Temporal variation in diet and food selection of shovelnose sturgeon in the Missouri River above Fort Peck Reservoir, Montana
by Douglas J Megargle

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University

Abstract:
Seasonal variation in discharge affects aquatic invertebrate distribution and production in rivers and may influence the foraging efficiencies of insectivores. I investigated the temporal variation in diet and food selection of shovelnose sturgeon (Scaphirhynchus platorynchus) inhabiting the Missouri River above Fort Peck Reservoir, Montana where discharge pattern is unaltered. I examined significant relations between changes in river discharge and changes in shovelnose sturgeon forage biomass, changes in sturgeon use of important prey, and changes in relative abundance and biomass of important prey in the benthos and water column. Results were compared to those of similar studies conducted in the flow-altered Missouri River below Gavins Point Dam, South Dakota. I sampled prey availability and sturgeon food habits monthly during ice-free periods. Ninety nine sturgeon stomachs and 105 forage availability samples were collected in 1994. Attempts to non-lethally remove sturgeon gut contents were unsuccessful. Shovelnose sturgeon consumed invertebrates from 12 aquatic invertebrate orders and small quantities of terrestrial invertebrates and larval fish. Representatives of Ephemeroptera, Diptera, Trichoptera, and Plecoptera made up most of the sturgeon diet. Trichoptera composed 54.4% of the annual average ration biomass, but their relative importance was less than that of Ephemeroptera. The relative composition of shovelnose sturgeon diet and the availability of important prey significantly varied between months; Electivity index indicated shovelnose sturgeon generally consumed prey in proportion to availability. I found little evidence that discharge influenced either shovelnose sturgeon forage availability or food selection. A significant positive relation was found among the average monthly sturgeon ration biomass and the average monthly discharge. Sturgeon from Montana and South Dakota had similar diets, but different relative diet composition. Shovelnose sturgeon in South Dakota fed predominantly on Chironomidae and Ephemeroptera, and foraged upon Chironomidae at rates not in proportion to their availability. In South Dakota, a significant negative relation was found among monthly discharge and average monthly ration biomass. Average sturgeon ration biomass trends were similar in Montana and South Dakota, but river flow patterns differed, suggesting discharge was not the major factor influencing sturgeon ration biomass.

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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Date — Chairperson, Graduate Committee

Approved for the Major Department

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ABSTRACT

Seasonal variation in discharge affects aquatic invertebrate distribution and production in rivers and may influence the foraging efficiencies of insectivores. I investigated the temporal variation in diet and food selection of shovelnose sturgeon (*Scaphirhynchus platorynchus*) inhabiting the Missouri River above Fort Peck Reservoir, Montana where discharge pattern is unaltered. I examined significant relations between changes in river discharge and changes in shovelnose sturgeon forage biomass, changes in sturgeon use of important prey, and changes in relative abundance and biomass of important prey in the benthos and water column. Results were compared to those of similar studies conducted in the flow-altered Missouri River below Gavins Point Dam, South Dakota. I sampled prey availability and sturgeon food habits monthly during ice-free periods. Ninety nine sturgeon stomachs and 105 forage availability samples were collected in 1994. Attempts to non-lethally remove sturgeon gut contents were unsuccessful. Shovelnose sturgeon consumed invertebrates from 12 aquatic invertebrate orders and small quantities of terrestrial invertebrates and larval fish. Representatives of Ephemeroptera, Diptera, Trichoptera, and Plecoptera made up most of the sturgeon diet. Trichoptera composed 54.4% of the annual average ration biomass, but their relative importance was less than that of Ephemeroptera. The relative composition of shovelnose sturgeon diet and the availability of important prey significantly varied between months. Electivity index indicated shovelnose sturgeon generally consumed prey in proportion to availability. I found little evidence that discharge influenced either shovelnose sturgeon forage availability or food selection. A significant positive relation was found among the average monthly sturgeon ration biomass and the average monthly discharge. Sturgeon from Montana and South Dakota had similar diets, but different relative diet composition. Shovelnose sturgeon in South Dakota fed predominantly on Chironomidae and Ephemeroptera, and foraged upon Chironomidae at rates not in proportion to their availability. In South Dakota, a significant negative relation was found among monthly discharge and average monthly ration biomass. Average sturgeon ration biomass trends were similar in Montana and South Dakota, but river flow patterns differed, suggesting discharge was not the major factor influencing sturgeon ration biomass.

INTRODUCTION

Shovelnose sturgeon (*Scaphirhynchus platorynchus*) evolved from the ancient bony fishes of the subclass Paleopterygii which was dominant during the Paleozoic Era and flourished during the late Paleozoic and early Mesozoic Era (U.S. Fish and Wildlife Service 1993). Including the shovelnose sturgeon, eight North American sturgeon species (Acipenseridae) now exist (U.S. Fish and Wildlife Service 1993). Other species include the pallid sturgeon (*Scaphirhynchus albus*), white sturgeon (*Acipenser transmontanus* Richardson), green sturgeon (*Acipenser medirostris* Ayres), Atlantic sturgeon (*Acipenser oxyrhynchus* Mitchilli), shortnose sturgeon (*Acipenser brevirostrum* LeSueur), lake sturgeon (*Acipenser fulvescens* Rafinesque), and a recently described Alabama sturgeon (*Scaphirhynchus suttkus* Williams) (U.S. Fish and Wildlife Service 1993).

Of the above species, only *Scaphirhynchus* spp. complete their life cycles in freshwater lotic systems. Pallid and shovelnose sturgeon are endemic to large rivers of the central United States of America, primarily in the Mississippi River Basin (Bailey and Cross 1954) and its major tributaries (Rochard et al. 1990). Shovelnose sturgeon are often found in sympatry with pallid sturgeon in the lower and middle Mississippi River and in the Missouri and Yellowstone Rivers (Carlson et al. 1985). Shovelnose are also reported from the Tombigbee River in Alabama, the Wichita River in Texas, and the Ohio River in Ohio (U.S. Fish and Wildlife Service 1994) and occur from the Hudson Bay drainage in Canada south to Kentucky, Arkansas, and New Mexico. Its historical range has been reduced by anthropogenic river modifications, commercial harvest, and pollution (Bailey and Cross 1954; Hurley et al. 1987; Rochard et al. 1990). Shovelnose sturgeon do not appear to sustain populations in reservoirs (Coker 1930; U.S. Fish and Wildlife Service 1994).

The shovelnose sturgeon is the smallest of the North American sturgeons (Bond 1979). Sexually mature adults range from 40-100 cm in fork length and from 0.4-2.3 kg in weight (Modde 1971). The congeneric pallid sturgeon can reach weights of 30.8 kg and lengths exceeding 1.2 m (Kallemeyn 1977).

The shovelnose is characterized by a tapered, compressed, and shovel-like snout. Typical of many bottom dwellers, the eyes are small (1/24 of total head length) and must be unimportant in detecting food (Weisel 1979). The shovelnose sturgeon has a ventrally-located protractile mouth. The fully-extended mouth of a mature shovelnose can project 15 mm beyond the ventral surface of the head (Weisel 1979). Shovelnose lips are papillose and plicate (Lagler et al. 1962). A transverse row of four similar lengthed ventral-barbels is located half the distance between the protractile mouth and the tip of the rostrum. Taste buds are copious on the papillose barbels and lips (Weisel 1979). The head is protected by bony plates joined by sutures. The endoskeleton is cartilaginous with a persistent notochord (Weisel 1979).

The body of the shovelnose sturgeon is long and sub-cylindrical with a flat, white ventral surface protected by small and numerous rhomboidal denticles (Weisel 1979). The dorsal and lateral surfaces are dark olive green to brown and armored with five longitudinal rows of large bony scutes. These carinate scutes are strongly spined in juveniles and dull with age. Minute dermal plates cover the body between the scutes. The shovelnose sturgeon is an ancient fish with posterior-positioned anal and dorsal fins, and a heterocercal caudal fin. The pectoral fins are large and situated near the ventro-lateral border of the anterior trunk (Moos 1978). Shovelnose sturgeon are morphometrically distinct and genotypically similar to the pallid sturgeon (Phelps and Allendorf 1979, 1983). Hybridization occurs among shovelnose and pallid sturgeon (Phelps and Allendorf 1979, 1983; Carlson and Pflieger 1981; Carlson et al. 1985).

The shovelnose sturgeon is a bottom dwelling species. Shovelnose sturgeon occur in greatest abundance in the swift channels of large rivers and usually prefer gravel or sand substrates (Bailey and Cross 1954; Moos 1978; Modde 1971). Shovelnose sturgeon abundance in the Missouri River was highest in substantial currents within main channel and sand bar habitats (Schmulbach et al. 1975; Kalleymeyn and Novotny 1977; Bramblett 1996). Commercial fishermen seek shovelnose sturgeon in habitats adjacent to the main channel, whereas sportsman concentrate in areas behind sandbars or adjacent to shoreline eddies. Shovelnose in the unchannelized Missouri River preferred deep water behind sand bars in spring and fall but dispersed widely during the warm summer months (Schmulbach et al. 1975). Shovelnose sturgeon preferred a current velocity of 0.5-0.8 m/sec in the Missouri River (U.S. Fish and Wildlife Service 1979). Shovelnose preferred a depth of 0.4-0.9 m in spring and early summer in the Tongue River, Montana (Elser et al. 1977).

Spawning habitat of the shovelnose sturgeon is not well documented. It has been suggested that this species ascended small streams to spawn (Forbes and Richardson 1920). Capture of adults in breeding condition has been used as circumstantial evidence of spawning in the Chippewa River, Wisconsin (Christianson 1976), the Tongue River, Montana (Elser et al. 1977), the Missouri River, South Dakota (June 1976; Moos 1978), and the Mississippi River, Iowa (Coker 1930; Helms 1974). Shovelnose sturgeon spawning occurs in the main channels of the Missouri and Mississippi Rivers and their smaller tributaries. Shovelnose sturgeon are thought to spawn in areas of rapid current (Eddy and Surber 1943) and on rocky bottoms (Coker 1930; June 1976).

The shovelnose sturgeon spawns in spring. They spawned from April to June in the Mississippi River bordering Illinois (Forbes and Richardson 1920) and Iowa (Helms 1972, 1973). Shovelnose sturgeon spawn from May to June in Minnesota and Wisconsin (Eddy and Surber 1943; Christenson 1975).

The age and length of shovelnose sturgeon at sexual maturity differ between sexes. Most shovelnose sturgeon females did not mature until they reached a fork length > 63.5 cm, but age of sexual maturity was difficult to determine (Monson and Greenbank 1947, Christenson 1975). Sexual maturity of male and female individuals occurs at lengths of about 55.9 and 63.5 cm, respectively (Helms 1972, 1973). Males mature earlier than females. About 40% of age IV males were mature or maturing, whereas females first spawned at age VII or older (Helms 1972). The shovelnose sturgeon mature at smaller sizes (i.e. 43.2-48.3 cm) in areas in the Missouri River where sturgeon grow more slowly (Zweiacker 1967).

Shovelnose sturgeon appear to be opportunistic feeders (Walburg 1971). Sturgeon forage benthically using sensory organs on the snout, barbels, and mouth to distinguish prey items from debris (Weisel 1979). They often consume non-benthic food items which settle in river deposition zones. Sturgeon often consume terrestrial insects (Modde and Schmulbach 1977), crustaceans (Held 1969), and isopods (Walburg 1971;

Moos 1978). Aquatic insect larvae and naiads dominated diets of shovelnose sturgeon from the Mississippi River (Eddy and Surber 1947; Barnickol and Starrett 1951; Hoopes 1960; Held 1969; Modde and Schmulbach 1977). Naiads (*Hexagenia* spp.) were included in the diets of shovelnose sturgeon from the Mississippi River at Andalusia, Illinois (Barnickol and Starrett 1951). Immature aquatic insects were present in over 97% of 75 stomach samples of shovelnose sturgeon collected from the Missouri River (Held 1969). Baetidae naiads, Tendipedidae larvae, and Heleidae larvae were the dominant food items (Held 1969). Shovelnose sturgeon also consume Odonata naiads (Eddy and Surber 1947).

The diet of shovelnose sturgeon from the Missouri River below Gavins Points Dam, South Dakota was made up largely of immature Trichoptera, Diptera, and Ephemeroptera (Modde and Schmulbach 1977). Shovelnose sturgeon diets were made up largely of drifting Tricoptera larvae (69%) when discharge decreased from October to January (Modde and Schmulbach 1977). Odonata naiads, crustaceans, and terrestrial insects were consumed by shovelnose sturgeon when discharges were consistently low from January to April (Modde and Schmulbach 1977). During high discharge in late spring and summer (May-September), shovelnose foraged predominantly on benthic Chironomidae (Modde and Schmulbach 1977). Shovelnose sturgeon prey availability and feeding patterns were related to upstream variations in discharge from Gavins Point Dam (Modde and Schmulbach 1977). Shifts in feeding behavior of shovelnose sturgeon were strongly influenced by the timing and magnitude of discharge from Gavins Point Dam (Modde and Schmulbach 1977).

My study evaluated temporal variation in food selection of shovelnose sturgeon in a non-impounded reach of the Missouri River. I examined the relation among river discharge and the diet of shovelnose sturgeon in the Missouri River. In my study area the hydrograph is less influenced by mainstem dam releases and closely resembled the natural river hydrograph. I examined the relation among seasonal discharge and the available shovelnose sturgeon prey in six river habitats. The habitats included the mainchannel (deepest point in river cross-section), midchannel (half the depth of the mainchannel), shoreline (near shore at a depth > 0.15 m and < 1 m), side-channel (flows separate from main river), and the water column (drift) habitats. I examined the relation among river discharge and shovelnose sturgeon diets.

A similar study was conducted concurrently by the South Dakota Cooperative Fish and Wildlife Research Unit in the flow-altered Missouri River below Gavins Point Dam, South Dakota (Berry 1996). This study repeated an earlier study (Modde 1971). My data were compared with data from Berry (1996), Modde (1971), and Modde and Schmulbach (1977).

The objectives of my study were to:

1. Quantify and compare food selection of shovelnose sturgeon across discharge levels and seasons.

2. Determine the relation among discharge level and invertebrate drift and benthic abundance in main channel, midchannel, shoreline, side-channel, and water column habitats.

3. Compare patterns of invertebrate resource abundance and use by shovelnose sturgeon among studies.

4. Evaluate the feasibility of a non-lethal means of extracting stomach contents from shovelnose sturgeon.

STUDY SITE DESCRIPTION

The Missouri River originates at the confluence of the Gallatin, Madison, and the Jefferson rivers in southwestern Montana. It flows easterly and southeasterly for about 4000 km and joins the Mississippi River just north of St. Louis, Missouri. Ten dams impound the Missouri River in Montana.

The Missouri River is not impounded in a 336-km reach from Morony Dam near Great Falls, Montana to the headwaters of Fort Peck Reservoir, Montana. The land adjacent to the river in this area has retained most of its primitive characteristics (Gardner and Berg 1980). The 240-km section of the Missouri River from Fort Benton, Montana, to Robinson Bridge, Montana was designated "Wild and Scenic" in 1976 (U.S. Congress 1975a). This designation affords considerable river protection in that no dams can be built on it and specific protective regulation is imposed on any new commercial development within adjacent designated areas (U.S. Congress 1975b). The law does allow minor diversions and pumping of water for agricultural uses. Private landowners in the area engage in traditional farming, grazing, residential, and recreational uses.

Fifty-three fish species from 14 families are known to occur in the Missouri River between Morony Dam and Fort Peck Dam (Berg 1981). The transition zone between cold water and warm water fish assemblages occurs in the Missouri River from Morony Dam, Montana to the confluence of the Marias River, Montana. Sauger (*Stizostedion canadense*) are the predominant game fish species, and significant numbers of trout, mountain whitefish (*Prosopium williamsoni*), sculpins, longnose dace (*Rhinichthys* *cataractae*) and suckers (Catostomidae) also occur (Gardner and Berg 1982). My study area was in the warm water zone between the Marias River confluence and the headwater of Fort Peck Reservoir, Montana. Shovelnose sturgeon, sauger, paddlefish (*Polyodon spathula*), channel catfish (*Ictalurus punctatus*), and a variety of cyprinids (Cyprinidae) and suckers are the predominant fish species of this reach (Gardner and Berg 1982).

My study area consisted of a 24.1-km reach of the Missouri River from river mile 1197 to 1182 (km 1926 to 1902) (Figure 1). The Judith Landing boat ramp and the Slaughter River campground are the only public access sites on the Missouri River near my study area. Judith Landing is located at T 23 N; R 16 E approximately 762 m above sea level. Average monthly flow ranged from about 170 m^3/s in October to 510 m^3/s in June (United States Geological Survey 1995). The gross seasonal timing of flow is not greatly altered by dams upstream from my study area (Scott et al. 1993). However, annual peak flows have decreased and annual low flows have increased since dam construction (Scott et al. 1993). The Missouri River in my study area has gradients ranging from 0.38 to 0.76 m/km (Gardner and Berg 1982). Water temperature ranged from <0 ^{0}C in winter, to 20-25 ^{0}C in late summer and early fall.

River channel characteristics in my study area include slight meandering profile, sloping sandy banks, islands, chutes (or side channels), rapids, and a river bed of rubble and cobble with limited sand patches. The upper section of the study site is confined by steep and narrow canyons with very few islands (Gardner and Berg 1982). The lower section is characterized by low-sloping sandy banks. There are nine islands during low flows within my study site, of which three have permanent vegetation (e.g. plains cottonwood, *Populus deltoides*). Other islands support young willows (*Salix* sp.), grasses, and shrubs.