm (2 – 3”) stretched mesh inner panels and 35 cm (14”) stretched mesh outer panels should be set bi-weekly as specified in the sampling protocol. In many upriver areas it may be necessary to use shorter nets, in which case their total length should equal 100 m. Sampling should be conducted for at least 8 weeks in two years, with three days of effort per week (24 h sets) from January until the water temperature exceeds 18°C (minimum sampling effort = 144, 100 m net days).

Conclusion

Sampling and handling procedures for Atlantic coast sturgeons have evolved over the past 30 years and differ among systems and sampling situations. Minimum sampling requirements also vary across systems. While we have addressed latitudinal differences in developing sampling guidelines, inter-system differences in sturgeon abundance can also affect minimum sampling requirements. The amount of effort required to document sturgeon presence is negatively correlated with sturgeon abundance (Figure 2). Therefore, we have attempted to provide conservative estimates of effort required so that sturgeon presence may be detected in systems where these fish are rare.

The minimum sampling protocols will certainly be affected by the availability of reliable anecdotal/historical information on sturgeon occurrence. With this information, sampling can be directed to specific sites within the protocol framework. We emphasize that obtaining this information is critically important. Sturgeon fishing has become an activity of the past, and sturgeon fishers are aging. When they die, a wealth of information about historical occurrences of sturgeon, movement patterns, and capture methods will be lost.

New sampling and handling methodologies may be developed on the basis of information from fishers or via research innovations and experimentation. We reiterate that this protocol is to serve as a current set of guidelines for use with Atlantic Coast sturgeons, and should in no way restrict testing of new techniques. However, we recommend that cultured sturgeon be used first when testing new and potentially harmful methods.

Acknowledgments

We wish to thank Mary Colligan for her administrative help and Marcia Hobbs for travel assistance. Terri Jordan, Marta Nammack, and Jacki Strader provided editorial assistance. The National Marine Fisheries Service funded this work.

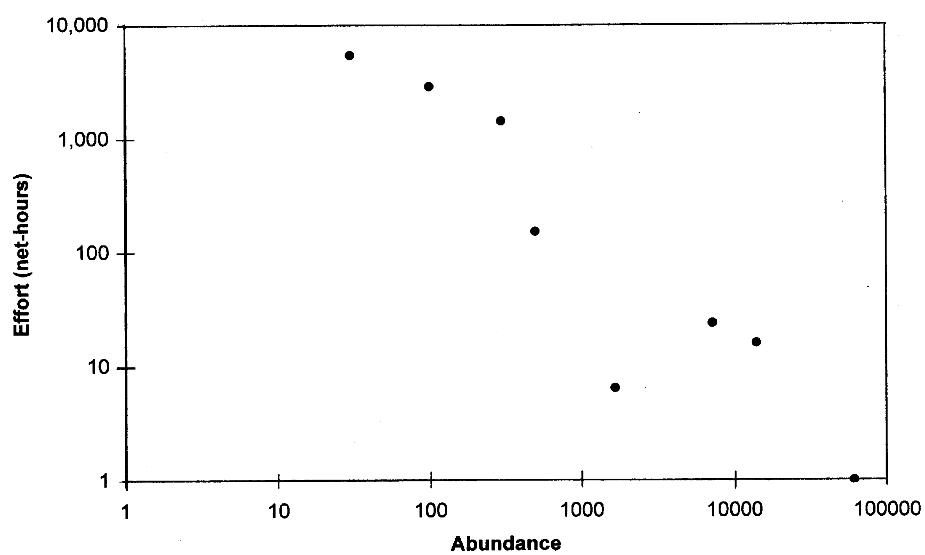


Figure 2. Effort expended (100 m gillnet set for 1 hour) to capture the first shortnose sturgeon in each of eight different systems vs. estimated shortnose sturgeon abundance in each system.

References Cited

Aadland, L.P., and C. Cook. 1992. An electric trawl for sampling bottom dwelling fishes in deep turbid streams. North American Journal of Fisheries Management 12:652-656.

Buckley, J., and B. Kynard. 1985. Yearly movements of shortnose sturgeon in the Connecticut River. Transactions of the American Fisheries Society 114:813820.

Collins, M.R., and T.I.J. Smith. 1993. Characteristics of the adult segment of the Savannah River population of shortnose sturgeon. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 47:485-491.

Collins, M.R., T.I.J. Smith, and L.D. Heyward. 1996. Effectiveness of six methods for marking juvenile shortnose sturgeon. Progressive Fish Culturist. 56:250-254.

Collins, M.R., S.G. Rogers, and T.I.J. Smith. 1996. Bycatch of sturgeons along the Southern Atlantic coast of the USA. North American Journal of Fisheries Management 16:24-29.

Collins, M.R., S.G. Rogers, T.I.J. Smith, and M.L. Moser. in press. Primary factors impacting sturgeon populations in the southeastern U.S.: fishing mortality and degradation of essential habitats. Bulletin of Marine Science.

Dadswell, M.J., B.D. Taubert, T.S. Squiers, D. Marchette, and J. Buckley. 1984. Synopsis of biological data on shortnose sturgeon, *Acipenser brevirostrum* LeSueur 1818. National Oceanic and Atmospheric Administration Technical Report NMFS 14, Washington, D.C.

Dovel, W.L., and T.J. Berggren. 1983. Atlantic sturgeon of the Hudson Estuary, New York.New York Fish and Game Journal 30:140-172.

Dovel, W.L., A.W. Pekovitch and T.J. Berggren. 1992. Biology of the shortnose sturgeon (*Acipenser brevirostrum* Lesueur, 1818) in the Hudson River estuary, New York. Pages 187-216 *in* C.L. Smith, editor, Estuarine Research in the 1980s. State University of New York Press, Albany, New York.

Elliott, J., and R. Beamesderfer. 1990. Comparison of efficiency and selectivity of gears used to sample white sturgeon in a Columbia River reservoir. California Fish and Game 76:174-180.

Geoghegan, P., M.T. Mattson, and R.G. Keppel. 1992. Distribution of the shortnose sturgeon in the Hudson River estuary, 1984-1988. Pages 217-277 *in* C.L. Smith (editor). Estuarine research in the 1980s. State University of New York Press, Albany, New York.

Haley, N. 1998. A gastric lavage technique for characterizing diets of sturgeons. North

American Journal of Fisheries Management. 18:978-981.

Hall, W.J., T.I.J. Smith, and S.D. Lamprecht. 1991. Movements and habitats of shortnose sturgeon *Acipenser brevirostrum* in the Savannah River. Copeia (3):695-702.

Hoff, T.B., R.J. Klauda, and J.R. Young. 1988. Contributions to the biology of shortnose sturgeon in the Hudson River estuary. Pages 171-189 *in* C.L. Smith (editor) Fisheries research in the Hudson River. Sate University of New York Press, Albany, New York.

Jenkins, W.E., T.I.J. Smith, L.D. Heyward, and D.M. Knott. 1993. Tolerance of shortnose sturgeon, Acipenser brevirostrum, juveniles to different salinity and dissolved oxygen concentrations. Proceedings of the Southeast Association of Fish and Wildlife Agencies, 47:476-484.

Kieffer, M., and B. Kynard. 1993. Annual movements of shortnose and Atlantic sturgeons in the Merrimack River, Massachusetts. Transactions of the American Fisheries Society 122:1088-1103.

Kynard, B. 1997. Life history, latitudinal patterns, and status of shortnose sturgeon. Environmental Biology of Fishes 48:319-334.

Kynard, B., M. Kieffer, M. Burlingame, and M. Horgan. In press. Studies on shortnose sturgeon, 1999. Final Report to Northeast Utilities Service Co., Berlin, Connecticut.

McCleave, J.D., S.M. Fried and A.K. Towt. 1977. Daily movements of shortnose sturgeon, *Acipenser brevirostrum*, in a Maine estuary. Copeia 1977:149-157.

McCord, J.W. 1998. Investigation of fisheries parameters for anadromous fishes in South Carolina. Completion report to National Marine Fisheries Service (AFC-53).

Moser, M.L., and S. W. Ross. 1993. Distribution and movements of shortnose sturgeon (*Acipenser brevirostrum*) and other anadromous fishes of the lower Cape Fear River, North Carolina. Final Report to the U.S. Army Corps of Engineers, Wilmington, North Carolina.

Moser, M.L., and S.W. Ross. 1995. Habitat use and movements of shortnose and Atlantic sturgeons in the lower Cape Fear River, North Carolina. Transactions of the American Fisheries Society 124:225-234.

Moser, M.L., J.B. Bichy, and S.B. Roberts. 1998. Sturgeon distribution in North Carolina. Final report to the U.S. Army Corps of Engineers, Wilmington District, Wilmington, North Carolina.

National Marine Fisheries Service. 1998. Recovery plan for the shortnose sturgeon (*Acipenser brevirostrum*). Prepared by the Shortnose Sturgeon Recovery Team for the

National Marine Fisheries Service, Silver Spring, Maryland.

O'Herron, J.C., and K.W. Able. 1990. A study of the endangered shortnose sturgeon (*Acipenser brevirostrum*) in the Delaware River. Final Performance Report to U.S. Fish and Wildlife Service and New Jersey Fish, Game, and Wildlife, Department of Environmental Protection, New Brunswick, New Jersey.

Rogers, S.G., and W. Weber. 1995. Status and restoration of Atlantic and shortnose Sturgeons in Georgia. Final Report to NMFS 9A46FA102-01, Georgia Department of Natural Resources, Brunswick, Georgia.

Smith, T.I.J. 1988. Collection of critical habitat and management information for Atlantic and shortnose sturgeon in South Carolina. Final Report (Federal Aid Project AFS-15) to U.S. Fish and Wildlife Service, Atlanta, Georgia.

Smith, T.I.J., M.R. Collins, and E. Kennedy. 1993. Identification of critical habitat requirements of shortnose sturgeon in South Carolina. Final Report to the U.S. Fish and Wildlife Service, Atlanta, Georgia.

Smith, T.I.J., S.D. Lamprecht, and J.W. Hall. 1990. Evaluation of tagging techniques for shortnose sturgeon and Atlantic sturgeon. AFS Symposium 7:134-141.

Summerfelt, R.C., and L.S. Smith. 1990. Anesthesia, surgery, and related techniques. Pages 213-272 *in* C.B. Schreck and P.B. Moyle, editors. Methods for fish biology. American Fisheries Society, Bethesda, Maryland

Weber, W. 1996. Population size and habitat use of shortnose sturgeon, *Acipenser brevirostrum*, in the Ogeechee River system, Georgia. masters Thesis, University of Georgia, Athens, Georgia.

Wei, Q., and B. Kynard. 1996. Study of Chinese sturgeon spawning in the Yangtze River. Yangtze River Fishery Research Institute, Progress Report.

National Marine Fisheries Service
Recommendations for the Contents of
Biological Assessments and Biological Evaluations
O:\FORMS\BA GUIDE-INITGUIDE COMBO .doc

When preparing a Biological Assessment (BA) or Biological Evaluation (BE), keep in mind that the people who read or review this document may not be familiar with the project area or what is proposed by the project. Therefore your BA or BE should present a clear line of reasoning that explains the proposed project and how you determined the effects of the project on each threatened or endangered species, or critical habitat, in the project area. Try to avoid technical jargon not readily understandable to people outside your agency or area of expertise. Remember, this is a **public document**. Some things to consider and, if appropriate, to include in your BA or BE, follow.

1. What is the difference between a Biological Evaluation and a Biological Assessment?

By regulation, a Biological Assessment is prepared for "major construction activities" — defined as "a construction project (or other undertaking having similar physical effects) which is a major Federal action significantly affecting the quality of the human environment (as referred to in the National Environmental Policy Act of 1969 (NEPA) [(42 U.S.C. 4332(2)(C)])." A BA is required if listed species or critical habitat may be present in the action area. A BA also may be recommended for other activities to ensure the agency's early involvement and increase the chances for resolution during informal consultation. Recommended contents for a BA are described in 50 CFR 402.12(f).

Biological Evaluation is a generic term for all other types of analyses in support of consultations. Although agencies are not required to prepare a Biological Assessment for non-major construction activities, **if a listed species or critical habitat is likely to be affected, the agency must provide the Service with an evaluation on the likely effects of the action.** Often this information is referred to as a BE. The Service uses this documentation along with any other available information to decide if concurrence with the agency's determination is warranted. Recommended contents are the same as for a BA, as referenced above.

The BAs and BEs should not be confused with Environmental Assessments (EA) or Environmental Impact Statements (EIS) which may be required for NEPA projects. These EAs and EISs are designed to provide an analysis of multiple possible alternative actions on a variety of environmental, cultural, and social resources, and often use different definitions or standards. However, if an EA or EIS contains the information otherwise found in a BE or BA regarding the project and the potential impacts to listed species, it may be submitted in lieu of a BE or BA.

2. What are you proposing to do?

Describe the project. A project description will vary, depending on the complexity of the project. For example, describing the construction or removal of a fixed aid-to-navigation in the Intracoastal Waterway, or the abandonment/dismantling of an oil-producing-platform may be relatively simple, but describing a the extent and amplitude of potential impacts of military training exercises involving different military assets, combinations of weaponry, locations, and seasons would necessarily be more detailed and complex. Include figures and tables if they will help others understand your proposed action and its relationship with the species' habitat.

How are you (or the project proponent) planning on carrying out the project? What tools or methods may be used? How will the site be accessed? When will the project begin, and how long will it last?

Describe the "action area" (all areas to be affected directly or indirectly by the Federal action and not merely the immediate areas involved in the action [50 CFR 402.02]). Always include a map (topographic maps are particularly helpful). Provide photographs including aerials, if available. Describe the project area (i.e., topography, vegetation, condition/trend).

Describe current management or activities relevant to the project area. How will your project change the area?

Supporting documents are very helpful. If you have a blasting plan, best management practices document, sawfish/sea turtle/sturgeon conservation construction guidelines, research proposal, NEPA or other planning document or any other documents regarding the project, attach them to the BA or BE.

3. What threatened or endangered species, or critical habitat, may occur in the project area?

A request for a species list may be submitted to the Service, or the Federal action agency or its designated representative may develop the list. If you have information to develop your own lists, the Service should be contacted periodically to ensure that changes in species' status or additions/deletions to the list are included. Sources of biological information on federally-protected sea turtles, sturgeon, Gulf sturgeon (and Gulf sturgeon critical habitat), and other listed species and candidate species can be found at the following website addresses: NMFS Southeast Regional Office, Protected Resources Division (http://sero.nmfs.noaa.gov/pr/protres.htm); NMFS Office of Protected Resources (http://www.nmfs.noaa.gov/pr/species); U.S. Fish and Wildlife Service (http://noflorida.fws.gov/SeaTurtles/seaturtle-info.htm); http://www.nmfs.noaa.gov/pr/; http://www.sad.usace.army.mil/protected%20resources/turtles.htm; http://endangered.fws.gov/wildlife.html#Species; the Ocean Conservancy (http://www.cmc-ocean.org/main.php3); the Caribbean Conservation Corporation (http://www.cccturtle.org/); Florida Fish and Wildlife Conservation Commission (http://floridaconservation.org/psm/turtles/turtle.htm); http://www.turtles.org; http://www/seaturtle.org; http://alabama.fws.gov/gs/; http://obis.env.duke.edu/data/sp_profiles.php; www.mote.org/~colins/Sawfish/SawfishHomePage.html; www.floridasawfish.com; http://www.flmnh.ufl.edu/fish/Sharks/sawfish/srt/srt.htm; www.flmnh.ufl.edu/fish/sharks/InNews/sawprop.htm; also, from members of the public or academic community, and from books and various informational booklets. Due to budget constraints and staff shortages, we are only able to provide general, state-wide, or country-wide (territory-wide) species lists.

Use your familiarity with the project area when you develop your species lists. Sometimes a species may occur in the larger regional area near your project, but the habitat necessary to support the species is not in the project area (including areas that may be beyond the immediate project boundaries, but within the area of influence of the project. If, for example, you know that the specific habitat type used by a species does not occur in the project area, it does not need to appear on the species list for the project. However, documentation of your reasoning is helpful for Service biologists or anyone else that may review the document.

4. Have you surveyed for species that are known to occur or have potential habitat in the proposed project area?

The “not known to occur here” approach is a common flaw in many BA/BEs. The operative word here is “known.” Unless adequate surveys have been conducted or adequate information sources have been referenced, this statement is difficult to interpret. It begs the questions “Have you looked?” and “How have you looked?” Always reference your information sources.

Include a clear description of your survey methods so the reader can have confidence in your results. Answer such questions as:

How intensive was the survey? Did you look for suitable habitat or did you look for individuals? Did the survey cover the entire project area or only part of it? Include maps of areas surveyed if appropriate.

Who did the surveys and when? Was the survey done during the time of year/day when the plant is growing or when the animal can be found (its active period)? Did the survey follow accepted protocols?

If you are not sure how to do a good survey for the species, the Service recommends contacting species experts. Specialized training is required before you can obtain a permit to survey for some species.

Remember that your evaluation of potential impacts from a project does not end if the species is/are not found in the project area. You must still evaluate what effects would be expected to the habitat, even if it is not known to be occupied, because impacts to habitat that may result indirectly in death or injury to individuals of listed species would constitute “take”.

5. Provide background information on the threatened or endangered species in the project area.

Describe the species in terms of overall range and population status. How many populations are known? How many occur in the project area? What part of the population will be affected by this project? Will the population’s viability be affected? What is the current habitat condition and population size and status? Describe related items of past management for the species, such as stocking programs, habitat improvements, or loss of habitat or individuals caused by previous projects.

6. **How will the project affect the threatened or endangered species or critical habitat that occur in the project area?**

If you believe the project will not affect the species, explain why. Effects analyses must include evaluating whether adverse impacts to species’ habitats, whether designated or not, could indirectly harm or kill listed species.

If you think the project may affect the species, explain what the effects might be. The Endangered Species Act requires you consider all effects when determining if an action funded, permitted, or carried out by a Federal agency may affect listed species. Effects you must consider include direct, indirect, and cumulative effects. Effects include those caused by interrelated and interdependent actions, not just the proposed action. Direct effects are those caused by the action and occur at the same time and place as the action. Indirect effects are caused by the action and are later in time but are reasonably certain to occur. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no significant independent utility apart from the action under consideration. Interrelated or interdependent actions can include actions under the jurisdiction of other federal agencies, state agencies, or private parties. Cumulative effects are those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal actions subject to consultation.

Describe measures that have or will be taken to avoid or eliminate adverse effects or enhance beneficial effects to the species. Refer to conversations you had with species experts to achieve these results.

Consider recovery potential if the project area contains historic range for a species.

Evaluate impacts to designated critical habitat areas by reviewing any project effects to the physical or biological features essential to the conservation of the species.

7. What is your decision? The Federal action agency must make a determination of effect.

Quite frequently, effect determinations are not necessarily *wrong;* they simply are not justified in the assessment. The assessment should lead the reviewer through a discussion of effects to a logical, well-supported conclusion. Do not assume that the Service biologist is familiar with the project and/or its location and that there is no need to fully explain the impact the project may have on listed species. If there is little or no connection or rationale provided to lead the reader from the project description to the effect determination, we cannot assume conditions that are not presented in the assessment. Decisions must be justified biologically. The responsibility for making and supporting the determination of effect falls on the Federal action agency; however, the Service cannot merely "rubber stamp" the action agency's determination and may ask the agency to revisit its decision or provide more data if the conclusion is not adequately supported by biological information.

You have three choices for each listed species or area of critical habitat:

1. "No effect" is the appropriate conclusion when a listed species will not be affected, either because the species will not be present or because the project does not have any elements with the potential to affect the species. "No effect" does not include a *small* effect or an effect that is *unlikely* to occur: if effects are insignificant (in size) or discountable (extremely unlikely), a "may affect, but not likely to adversely affect" determination is appropriate. A "no effect" determination does **not** require written concurrence from the Service and ends ESA consultation requirements unless the project is subsequently modified in such manner that effects may ensue.

2. "May affect - is not likely to adversely affect" (NLAA) means that all effects are either beneficial, insignificant, or discountable. Beneficial effects have concurrent positive effects without any adverse effects to the species or habitat (i.e., there cannot be "balancing," wherein the benefits of the project would be expected to outweigh the adverse effects - see #3 below). Insignificant effects relate to the magnitude or extent of the impact (i.e., they must be small and would not rise to the level of a take of a species). Discountable effects are those extremely unlikely to occur. Based on best judgment, a person would not: (1) be able to meaningfully measure, detect, or evaluate insignificant effects; or (2) expect discountable effects to occur. A "NLAA" determination by the action agency requires **written** concurrence from the Service.

3. "May affect - is likely to adversely affect" means that all adverse effects cannot be avoided. A combination of beneficial and adverse effects is still "likely to adversely affect," even if the net effect is neutral or positive. Adverse effects do not qualify as discountable simply because we are not certain they will occur. The probability of occurrence must be extremely small to achieve discountability. Likewise, adverse effects do not meet the definition of insignificant because they are less than major. If the adverse effect can be detected in any way or if it can be meaningfully articulated in a discussion of the results, then it is not insignificant, it is likely to adversely affect. This requires formal consultation with the Service.

A fourth finding is possible for proposed species or proposed critical habitat:

4. "Is likely to jeopardize/destroy or adversely modify proposed species/critical habitat" is the appropriate conclusion when the action agency identifies situations in which the proposed action is likely to jeopardize a species proposed for listing, or destroy or adversely modify critical habitat proposed for designation. If this conclusion is reached, conference is required.

List the species experts you contacted when preparing the BE or BA but avoid statements that place the responsibility for the decision of "may affect" or "no effect" on the shoulders of the species experts. Remember, this decision is made by the Federal action agency.

Provide supporting documentation, especially any agency reports or data that may not be available to the Service. Include a list of literature cited.

Originally prepared: January 1997
U.S. Fish and Wildlife Service
Arizona Ecological Services Field Office

Revised: January 2006
National Marine Fisheries Service
Protected Resources Division
263 13th Avenue South
St. Petersburg, FL 33701
(727) 824-5312

OUTLINE EXAMPLE FOR A
BIOLOGICAL ASSESSMENT OR BIOLOGICAL EVALUATION

Cover Letter - **VERY IMPORTANT -** Include purpose of consultation, project title, and consultation number (if available). A determination needs to be made for each species and for each area of critical habitat. You have three options: 1) a "no effect" determination; 2) request concurrence with an "is not likely to adversely affect" determination; 3) make a "may affect, is likely to adversely affect" determination, and request "formal" consultation. If proposed species or critical habitat are included, state whether the project is likely to result in jeopardy to proposed species, or the destruction or adverse modification of proposed critical habitat. If the critical habitat is divided into units, specify which critical habitat unit(s) will be affected.

Attached to Cover Letter: Biological Assessment or Biological Evaluation document, broken down as follows:

Title: e.g., BA (or BE) for "Project X"; date prepared, and by whom.

A. Project Description - Describe the proposed action and the action area. Be specific and quantify whenever possible.

For Each Species:
1. Description of affected environment (quantify whenever possible)
2. Description of species biology
3. Describe current conditions for each species
    a. Range-wide
    b. In the project area
    c. Cumulative effects of State and private actions in the project area
    d. Other consultations of the Federal action agency in the area to date
4. Describe critical habitat (if applicable)
5. Fully describe effects of proposed action on each species and/or critical habitat, and species' response to the proposed action.
    a. Direct effects
    b. Indirect effects
    c. Interrelated and interdependent actions
    d. Potential incidental take resulting from project activities

Factors to be considered/included/discussed when analyzing the effects of the proposed action on each species and/or critical habitat include: 1) Proximity of the action to the species, management units, or designated critical habitat units; 2) geographic area(s) where the disturbance/action occurs); timing (relationship to sensitive periods of a species' lifecycle; 3) duration (the effects of a proposed action on listed species or critical habitat depend largely on the duration of its effects); 4) disturbance frequency (the mean number of events per unit of time affects a species differently depending on its recovery rate); 5) disturbance intensity (the effect of the disturbance on a population or species as a function of the population or species' state after the disturbance); 6) disturbance severity (the effect of a disturbance on a population or species or habitat as a function of recovery rate – i.e., how long will it take to recover)

6. Conservation Measures (protective measures to avoid or minimize effects for each species)
7. Conclusions (effects determination for each species and critical habitat)
8. Literature Cited
9. Lists of Contacts Made/Preparers
10. Maps/Photographs

Guidance on Preparing an Initiation Package for Endangered Species Consultation

This document is intended to provide general guidance on the type and detail of information that should be provided to initiate consultation with U.S. Fish and Wildlife Service (USFWS) and/or National Marine Fisheries Service (NMFS). This is not intended to be an exhaustive document as specific projects may require more or less information in order to initiate consultation. Also, note that this contains guidance on the information required to initiate formal consultation procedures with USFWS and/or NMFS. Additional information needs may be identified during consultation. Texts in italics below are examples. Normal text is guidance. A glossary of terms is appended.

INTRODUCTION

Here is an example of introductory language:

The purpose of this initiation package is to review the proposed [project name] in sufficient detail to determine to what extent the proposed action may affect any of the threatened, endangered, proposed species and designated or proposed critical habitats listed below. In addition, the following information is provided to comply with statutory requirements to use the best scientific and commercial information available when assessing the risks posed to listed and/or proposed species and designated and/or proposed critical habitat by proposed federal actions. This initiation package is prepared in accordance with legal requirements set forth under regulations implementing Section 7 of the Endangered Species Act (50 CFR 402; 16 U.S.C. 1536 (c)).

Threatened, Endangered, Proposed Threatened or Proposed Endangered Species

Example language:

The following listed and proposed species may be affected by the proposed action:

common name (Scientific name) ***T***

common name (Scientific name) ***E***

common name (Scientific name) ***PT***

common name (Scientific name) ***PE***

This list should include all of the species from the species lists you obtained from USFWS and NMFS. If it doesn't, include a brief explanation here and a more detailed explanation in your record to help USFWS, NMFS and future staff understand your thought process for excluding a species from consideration.

Critical Habitat

Example language:

The action addressed within this document falls within Critical Habitat for [identify species].

CONSULTATION TO DATE

"Consultation" under the ESA consists of discussions between the action agency, the applicant (if any), and USFWS and/or NMFS. It is the sharing of information about the proposed action and related actions, the species and environments affected, and means of achieving project purposes while conserving the species and their habitats. Under the ESA, consultation can be either informal or formal. Both processes are similar, but informal consultation may result in formal consultation if there is a likelihood of unavoidable take. Formal consultation has statutory timeframes and other requirements (such as the submission of the information in this package and a written biological opinion by USFWS or NMFS).

Summarize any consultation that has occurred thus far. Identify when consultation was requested (if not concurrent with this document). Be sure to summarize meetings, site visits and correspondence that were important to the decision-making process.

DESCRIPTION OF THE PROPOSED ACTION

The purpose of this section is to provide a clear and concise description of the proposed activity and any interrelated or interdependent actions.

The following information is necessary for the consultation process on an action:

1. The action agency proposing the action.

2. The authority(ies) the action agency will use to undertake, approve, or fund the action.

3. The applicant, if any.

4. The action to be authorized, funded, or carried out.

5. The location of the action.

5. When the action will occur, and how long it will last.

6. How the action will be carried out

7. The purpose of the action.

8. Any interrelated or interdependent actions, or that none exist to the best of your knowledge.

Describe and specify: **WHO** is going to do the action and under what authority, include the name and office of the action agency and the name and address of the applicant; **WHAT** the project or action is; **WHERE** the project is (refer to attached maps); **WHEN** the action is going to take place, including time line and implementation schedules; **HOW** the action will be accomplished, including the various activities that comprise the whole action, the methods, and the types of equipment used; **WHY** the action is proposed, including its purpose and need; and **WHAT OTHER** interrelated and interdependent actions are known. This combination of actions are what is being consulted on for the 7(a)(2) analysis.

Include a clear description of all conservation measures and project mitigation such as avoidance measures, seasonal restrictions, compensation, restoration/creation (on-site and in-kind, off-site and in-kind, on-site and out-of-kind, off-site and out-of-kind), and use of mitigation or conservation banks.

Here are some examples of commonly overlooked items to include in your project description:

Type of project

Project location

Project footprint

Avoidance areas

Start and end times

Construction access

Staging/laydown areas

Construction equipment and techniques

Habitat status on site

Habitat between work areas and endangered species locations

Permanent vs. temporary impacts

Surrounding land-use

Hydrology and drainage patterns

Duration of "temporary" impacts

Prevailing winds and expected seasonal shifts

Restoration areas

Conservation measures

Compensation and set-asides

Bank ratios and amounts

Mitigation: what kind and who is responsible?

Dust, erosion, and sedimentation controls

Whether the project is growth-inducing or facilitates growth

Whether the project is part of a larger project or plan

What permits will need to be obtained

Action Area

Describe all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action. This includes any interrelated and interdependent actions. Remember that the action area is not based simply on the Federal action and should not be limited to the location of the Federal action. The same applies to the applicant's action. The action area is defined by measurable or detectable changes in land, air and water, or to other measurable factors that may elicit a response in the species or critical habitat.

To determine the action area, we recommend that you first break the action down into its components (*e.g.,* vegetation clearing, construction of cofferdams, storage areas, borrow areas, operations, maintenance, etc.,) to assess the potential impacts resulting from each component.

Determine the impacts that are expected to result from each component. For example, instream actions may mobilize sediments that travel downstream as increased turbidity and then settle out as sediments on the stream substrate. Sound levels from machinery may be detectable hundreds of feet, thousands of feet, or even miles away. Use these distances when delineating the extent of your action area. Note: don't forget to subsequently reconstruct the action to assess the combined stressors of the components. You may find that some stressors are synergistically minimized or avoided, whereas other stressors may increase.

Finally, describe the action area, including features and habitat types. Include photographs and an area map as well as a vicinity map. The vicinity map for terrestrial projects should be at a 1:24,000 scale with the USGS quad name included.

SPECIES ACCOUNTS AND STATUS OF THE SPECIES IN THE ACTION AREA

Provide local information on affected individuals and populations, such as presence, numbers, life history, etc. Identify which threats to the species' persistence identified at the time of listing are likely to be present in the action area. Identify any additional threats that are likely to be present in the action area.

If the species has a distribution that is constrained by limiting factors, identify where in the action area factors are present that could support the species and where they are absent or limiting. For example, if a species is limited to a narrow thermal range and a narrow humidity range, show where in the action area the temperatures are sufficient to support the species, where the humidity is sufficient to support the species, and where those areas overlap.

Include aspects of the species' biology that relate to the impact of the action, such as sensitivity to or tolerance of: noise, light, heat, cold, inundation, smoke, sediments, dust, etc. For example, if the species is sensitive to loud sounds or vibration, and your project involves loud tools or equipment, reference that aspect of their biology. Include citations for all sources of information

Describe habitat use in terms of breeding, feeding, and sheltering. Describe habitat condition and habitat designations such as: critical habitat (provide unit name or number, if applicable), essential habitat, important habitat, recovery area, recovery unit (provide unit name or number, if applicable). Also discuss habitat use patterns, including seasonal use and migration (if relevant), and identify habitat needs.

Identify and quantify the listed-species habitat remaining in the action area. GIS layers are useful here, as are land ownership patterns--especially local land trusts and open space designations.

Identify any recovery plan implementation that is occurring in the action area, especially priority one action items from recovery plans.

Include survey information. For all monitoring and survey reports, please clearly identify how it was done, when, where, and by whom. If survey protocols were followed, reference the name and date of the protocol. If survey protocols were modified, provide an explanation of how the surveying occurred and the reasoning for modifying the protocol.

Keep it relevant. It is unnecessary to discuss biology that is totally unrelated to project impacts--*e.g.*, discussion of pelage color, teat number, and number of digits fore and aft when the project is a seasonal wetland establishment.

Utilize the best scientific and commercial information available. Use and cite recent publications/journal articles/agency data and technical reports. Include local information, relative to the action area, views of recognized experts, results from recent studies, and information on life history, population dynamics, trends and distribution. Reference field notes, unpublished data, research in progress, etc.

Things to consider:

Existing threats to species

Fragmentation

Urban growth area

Drainage patterns

Information on local sightings and populations

Population trends

Home range and dispersal

Sensitivity of endangered species to: dust, noise, head, desiccation, etc.

Trap stress/mortality

Predators

ENVIRONMENTAL BASELINE AND CUMULATIVE EFFECTS

Provide information on past, present and future state, local, private, or tribal activities in the action area: specifically, the positive or negative impacts those activities have had on the species or habitat in the area in terms of abundance, reproduction, distribution, diversity, and habitat quality or function. Include the impacts of past and present federal actions as well. Don't forget to describe the impacts of past existence and operation of the action under consultation (for continuing actions).

Cumulative effects include the effects of future State, Tribal, local or private actions that are reasonably certain to occur in the action area. Future Federal actions that are unrelated (*i.e.,* not interrelated or interdependent) to the proposed action are not considered in this analysis because they will be subject to separate consultation pursuant to section 7 of the Act. (Note: Cumulative effects under ESA are ***not*** the same as the definition under NEPA. Be careful not to mix them up.) Describe the impacts of these cumulative effects in terms of abundance, reproduction, distribution, diversity, and habitat quality or function.

Present all known and relative effects to population, *e.g.,* fish stocking, fishing, hunting, other recreation, illegal collecting, private wells, development, grazing, local trust programs, etc. Include impacts to the listed and proposed species in the area that you know are occurring and that are unrelated to your action-- *e.g.,* road kills from off-road vehicle use, poaching, trespass, etc.

EFFECTS OF THE ACTION

The purpose of this section is to document your analysis of the potential impacts the proposed action will have on species and/or critical habitats. This analysis has two possible conclusions for listed species and designated critical habitat:

(1) May Affect, Not Likely to Adversely Affect – the appropriate conclusion when effects on a listed species are expected to be *discountable*, *insignificant*, or completely *beneficial*.

Beneficial effects – contemporaneous positive effects without any adverse effects

Insignificant effects – relate to the size of the impact and should never reach the scale where take would occur.

Discountable effects – those that are extremely unlikely to occur. Based on best judgment, a person would not: (1) be able to meaningfully measure, detect, or evaluate insignificant effects; or (2) expect discountable effects to occur.

(2) May Affect, Likely to Adversely Affect – the appropriate finding if *any* adverse effect may occur to listed species or critical habitat as a direct or indirect result of the proposed action or its interrelated or interdependent actions, and the effect is not discountable, insignificant, or beneficial.

A finding of "may affect" is the primary trigger for initiating section 7 consultation. Further analysis leads to one of the two conclusions above. In the case of a determination that an action is "not likely to adversely affect" a species or critical habitat, you can request USFWS and/or NMFS concurrence with this determination and consultation can be concluded upon receipt of our concurrence. Determinations of "likely to adversely affect" require further consultation between the action agency and USFWS and NMFS. These consultations typically lead to the preparation of a biological opinion, although they can also lead to incorporation of additional protective measures that render the project "not likely to adversely affect" listed species or designated critical habitat. Any actions that are likely to result in the incidental take of a listed species are automatically considered "likely to adversely affect."

In the case of proposed species or proposed critical habitat, the possible conclusions are:

<u>Species</u>

Likely to Jeopardize the Continued Existence

Not Likely to Jeopardize the Continued Existence

<u>Critical Habitat</u>

Likely to Destroy or Adversely Modify

Not Likely to Destroy or Adversely Modify

The effects analysis includes assessment of:

Direct and indirect effects (stressors) of Federal action

Direct and indirect effects (stressors) of applicant's action

Direct and indirect effects (stressors) of interrelated or interdependent actions

Direct and indirect effects (stressors) of conservation and minimization measures

Remember: Direct and indirect effects under ESA are **not** the same as direct and indirect effects under NEPA. Be careful not to mix them up. Under ESA, direct effects are those that are caused by the action(s) and occur at the time of the action(s), and indirect effects are those that are caused by the action(s) and are later in time, but are still reasonably certain to occur.

Based on the various components of your action that you used to determine the extent of the action area, this analysis assesses the potential stressors resulting from each component and predicts the likely responses species and critical habitat will have. Note: don't forget to subsequently reconstruct the action to assess the combined stressors of the components. You may find that some stressors are synergistically minimized or avoided, whereas other stressors may increase.

Describe the stressors that are expected to result from each component. For example, instream actions may mobilize sediments that travel downstream as increased turbidity and then settle out as sediments on the stream substrate. Sound levels from machinery may be detectable hundreds of feet, thousands of feet, or even miles away. Describe these stressors in terms of their intensity, frequency, and duration.

Once you have determined the expected stressors resulting from an activity, the next step is to assess the overlap between those stressors and individuals of the species or components of critical habitat. The purpose of determining this overlap is to accurately and completely assess the potential exposure of species and habitat to the stressors resulting from the action. This exposure is the necessary precursor to any possible response those species and habitat may have. Your conclusions of "not likely to adverse affect" or "likely to adversely affect" are based in large part on this response.

To determine exposure, here is a basic set of questions you might answer:

- What are the specific stressors causing the exposure
- Where the exposure to the stressors would occur
- When the exposure to stressors would occur
- How long the exposure to stressors would occur
- What is the frequency of exposure to stressor
- What is the intensity of exposure to stressor
- How many individuals would be exposed
- Which populations those individuals represent
- What life stage would be exposed

For critical habitat, the questions would be similar but would focus on constituent elements of critical habitat.

Remember that exposure to a stressor is not always direct. For example, in some cases individuals of a species may be directly exposed to the sediment mobilized during construction. However, in other cases, individuals of the species would be exposed indirectly when sediment mobilized during construction settles out in downstream areas, rendering those areas unusable for later spawning or foraging.

Here are some examples of stressors you should address:

Exposure to abiotic factors affecting land, air, or water

Exposure to biotic factors affecting species behavior

Spatial or temporal changes in primary constituent elements of critical habitat

Loss or gain of habitat--direct and indirect

Fragmentation of habitat

Loss or gain of forage and/or foraging potential

Loss or gain of shelter/cover

Loss or gain of access through adjacent habitat/loss of corridors determine the potential response or range of responses the exposed individuals or components of critical habitat will have to those levels and types of exposure.

This is where the use of the best scientific and commercial information available becomes crucial. Your analysis must take this information into consideration and the resulting document must reflect the use of this information and your reasoning and inference based on that information. Bear in mind that this analysis may not be the final word on the expected responses as further consultation with USFWS or NMFS may refine this analysis.

Be sure to describe the expected responses clearly and focus your analysis towards determining if any of the possible responses will result in the death or injury of individuals, reduced reproductive success or capacity, or the temporary or permanent blockage or destruction of biologically significant habitats (*e.g.,* foraging, spawning, or lekking grounds; migratory corridors, etc.,). Any of these above responses are likely to qualify as adverse effects. If the available information indicates that no observable response is expected from the levels and types of exposure, the action may be unlikely to adversely affect a species or critical habitat. However, remember that no observable response may actually mask an invisible internal response such as increased stress hormone levels, elevated heart rate, etc. Depending on the fitness of the exposed individual and the surrounding environment (including other threats), these "invisible" responses may lead to more serious consequences. We recommend working with your NMFS or USFWS contact to determine the appropriate conclusion.

Don't forget to consider:

Individual responses based on the species biology and sensitivity to exposure

The combined effects of existing threats and new exposure

The combined effects of limiting factors and new exposure

Disrupted reproduction and/or loss of reproduction

Exposure and response of species and critical habitat to interrelated and interdependent actions

Understanding and avoiding the common flaws in developing an effect determination will save you considerable time. These common flaws are: the "Displacement" Approach (*i.e*., the species will move out of the way; there are plenty of places for them to go); the "Not Known to Occur Here" Approach (*i.e.*, looking at survey results, or lack of results, instead of the Recovery Plan for the species); the "We'll Tell You Later" Approach (*i.e.*, if we find any, then we'll let you know and that is when we will consult); or the "Leap of Faith" Approach (*i.e.*, the agency wants the USFWS or NMFS to accept a determination based on trust, rather than the best scientific and commercially available information.). Sticking to flawed determinations will cost everyone time, money, and aggravation.

Analysis of alternate actions

This analysis is required for actions that involve preparation of an EIS. For all other actions, a summary of alternatives discussed in other environmental documents is useful.

OTHER RELEVANT INFORMATION

Provide any other relevant available information the action, the affected listed species, or critical habitat. This could include local research, studies on the species that have preliminary results, and scientific and commercial information on aspects of the project.

CONCLUSION

This is where you put your overall effect determination after you have analyzed the exposure and response of species and habitat to the stressors resulting from the proposed action and interrelated or interdependent actions. Effect determinations must be based on a sound reasoning from exposure to response and must be consistent with types of actions in the project description, the biology in the species accounts, the habitat status and condition, changes to the existing environment, and the best scientific and commercial information available.

Again, the two potential conclusions for **listed species** are:

Not likely to adversely affect species

Likely to adversely affect species

The two potential conclusions for **designated critical habitat** are:

Not likely to adversely affect critical habitat

Likely to adversely affect critical habitat

The two potential conclusions for **proposed species** are:

Not likely to jeopardize species

Likely to adversely jeopardize species

The potential conclusions for **proposed critical habitat** are, under informal and formal consultation respectively:

Not likely to adversely affect species

Likely to adversely affect species

Not likely to destroy or adversely modify critical habitat

Likely to destroy or adversely modify critical habitat

Include the basis for the conclusion, such as discussion of any specific measures or features of the project that support the conclusion and discussion of species expected response, status, biology, or baseline conditions that also support conclusion.

If you make a "no effect" determination, it doesn't need to be in the assessment, but you might have to defend it. Keep the documentation for your administrative record.

LIST OF DOCUMENTS

Provide a list of the documents that have bearing on the project or the consultation, this includes relevant reports, including any environmental impact statements, environmental assessment, or biological assessment prepared for the project. Include all planning documents as well as the documents prepared in conformance with state environmental laws

IMPORTANT NOTE: Each of these documents must be provided with the initiation package consultation for the Services to be able to proceed with formal consultation.

LITERATURE CITED

We are all charged with using the best scientific and commercial information available. To demonstrate you did this, it is a good idea to keep copies of search requests in your record. If you used a personal communication as a reference, include the contact information (name, address, phone number, affiliation) in your record.

LIST OF CONTACTS/CONTRIBUTORS/PREPARERS

Please include contact information for contributors and preparers as well as local experts contacted for species or habitat information.

GLOSSARY

Action Area - all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action.

Beneficial Effects – contemporaneous positive effects without any adverse effects.

Cumulative Effects – are those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur in the action area of the Federal action subject to consultation.

Discountable Effects – those that are extremely unlikely to occur. Based on best judgment, a person would not: (1) be able to meaningfully measure, detect, or evaluate insignificant effects; or (2) expect discountable effects to occur.

Effects of the Action – refers to the direct and *indirect effects* of an action on the species or critical habitat, together with the effects of other activities that are *interrelated* or *interdependent* with that action, that will be added to the environmental baseline.

Environmental Baseline – includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions that are contemporaneous with the consultation in process.

Indirect Effects - Indirect effects are those that are caused by the action(s) and are later in time, but are still reasonably certain to occur.

Insignificant Effects – relate to the size of the impact and should never reach the scale where take would occur.

Interdependent Actions - Interdependent actions are those that have no significant independent utility apart from the action that is under consideration, *i.e.* other actions would not occur "but for" this action.

Interrelated Actions - Interrelated actions are those that are part of a larger action and depend on the larger action for their justification, *i.e.* this action would not occur "but for" a larger action.

Likely to Jeopardize the Continued Existence of – to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species.

May Affect, Likely to Adversely Affect – the appropriate finding if any adverse effect may occur to listed species or critical habitat as a direct or indirect result of the proposed action or its interrelated or interdependent actions, and the effect is not discountable, insignificant, or beneficial. Requires that a biological opinion be prepared by the Service.

May Affect, Not Likely to Adversely Affect – the appropriate conclusion when effects on a listed species are expected to be *discountable*, *insignificant*, or completely *beneficial*. Requires written concurrence from the Service.

No Effect – the appropriate conclusion when a listed species will not be affected, either because the species will not be present or because the project does not have any elements with the potential to affect the species. A "no effect" determination does **not** require written concurrence from the Service and ends

ESA consultation requirements. Action agency should document their reasoning for this conclusion in their file.