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RESEARCH CHRONOLOGY OF PALLID STURGEON, SHOVELNOSE STURGEON, BLUE SUCKER, SICKLEFIN CHUB AND STURGEON CHUB IN THE MISSOURI AND YELLOWSTONE RIVERS IN MONTANA AND NORTH DAKOTA

Grant G. Grisak

Montana Cooperative Fisheries Research Unit
Montana State University
Bozeman, Montana 59715

Prepared for

United States Fish & Wildlife Service
Missouri River Fish and Wildlife Management Assistance Office
1500 East Capitol Avenue
Bismarck, North Dakota 58501

October 1997

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Most of the reports listed in this document are in the possession of the author and can be obtained for loan by contacting the Montana Cooperative Fisheries Research Unit, Department of Biology, Montana State University, Bozeman, Montana, 59715 (406-994-4549).

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Introduction

The pallid sturgeon working group was formed in 1993 to coordinate implementation of the pallid sturgeon recovery plan in Montana and the Dakotas. The group is comprised of fisheries biologists and support staff from the U.S. Fish & Wildlife Service, North Dakota Game & Fish Department, Montana Department of Fish, Wildlife & Parks, and personnel from local Universities, U.S. Bureau of Reclamation, U.S. Department of Energy-Western Area Power Administration and Montana Power Company.

Each year this group meets to discuss the activities of past years, to prioritize funding for research proposals and the direction of future research and recovery efforts. In recent years species like shovelnose sturgeon (*Scaphirhynchus platorynchus*), blue sucker (*Cycleptus elongatus*), sicklefin chub (*Macrhybopsis meeki*) and sturgeon chub (*Macrhybopsis gelida*) have been considered during deliberations of the group because they have similar distribution, relatively limited abundance and are commonly sampled during pallid research efforts.

In 1996 the group proposed to consolidate, into one document, research chronology, sampling gear and technical knowledge generated for these five species. The areas of interest in Montana include the Missouri River from Great Falls to Fort Peck Reservoir (Figure 1), the Missouri River from Fort Peck Dam to the headwaters of Lake Sakakawea (Figure 2), the Yellowstone River from its confluence with the Missouri River to Miles City (Figure 3), and in North Dakota, the Missouri and Yellowstone rivers above Lake Sakakawea to Montana border (Figure 4) and the Missouri River from Garrison Dam to Bismarck (Figure 5).

The objective of this paper is to provide a succinct listing of recent research that has been conducted on the above species. The goal is to provide a chronology of techniques and results in each study area starting at the point of discovery or when formal research and monitoring began on each species.

Reporting on data collected from the lower Missouri and Yellowstone rivers is somewhat complex due to the involvement of two state agencies; the North Dakota Game and Fish Department and Montana Department of Fish, Wildlife & Parks, and one federal agency; the United States Fish and Wildlife Service.

Information in this report has been separated based on the location of the agencies conducting the work.

MONTANA

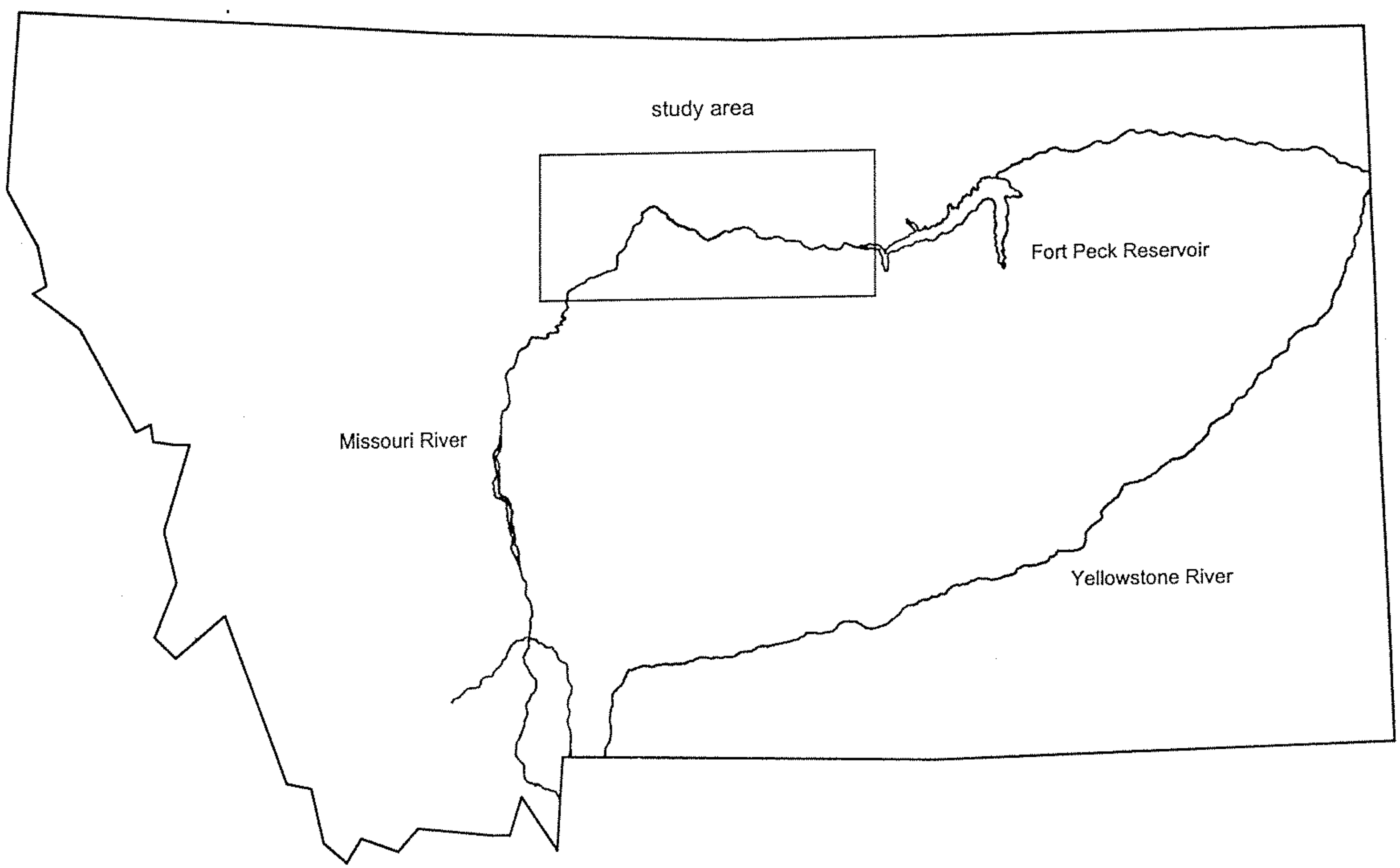
Pallid Sturgeon

(*Scaphirhynchus albus*)

Missouri River above Fort Peck Reservoir (Figure 1).

The pallid sturgeon recovery project was started in Montana in **1989** following the proposed listing of the species as endangered. The project in the upper Missouri River section began by compiling a history of sightings including angler interviews. Gardner (1990a) documented only 35 sightings over a 123 year period spanning from 1876 to 1989, with the most recent being one collection and three observations by Berg (1981) during electrofishing. Under the recovery project, sampling began with the use of stationary gill nets, setlines baited with flathead chub and electrofishing, but was largely unsuccessful during the first year.

It wasn't until **1990** that 5 pallids were sampled, 3 by trammel net and 2 by setline, the largest being 55 lbs (Gardner 1991a). Trammel nets 150' by 6' were used, one with 1 inch inner and 10 inch outer net and the other with 2 inch inner and 12 inch outer net. Two specimens were fitted with external radio transmitters on their backs. Radio frequencies ranged from 40-41 MHz.



Firuge 1. Missouri River study area above Fort Peck Reservoir.

Their activity was monitored by telemetry in an effort to work toward a functional tracking and monitoring system. In addition, morphometric data were recorded and applied to a character index to determine if hybridization with shovelnose sturgeon was present. The results were negative.

In **1991**, two additional pallids were captured by trammel net (Gardner 1992a). One was sampled while trying to recapture a previously radioed fish and was also fitted with an external transmitter. Tracking of pallids fixed with "piggy-back" transmitters lead to speculation that this type of attachment was influencing behavior in the form of downstream movement as much as 69 miles. With the apparent loss of one transmitter and observed irritation to the fish's skin, internal transmitters were explored using shovelnose sturgeon as surrogates. Signal strength, size and longevity were among the parameters experimented with. Surgically implanted transmitters were markedly more effective and made relocating with boat and aircraft more successful.

Field efforts in **1992** concentrated on intensive sampling and continued monitoring of the 4 radio tagged pallids from the previous seasons. A redundant tagging system was used for pallids including a spaghetti tag, PIT tag and endangered species tag; all placed near the base of the dorsal fin to ensure some level of tag retention. Catch rates continued to improved as sampling techniques became more refined. Eleven new specimens were sampled (Gardner 1993a). Trammel nets sampled 9 and setlines sampled 6. Limitations to setlining became evident as increase filamentous algae production made this method virtually useless beyond June. A pallid sturgeon creel census was run consecutively with the paddlefish creel census. In an effort to educate anglers of the endangered species status, information pamphlets were distributed to assist with identification and help deter incidental harvest during the paddlefish snagging season. Two pallid catches were confirmed by bait anglers.

In 1992 efforts were made toward developing techniques for artificial reproduction and subsequent maintenance of a broodstock for pallid sturgeon. Shovelnose sturgeon were used as a surrogate. Results of these techniques are detailed in the following section on Shovelnose Sturgeon.

In **1993** the hybridization character index provided the first indication of hybridization in three sturgeon sampled (Gardner 1994a). Experimentation with radio transmitter design continued with the testing of: 1) internal transmitter-internal antenna, 2) external transmitter-whip antenna fixed to dorsal fin base, and 3) internal transmitter-external whip antenna. Fish equipped with completely internal transmitters were found to be least affected and most effective. There were 104 microhabitat measurements recorded at sites where 13 different radioed pallid sturgeon were relocated. Numerous habitat utilization characterizations were made relative to seasonal locations and habitat use by pallids by sub-section within the study area. Depth ranged from 3 to 15 feet. Generally, pallids were found in the deeper water habitats, within each study section. Pallid relocations were generally associated with gravel and cobble substrates.

In **1994**, Gilge (fisheries biologist, MDFWP, personal communication, 1996) observed 2 pallid sturgeon while drifting 150' by 8' by 5 inch bar mesh surface gill nets in the Wild and Scenic section during paddlefish tagging. Discharge was unusually low that season with and abundance of shallow water areas. These fish were sampled in areas <8' deep where the net was likely dragging the bottom. One fish reportedly rose to the surface and broke lose. The other became entangled in a net where an external radio transmitter, that had been affixed to the dorsal fin-base 2 years prior, was found in the net after apparently being torn lose from the fish .

1994 also saw a major shift in project objectives as young sturgeon were targeted (Gardner 1995a). A modified beam trawl, conical plankton nets and "D" nets were used to sample for young-of-the-year and larval fish. A 50' x 4' x 0.25" minnow seine was used to sample shallow water habitats. A trawling technique was developed in conjunction with another study focusing on sicklefin chub. The first young of the year (YOY) shovelnose sturgeon sampled in Montana was collected in the trawl (Grisak 1996a) and presumably could sample YOY pallids, assuming they exist. Adult pallid sturgeon catches during this year were all recaptures which lead to speculation that much of the adult population was being sampled. Eight sturgeon larvae were collected in plankton nets and positively differentiated from paddlefish larvae by the Larval Fish Laboratory in Fort Collins, Colorado. Due to likeness in pallid and shovelnose larvae, differentiation is difficult. Completion of a larval key is not expected until pallids can be successfully reared in captivity. The creel census was continued and at least one pallid was encountered by snagging during the paddlefish season. Blood and tissue samples were taken from pallids in an effort to 1) identify loci for genetic comparison with shovelnose and suspected hybrids, and 2) measure blood calcium and vitellogenin protein levels to determine maturity level of eggs. One female was identified as having calcium levels consistent with a fish that would likely spawn that season (Dave Erdahl, USFWS, Bozeman Fish Technology Center, personal communication, 1997).

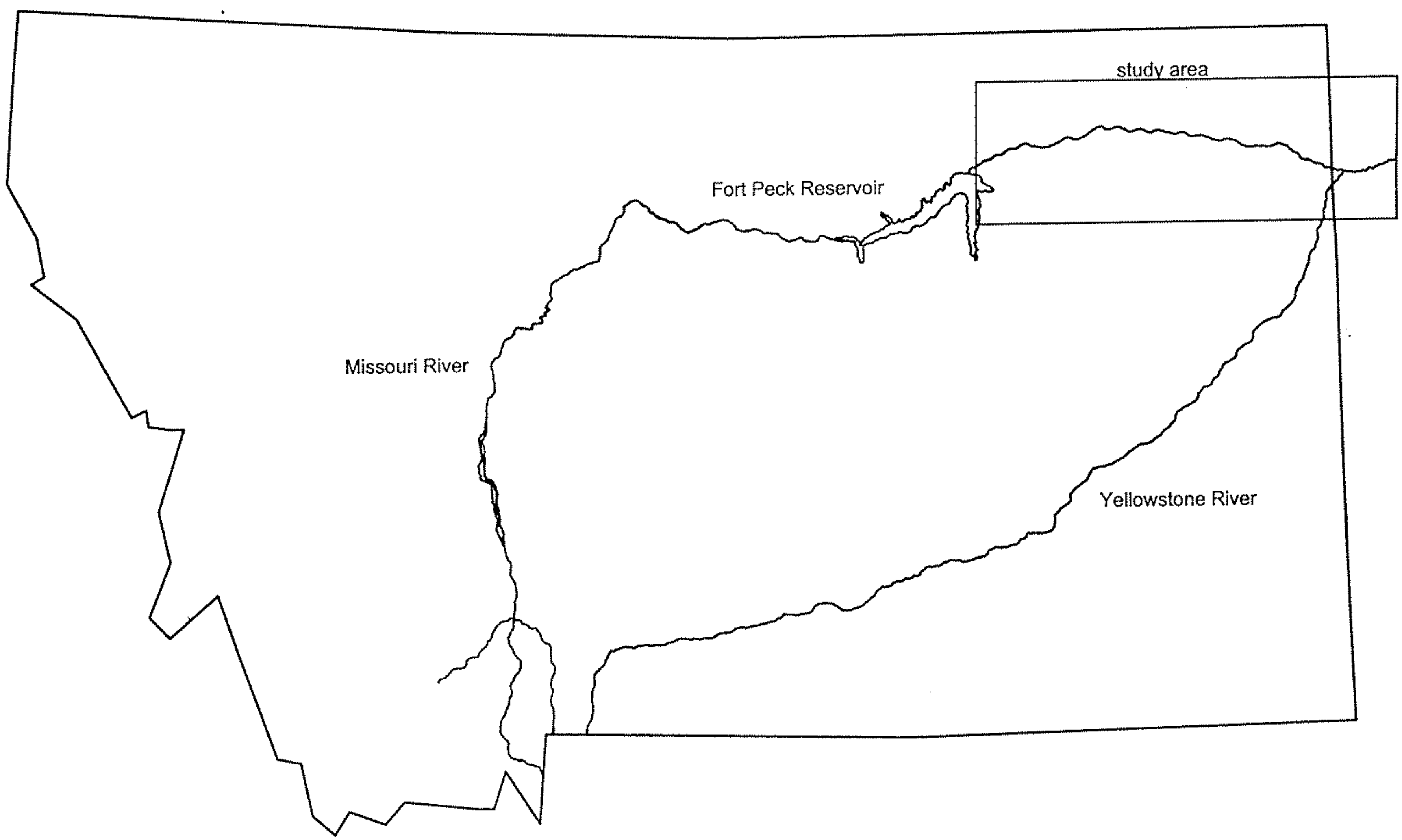
In **1995** experimentation with radio transmitters continued with the use of small microprocessor-type tags implanted in shovelnose sturgeon (Gardner 1996a). These were equipped with program delay mechanisms set to operate on 20 day intervals for 6 hours/day during activation. In light of anticipation of future release of hatchery reared pallid sturgeon juveniles, this system was successfully tested using small shovelnose sturgeon as surrogates. In June, one pallid sturgeon captured in a trammel net appeared to be flaccid and had eggs present in the vent (Randy Rodencal, MDFWP, personal communication, 1997). This observation is the most recent evidence of pallid spawning in the study area. Four of the 25 pallid sturgeon sampled in the study area to date are suspected pallid x shovelnose hybrids based on the hybrid character index. Using a modified Schnabel population estimate, roughly 45 adult pallid sturgeon were estimated to reside in the study area. Twenty-eight YOY shovelnose sturgeon were sampled in the trawl near the headwaters of Fort Peck Reservoir. Twenty-one sturgeon larvae were collected using conical and "D" plankton nets and positively identified at the Larval Fish Laboratory in Fort Collins, Colorado.

The results of a study evaluating tissue and blood samples collected in previous years from 18 pallid and 20 shovelnose sturgeon were reported (Campton et al. 1995). A 435 base pair sequence was evaluated from the mitochondrial DNA (mtDNA) control region. Haplotype frequencies were distinctly different on 13 shovelnose sturgeon when compared to the 18 pallid sturgeon. These data indicate that pallid and shovelnose sturgeon are reproductively isolated.

Missouri River from Fort Peck Dam to Lake Sakakawea headwaters (Figure 2)

Gardner and Stewart (1987) reported one pallid sturgeon collected in an experimental gill net set in the Fort Peck dredge cuts between **1979** and **1984**.

The Fort Peck Pallid Sturgeon Study was begun in **1989** following the proposal to list the species as endangered (Clancey 1989). Recreational divers using SCUBA, captured pallids by hand and brought them to the surface for observation. Three were weighed, measured for the hybrid character index, fitted with radio transmitters on their backs and tagged in the dorsal fin. Transmitter frequency ranged from 47 to 49 MHz. Their activity was monitored by aircraft and boat to establish movement patterns. Habitat data were collected at 5 relocation sites between May 1 and June 15. Velocity ranged from 0.35 to 0.90 m/s, depth ranged 5 to 8 feet and temperature ranged 7 to 17 °C. Two fish moved downstream 45 and 105 miles and later sloughed their transmitters. It was suspected that stainless steel wire used for attaching the devices pulled through the fish's flesh. Movement of the third fish was minimal and it too lost its transmitter. This fish was later recaptured using gill nets and again received a transmitter attached with monel wire. A 400 kHz PIT tag was also implanted near the dorsal fin. Multiple pallid



Firuge 2. Missouri River study area from Fort Peck Dam to Lake Sakakawea headwaters.

relocations near the Milk River confluence suggest an affinity for the turbid water discharged by the Milk.

In **1990**, SCUBA, larval fish nets, radio and sonic telemetry were used to track fish (Clancey 1990). A survey distributed in local stores and newspapers provided information of several credible and recent pallid encounters. Information posters were circulated statewide to help anglers identify pallid from shovelnose sturgeon and where to report sightings. Two fish captured with SCUBA equipment were fitted with both radio and sonic transmitters. Sonar was effective in locating fish in deep water, but equipment failure ultimately lead to losing contact with these fish. Four additional pallids were captured with gill nets near the Yellowstone confluence and fitted with external radio transmitters. Relocation was sporadic and suspected to be a function of both water depth and transmitter quality. Larval sampling was unsuccessful and effort was placed on perfecting the technique.

In **1991**, experts were consulted to assist in developing a dependable tracking system. Internal radio implants with external antennae were tested (Clancey 1991). Winter diving surveys in the tailrace provided consistent sightings of previously sampled fish. Continued experimentation with sonic and radio transmitters was conducted on 7 shovelnose sturgeon. One received both types of transmitters. Two new pallids were captured with

SCUBA in the tailrace area. Two others were captured in gill nets near the Yellowstone River confluence. All 4 were fitted with external radio transmitters. Head and body measurements were made and applied to the character index to discern hybridization. One fish previously sampled in the tailrace area was recaptured 172 miles downstream in North Dakota. Relocations of radioed pallids were again inconsistent and unreliable. Larval fish sampling was not conducted due to equipment failure.

A significantly greater number of pallid sturgeon were encountered in **1992** as 33 new individuals were sampled in addition to two recaptures (Tews and Clancey 1993). Changes were made in netting techniques by using longer nets, more weight on the lead line and longer drift duration. Trammel nets were more effective than gill nets. No pallids were observed during winter dives in the Fort Peck tailrace. Twenty five of the new pallids were sampled in August from the same general area directly downstream of the Yellowstone confluence. All pallids were measured and received PIT and spaghetti tags. None of the sturgeon sampled were considered hybrids based on the character index. Blood and tissue samples were collected from 11 pallid sturgeon for genetic analyses. Nine pallids were fitted with radio transmitters, four of which also had sonic transmitters. Considerable microhabitat data were collected at 31 pallid relocation sites. Depth occupied ranged from 2.5 to

3.1m. Point velocities were variable, averaging 0.7 m/s. Comparisons with shovelnose relocations indicated pallids utilized depths nearly twice as great as shovelnose, whereas velocities were similar.

A study investigating habitat and movements of pallid and shovelnose sturgeon was begun (Bramblett 1996). The study area also included the Yellowstone River because fish used both sections, which are contiguous. Internal and external radio and sonic transmitters were fitted to pallid sturgeon. One fish had both radio and sonic equipment. Fish were captured by trammel net, gill net and SCUBA. Pallids were observed traveling over 185 miles over a 27 d period. Although pallids displayed extensive movements, most had an affinity for the Yellowstone River regardless of where they were initially captured. One pallid sturgeon was documented moving upstream over the Intake diversion dam. Pallids utilized the Missouri River in fall and winter but most occupied the Yellowstone River in spring and summer months. Pallid sturgeon utilized fine substrate more than shovelnose which used gravel and cobble more. Depths at pallid and shovelnose relocation sites were similar, but pallids utilized greater depths more often. Pallid depths ranged 0.6 to 7 m in the Yellowstone river, 2 to 14.5 m in the upper Missouri above the confluence, and 0.8 to 8.2 m in the lower Missouri River below the confluence. Mean bottom velocity at pallid sites was 0.65 m/s ranging from 0 to 1.37 m/s. Habitat use characteristics of both species appeared to be different and comparison between the two is of limited use.

A standardized sampling protocol was established in **1993** and included sample location, equipment, duration of effort and habitat data collection (Tews 1994). A minnow seine was used in shallow water areas to sample for young pallid sturgeon but none were captured. By virtue of rare captures of small pallids, it appears as if successful reproduction has not occurred within in this population for quite some time. Evaluation of the four attachment methods for radio/sonic transmitters found, with the exception of external back transmitters, that all systems had some degree of benefit over others, but ultimately the completely internal system was rated best. Loading weight of all transmittered fish in the study ranged from 0.5 to 3.0% body weight. Copper crimps were used for attaching external dorsal transmitters because of loss due to steel crimps rusting through. Of the many tagging systems implemented, cinch tags had a longevity of at least 12 years on shovelnose sturgeon while properly installed PIT tags were found to be the most reliable means of providing unique identification for pallid sturgeon. One pallid captured in 1993 regurgitated 4 flathead chubs (*Platygobio gracilis*) while in captivity suggesting piscivory is one component of the diet. Habitat data suggested the species generally prefers sandy substrate.

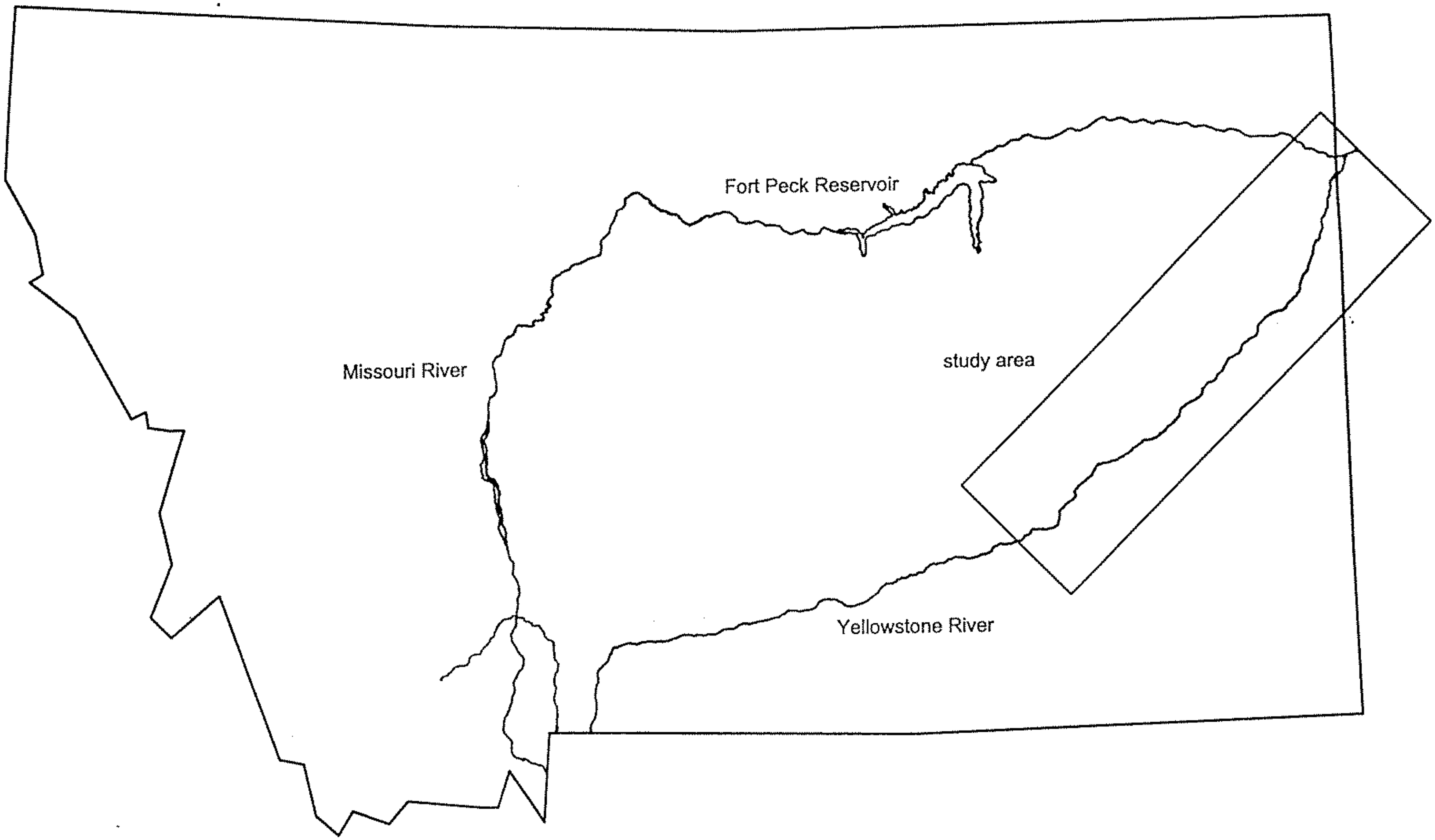
From **1994** to **1995** the equipment used to sample for pallid sturgeon included trammel nets, gill nets, trawling, larval fish nets and beach seining (Liebelt 1996). Extensive invertebrate sampling was conducted using a Ponar dredge and kick nets. Project focus for this period was on documenting reproduction and collecting young sturgeon. Six YOY shovelnose sturgeon were sampled with seine and trawl, indicating small pallids should be detectable, providing they exist. Twenty three adult pallids were sampled. The largest fish captured was 70.5 lbs and is the second largest to date observed by the recovery project. All specimens received two 125 kHz PIT tags in the dorsal fin base. Habitat measurements at pallid capture sites was continued. Minimum and maximum depths at capture sites in 1994 and 1995 were 1.7 and 4.1 m and 2.4-5.4 and ranged from 0.9 to 6.7 m and 1.5-6.7 m respectively. Average current velocities were 0.74 m/s (0.65-0.90) in 1994 and 0.66 m/s (0.59-0.94) in 1995. Substrate was exclusively sand at pallid sites. One recaptured fish illustrated a 28% weight increase over a 3 year period. Meristic measurements collected from pallid sturgeon were applied to the hybrid character index and results were negative.

Yellowstone River from Missouri Confluence to Miles City (Figure 3)

From 1973 to 1976 extensive efforts were made at surveying the fish community in the lower Yellowstone River. In **1975** one pallid sturgeon weighing 24 lbs was sampled by electrofishing near the Intake diversion dam (Haddix and Estes 1976).

In **1989** a study was initiated to evaluate the spawning success of paddlefish in the lower Yellowstone and Missouri rivers (Gardner 1990b, 1991b, 1992b, 1993b, 1994b). Conical and "D" shaped plankton nets were used to sample for larvae and eggs. "D" nets were more successful at collecting paddlefish eggs and larvae from the bottom than conical nets were at collecting from the water column. Numbers of paddlefish larvae collected per year, to date, ranged from 0 to 98. As paddlefish and sturgeon eggs and larvae are very similar, experts at the larval fish laboratory in Fort Collins, Colorado have been consulted for positive identification of suspect specimens.

In **1991** the Lower Yellowstone Pallid Sturgeon Study was initiated in the reach from Intake diversion dam to Cartersville diversion dam near Forsyth. Trammel nets measuring 150' by 6' with 2" inner and 12" outer mesh and both 50' and 100'-3" bar mesh gill nets 6' deep were drifted throughout the summer. One pallid sturgeon was captured and tagged on the dorsal fin with a cinch tag (Watson and Stewart 1991).



Firuge 3. Yellowstone River study area from Missouri River confluence to Miles City.

Due to the success the first year, effort was continued in **1992**, but no pallids were captured (Backes et al. 1992). One pallid sturgeon was snagged directly downstream of Intake diversion dam by a paddlefish angler. A fisheries technician at this site collected meristic data and the fish was tagged with an orange cinch tag and released.

Sampling continued through **1993** with no pallids being encountered. The rare observation of pallid sturgeon above Intake lead researchers to evaluate the diversion dam as a possible barrier to sturgeon passage.

In **1994** shovelnose sturgeon were captured and tagged below the dam. There were 4 pallid sturgeon captured directly below Intake diversion dam during these efforts; 3 by netting and one was snagged by a paddlefish angler (Backes et al. 1994). One pallid had been captured and tagged 2 years previous. All fish were tagged with a spaghetti and PIT tag. One was fitted with an external radio transmitter attached to it's dorsal fin base. One especially small pallid, weighing only 8.5 lbs was suspected of being a pallid x shovelnose hybrid. Application of physical measurements to the hybrid character index, however, confirmed it to be a pallid and is the smallest recorded in Montana. Again, no pallids were collected above the Intake diversion dam during 1994. Collections of pallids directly downstream of the

Intake structure suggests that the fish are concentrated there when upstream migration is blocked.

Gardner and Stewart (1995) reported the first confirmed *Scaphirhynchus* larvae collected in the lower Missouri River. This finding indicates wild reproduction of sturgeon, and sampling techniques are sufficient to monitor reproduction of both paddlefish and sturgeon.

Results from a study investigating identification techniques of pallid, shovelnose and hybrid sturgeon larvae were reported by the Larval Fish Laboratory in Fort Collins, Colorado (Snyder 1994).

Shovelnose Sturgeon

(*Scaphirhynchus platorynchus*)

A large amount of data have been collected on shovelnose sturgeon from the Missouri and Yellowstone rivers over the past 20 years. The species is one of the most ubiquitous in these systems and probably accounts for the most commonly encountered species due to the nature of studies conducted in the areas. From the outset of the pallid sturgeon recovery project in 1989, the shovelnose has been used as a surrogate for many testing programs ranging from radio transmitter design to synthetic LH/RH hormone development used in captive breeding programs. On the Yellowstone River, shovelnose have been used to assess sturgeon movements over Intake diversion dam and possible habitat characteristics of pallid sturgeon.

Missouri River above Fort Peck Reservoir (Figure 1)

From **1975** through **1980,** electrofishing, gill nets, baited hoop nets and seines were employed to survey the fish community in the Missouri River above Fort Peck Reservoir (Berg 1981). Although shovelnose were sampled by all methods, electrofishing was most effective and sturgeon were among the most abundant fish sampled. Fish were aged between 8 and 33 years by using cross-sections of pectoral fin rays. Missouri River specimens had a higher condition factor rating when compared with other populations. A great deal of effort was placed on identifying the contribution and importance of the Teton and Marias river tributaries as functional spawning sites. Sturgeon spawning sites were identified by observing concentrations of adults and subsequent collection of *Scaphyrhynchus* larvae. Fish were tagged in the lower reaches in an effort to monitor upstream spawning movements and to a lesser degree angler harvest.

In **1982**, shovelnose food habits were reported in a follow-up study investigating the instream flow requirements of selected fishes (Gardner and Berg 1982). Electrofishing was used to collect 68 sturgeon for stomach content analyses. Food items consisted of aquatic insects with trace evidence of fish eggs and fish tissue. Twenty-three subordinal taxa of aquatic insects were observed. Mayflies were the most abundant Order representing 44% of the average relative importance (RI) for all seasons sampled. Seasonal variation and relative importance of remaining taxa were reported in detail. These data suggest that shovelnose forage non-selectively on insects in swift current habitats within the study area. Recommended minimum instream flow ranged from 3,700 to 23,500 cfs and addressed 1) riffle maintenance for insect production, 2) side channel maintenance for rearing of young fish, 3) paddlefish migration flows and 4) overall main-channel morphology maintenance.

Shovelnose sturgeon have been sampled largely in conjunction with pallid sturgeon research efforts. In **1989**, when the pallid recovery project began, electrofishing and gill nets were used. Most of the 69 shovelnose were sampled by electrofishing. Setlines were ineffective for all sturgeon.

In **1990**, improvements in sampling gear and technique markedly increased catch rates. Trammel netting (described in pallid section) sampled 363 and setlines sampled 22 shovelnose sturgeon. All fish were weighed, measured and tagged with a plastic cinch tag. One hundred thirty shovelnose were measured and evaluated by the hybrid character index. No hybrids were identified

In **1991**, 624 shovelnose were sampled with trammel nets and 6 with setlines. Three shovelnose sturgeon were surgically implanted with radio transmitters. This test was to determine the expected effectiveness for use in pallid sturgeon. The specimens suffered no ill effects from the surgery and relocating the fish, by telemetry, from boat and aircraft was successful. All fish were weighed, measured and tagged with a plastic cinch tag. The hybrid character index continued to yield negative results.

In **1992**, catch rates of shovelnose sturgeon were not reported, probably due to being overshadowed by a high pallid sturgeon catch. One additional shovelnose was fitted with an external transmitter at the dorsal fin base and monitored in conjunction with the three previously fitted with internal tags.

Young sturgeon were transported to the Bozeman FTC in an effort to develop and maintain a captive brood stock (Erdahl 1995).

As of **1993**, 2,602 shovelnose sturgeon have been sampled during the pallid recovery project; 97% by trammel net (Gardner 1994). Setlines appear to be selecting for larger fish as weight averaged 2.7 lbs./fish greater than trammel net catches. Three sturgeon sampled in 1993 were suspected shovelnose x pallid hybrids based on the hybrid character index. Tissue and blood samples were collected from shovelnose for genetic analyses expected to differentiate between shovelnose and pallid.

A study investigating food habits of shovelnose sturgeon was begun (Megargle 1997). Trammel nets and gill nets were once again the preferred methods of sampling. One hundred forty two fish were collected for analyses. Specimens had blood and tissue removed for another study investigating blood calcium and vitellogenin protein levels as an indicator of spawning (Bob White, Unit leader, Montana Cooperative Fisheries Research Unit, personal communication, 1997). Furthermore, dorsal fin rays were removed to age fish in an effort to determine age structure of spawning adults.

The captive 1992 and 1993 year classes at the Bozeman FTC were lost due to a suspected systemic bacterial infection (Erdahl 1994). Adult sturgeon were collected from the Tongue and Yellowstone rivers and transported to the station. Water temperature and behavior were among the parameters monitored this season. Experimentation with preservation methods of sperm continued. Frozen sperm maintained mobility similar to unfrozen sperm, but with reduced fertilization capabilities.

Additional sturgeon were delivered to the Bozeman FTC for the ongoing development and maintenance of the domesticated strain (Erdahl 1995). The use of synthetic Leuteinizing Hormone-Releasing Hormone and carp pituitary was successful at inducing ovulation and spermiation. It is recognized that sperm preservation techniques will be instrumental in the culture and subsequent recovery of the pallid sturgeon. Two methods, both non-frozen and frozen, were tested for use and preservation of sperm. Non-frozen methods yielded best results when milt was stored in a thin layer at 4°C in an oxygen environment. Sperm viability was rated as good up to 20 days with maximum longevity of 29 days. Frozen storage techniques employed a number of additives as extender media. All but one compound was effective in preserving milt. Sperm viability was greatest in agents containing egg yolk additive, with 70-80% motility. Two thawing techniques were used on milt frozen to -196°C. Milt allowed to slow thaw at room temperature had greater sperm motility than sperm thawed in a 20°C water bath. Fertilization rates are still low with frozen sperm, but nonetheless maintain some level of fertility. Cesarean section was effective in maximizing egg take, but females experienced low survival following surgery. High levels of stress were reported from sturgeon held on station. The use of chemotherapeutants was considered in relieving stress and increasing survival of adults. Sturgeon diet experimentation was continued.

In addition to trammel nets and setlines, a seine, beam trawl and plankton nets were used to sample for young sturgeon in **1994** (Gardner 1995). Trawl design, experimentation and techniques were developed in conjunction with a study focusing on the sicklefin chub population. All sturgeon were measured and tagged with a spaghetti tag. One young-of-the year shovelnose sturgeon was sampled in the trawl in 1994. Conical and "D" shaped plankton nets were used and collected 8 *Scaphirhynchus* larvae. An additional 709 shovelnose were sampled in trammel nets comprising nearly 60% of the total catch this season. Efforts to identify sturgeon movement into

Fort Peck Reservoir suggest that, although present, sturgeon are rarely found there.

The Bozeman FTC participated in a study with the Montana Cooperative Fisheries Research Unit investigating the feasibility of using enzyme -linked immunosorbent assay (ELISA) to detect blood plasma vitellogenin as an indicator of reproductive readiness in wild pallid sturgeon (Dave Erdahl, USFWS Bozeman Fish Technology Center, personal communication, 1997). The potential exists to use blood calcium levels as a similar indicator. Efforts continued toward developing a photo-record of embryology and larval development.

In **1995** trawling continued as did larval fish sampling. Thirty additional young-of-the-year shovelnose ranging from 39-70 mm total length were sampled in the trawl (Grisak 1996a) (28 of which were reported in Gardner 1996). One additional sturgeon suspected of being a shovelnose x pallid hybrid was sampled. Three YOY sturgeon sampled in the trawl were transported to the Fish Technology Center in Bozeman for histological analyses and comparisons with artificially propagated sturgeon which have been difficult to rear beyond the juvenile stage.

There were 942 shovelnose sampled during a population estimate in 1995 (Gardner 1996). Densities were estimated to be 1,242 shovelnose per mile, and is considerably greater than reported for other populations. Once again, shovelnose were used as surrogates to test radio transmitter prototypes that are expected to be used in small pallids. Two shovelnose $\leq$ 1lbs were implanted with mini-transmitters programmed to operate for 6 hrs/day on 20 day cycles. Recipients responded well to the implants both physically and behaviorally. Continued use of conical and "D" plankton nets sampled 21 *Scaphyrhynchus* larvae which were subsequently confirmed by the Larval Fish Lab in Fort Collins, Colorado.

Wild shovelnose sturgeon captured from the Tongue and Yellowstone rivers were spawned using techniques developed in previous years (Erdahl 1995). Techniques to increase fertilization and egg survival yielded excellent results (90% survival). Of the five fish held at the Miles City State Fish Hatchery, two survived the C-section procedures whereas all fish held at the Bozeman Fish Technology Center perished. This points out the need to examine the function of water chemistry in captive spawning programs. Efforts continued toward perfecting C-section, egg incubation and sperm preservation techniques.

Three male and two female pallids, were captured from the lower Yellowstone River and transported the Miles City hatchery in an effort to spawn them (Erdahl 1995, Krentz 1995). Eggs from neither female were viable. Milt extracted from male pallids was used to fertilize shovelnose sturgeon eggs to produce pallid x shovelnose hybrids. Some progeny were used for the development of larval fish keys. Milt samples were also cryopreserved for future use in culture and studies. Pure shovelnose sturgeon were also produced for the State of Wyoming for future reintroduction into the upper Big Horn River.

The results of a study investigating genetic differences in pallid and shovelnose sturgeon were reported (Campton et al. 1995). A 435 base pair sequence of mitochondrial DNA was analyzed from 20 shovelnose and 18 pallid sturgeon. Thirteen of the 20 shovelnose expressed two haplotypes that were absent among the 18 pallid sturgeon. These findings indicate the two species are reproductively distinct despite their sympatry.

In **1996** one component of a study investigating the benthic fish community of the Missouri River basin was initiated in this section. Sampling methods included trammel nets, electrofishing, gill nets, seine and benthic trawl.

In **1997** (Megargle) results of a comprehensive study of food habits of shovelnose sturgeon were reported. Sturgeon diet was predominantly insects belonging to 12 aquatic and 6 terrestrial orders. There was trace evidence of fish larvae. Extensive data and findings were reported on subordinal taxa in sturgeon diet. Some level of food item selectivity was present based on electivity values of food items and abundance compared to presence in stomachs. A significant relationship was found in changes with discharge and temperature and invertebrates observed in sturgeon diet. Sturgeon growth rates were four times greater than observed in South Dakota.

Missouri River from Fort Peck Dam to Lake Sakakawea headwaters (Figure 2)

Data from **1979** through **1984** were compiled in an effort to assess fish populations in this section (Gardner and Stewart 1987). A total of 950 shovelnose were sampled, 358 by electrofishing and 592 by gill net. Shovelnose were distributed throughout the study area. Stomach samples from 26 specimens contained aquatic insects, primarily *chironomids*. Aging of pectoral rays from 77 specimens indicated an age structure from 7 to 33 years.

In **1989** (Clancey), two shovelnose sturgeon were fitted with internal transmitters to assess tag design and effectiveness. There were no subsequent relocations of these fish. Signal strength was believed to be hindered due to the internal antenna design. Head and body measurements were collected from nearly 180 shovelnose in an effort to build a database of meristics for a character index to assess hybridization with pallid sturgeon.

In **1990** (Clancey), shovelnose in the Tongue River were collected by electrofishing and gill net to be used as surrogates to develop culture techniques for pallid sturgeon. Specimens were transported to the MDFWP Miles City fish hatchery where synthetic hormone and cesarean techniques were used to facilitate spawning. Fertilized eggs were transported to Gavins Point National Fish Hatchery in S.D. Despite overcoming initial problems with diet and disease (Dave Erdahl, USFWS Bozeman Fish Technology Center, personal communication, 1997), unusual deformities were noticed on nearly all survivors of the 1990 year class. The embryos were suspected of being shocked at some point during transit.

In **1991**, shovelnose were used as surrogates to test new radio and sonic transmitter design for pallid sturgeon tracking (Clancey). The results were encouraging. Extensive movements of shovelnose were documented. Nearly 130 fish were measured and added to the data base for the hybrid character index. Nearly 4,000 shovelnose were encountered incidental to the paddlefish snagging below Intake diversion dam.

An additional 402 shovelnose were sampled in **1992** (Tews and Clancey 1993). One specimen was surgically implanted with an internal transmitter. Eleven shovelnose having sonic and/or radio transmitters were monitored this season. Two shovelnose having radio transmitters were documented moving over the Intake Diversion Dam. Habitat data were collected at 34 relocations sites. There were small differences in velocity measurements between shovelnose and pallid sturgeon locations. Shovelnose were found over gravel substrate more often. Transmittered fish illustrated movements up to 70 miles during this season. Three hundred twenty shovelnose were added to the hybrid character index and provided no evidence of hybridization. One fish recaptured near the Yellowstone confluence was tagged in 1980 near the Tongue River confluence.

From **1994** to **1995** (Liebelt), 894 shovelnose sturgeon were sampled with gill nets and trammel nets. Shovelnose sturgeon were the most abundant species sampled by these methods. Eleven small shovelnose were sampled with a seine including one measuring only 35 mm total length. This was the first documented YOY sturgeon collected from the study area. Trawling sampled 5 YOY shovelnose from the Missouri and Yellowstone rivers. Recaptures of tagged shovelnose indicated movements of up to 252 miles and significant interchange between the Missouri and Yellowstone rivers.

In **1996**, Bramblett reported no observable differences in seasonal habitat use by shovelnose sturgeon. Shovelnose were found over gravel and cobble 69% of the time. Depths utilized by shovelnose ranged from 0.9-8.8 m in the Yellowstone River, 4.3-10.1 m in the Missouri River above the confluence and 1.2-5.8 in the Missouri River below the confluence. Bottom velocities ranged 0.03-1.51 m/sin the Yellowstone, 0.02-0.20 m/s in the Missouri above the confluence and 0.40-0.82 in the Missouri below the confluence. Velocity at shovelnose and pallid sturgeon locations overlapped, but marked differences were observed in substrate and depths which indicates that inferences of pallid habitat use based on shovelnose habitat use are not reliable.

Yellowstone River from Missouri Confluence to Miles City (Figure 3)

From **1973** to **1976** AC and DC electrofishing, gill nets, seines, hoop nets, set lines and angling were employed to survey the fish community in this study area (Haddix and Estes 1976). Movements, spawning and length-weight relationships were among the data reported. DC electrofishing was most effective in collecting sturgeon. Significant numbers of sturgeon were sampled from the mouths of the Tongue and Powder rivers. In general, sturgeon from this study area have higher condition rating than reported for other populations. Various tagging systems were employed to monitor movements. Shovelnose sturgeon were not found in the Yellowstone above Cartersville diversion dam. This suggests the dam may be a barrier to passage. Heavy metals analyses were conducted on shovelnose sturgeon in an effort to provide comparative data for future monitoring of metal loading in fish species.

From **1974** through **1976**, a study was conducted to assess the effects of water withdrawals on fish in the Yellowstone and Tongue rivers (Elser et al. 1977). Shovelnose sturgeon were sampled with gill nets and electrofishing. Stomach analyses revealed that insects comprised 95% of sturgeon diet. Hydropsychid caddisflies were present in 90% of the stomachs. Sturgeon selected for *Baetis* and Chironomidae which suggests they feed in riffle habitats. Tagging for movement, spawning and harvest of shovelnose sturgeon was conducted. Sampling for larvae and eggs failed to produce any specimens. Three estimators of population density indicated there to be roughly 400 shovelnose per Km in the Tongue River. It is apparent that the Tongue River is a fundamental component of sturgeon habitat in the Yellowstone system. Reduction of flows in the Yellowstone system would ultimately affect sturgeon by: 1) reducing aquatic insect density and assemblage, 2) reduce discharge which stimulates movement and spawning, and 3) degrade spawning and rearing areas for young sturgeon.

From **1975** through **1978**, electrofishing, gill nets, hoop nets and seines were used to sample the fish community of the Powder River during a study investigating the ecology of the system (Rehwinkel 1978). Drifting gill nets were very effective in collecting adult shovelnose sturgeon. A total of 543 sturgeon were sampled. Shovelnose were using the Powder River as a spawning tributary based on high concentrations of fish observed in the spring of the year. One sturgeon tagged in the Powder River was harvested by an angler 21 days later in the Yellowstone River, 131 miles downstream of where it was tagged. Other sturgeon tagged in the Tongue River were recaptured in the Powder River. It is evident that shovelnose sturgeon are quite mobile throughout the Yellowstone River and utilize large tributaries frequently. Sturgeon were sampled in the Powder River as far upstream as 55 miles from it's mouth.

Again, the majority of shovelnose sturgeon work in this section was conducted in conjunction with the Lower Yellowstone River Pallid Sturgeon Study that was started in **1991**.

In **1992**, 1,082 shovelnose were sampled with trammel and gill nets and comprised 51% of the total catch (Backes et al. 1992). Fork length and weight data were recorded. Sturgeon were systematically fin clipped to denote the particular year of capture. Only 31 specimens had tags from previous years, some as early as 1974.

In **1993**, 663 shovelnose were sampled in trammel nets incidental to pallid sturgeon efforts (Backes and Gardner 1994). The virtual absence of pallid sturgeon above Intake diversion dam prompted researchers to evaluate sturgeon passage over the structure.

In **1994**, trammel nets and gill nets were used in tagging 1,373 shovelnose sturgeon below the Intake diversion dam (Backes et al. 1994). Subsequent netting upstream of the structure captured only 36 tagged sturgeon indicated some sturgeon passage occurs. Comparisons with previous data indicate shovelnose sturgeon captured above the structure are generally larger than those captured below and leads to speculation that the dam may be limiting upstream passage for smaller shovelnose. As collections of the larger pallid sturgeon are rare above intake, the dam may be limiting passage for this size class as well. Also, fish passage is of special concern in years of particularly low discharge.

Results from a study investigating identification techniques of pallid, shovelnose and hybrid sturgeon larvae were reported (Snyder 1994).

In **1995**, 16 shovelnose sturgeon were sampled by DC electrofishing while conducting the annual fish population survey on the Yellowstone River (Stewart 1996).

Blue Sucker

(*Cycleptus elongatus*)

Little is known about the life history of the blue sucker. As it is not considered a game fish, much of the available information is general. The fish has been sampled incidental to other research efforts on endangered, threatened or game species.

<u>Missouri River above Fort Peck Reservoir</u> (Figure 1)

During Berg' s (1981) **1975** through **1980** study, in this section, blue suckers were sampled frequently. Electrofishing was especially effective in sampling, and a few were sampled by gill nets. Blue suckers were common and distributed throughout the study area. Age of sampled fish ranged from 9 to 14 years. Tags were placed on 423 fish. Recapture of tagged fish indicated seasonal upstream movements as great as 196 km. Significant numbers of blue suckers were observed staging in the lower Marias River for spawning. The spawning period, based on observations of ripe adults, is somewhere near the 13^{th} of May. Many *Catostomidae* larvae were sampled from the mainstem Missouri, but lack of good larval fish keys at the time precluded positive identification. Of the 6,100 larvae collected, it is likely that some blue sucker larvae were present.

During the period of **1989** to **1995** many blue suckers were sampled by trammel net in conjunction with the pallid sturgeon recovery project (Bill Gardner, personal communication, 1997).

A statewide status report on the blue sucker was prepared in **1995** (Gardner 1995b). Comparisons with past years data indicate at least stable population, and in some areas, improvement of population structure is suggested by better length distribution in recent years. Due to the documentation of large adults, reproductive success and improving length distribution, the status of the population is good. Future management recommendations include routine monitoring of all populations.

In **1996**, 86 blue suckers were sampled from the Missouri and Marias rivers. Size ranged from 3 to 12 lbs. One notably small fish measuring 13 inches and weighing 0.6 lbs. was sampled. Five fish sampled near the Marias confluence were surgically implanted with mini transmitters to monitor their movements. Radioed fish moved downstream nearly 70 miles in the fall. Blue suckers were reportedly observed spawning in the Teton River near it's mouth (Randy Rodencal, MDFWP, personal communication, 1997). Electrofishing was conducted directly below Tiber Dam on the Marias River to investigate angler reports of large numbers of fish staging in the tailrace. Unusually high densities of blue suckers were sampled from this pool, apparently involved in some sort of spawning activity. During paddlefish tagging, large adult blue suckers were collected with 5 inch bar mesh floating gill nets (Kent Gilge, MDFWP, fisheries biologist, personal communication, 1997). One blue sucker measuring 10 inches total length was sampled from a pool 39 feet deep by drifting gill nets (Grant Grisak, Montana Cooperative Fisheries Research Unit, Bozeman, personal observation, 1996). This is only the second observation of juvenile blue suckers in the study area.

Missouri River from Fort Peck Dam to Lake Sakakawea headwaters (Figure 2)

Blue suckers appear to have a secure foundation in this section of river by virtue of good density and distribution throughout the study area. During **1979** through **1981** (Stewart and Gilge 1982) adults were sampled regularly (1981 n=68) with electrofishing and a few with gill nets. Blue sucker larvae were sampled at the mouths of the Milk and Poplar rivers.

In **1979**, a large concentration of juvenile blue suckers was sampled in larval fish nets in Big Muddy Creek near its mouth (Kent Gilge, personal communication, 1997). Numbers were not reported. This indicates Big Muddy Creek is used for both spawning and rearing of blue suckers.

In **1982**, Gilge and Needham first documented blue sucker reproduction in the Milk River by collecting larvae near it's mouth.

Data from **1979** through **1984** were compiled to assess fish populations in this section (Gardner and Stewart 1987). Gill nets and electrofishing sampled 74 adult blue suckers in the study area. Several individuals were sampled from the mouth of the Milk River with gill nets. Electrofishing sampled 59 in the Nichols Ferry section. Sampled fish were 6 to 12 years old. Length-weight comparisons were reported.

Annual gill net sampling of the Fort Peck dredge cuts between **1979** and **1991** occasionally yielded blue sucker adults (Gilge and Needham 1982). Although fish were present and reproduction was evidently taking place, little else is known of this population.

Tews (1993) reported that adult blue suckers were the fifth most abundant species sampled during the Fort Peck Pallid Sturgeon Study spanning from **1989** to **1993**. Gill nets and trammel nets were the primary sampling methods.

During **1994** and **1995**, 60 adult blue suckers were sampled in trammel nets from the Missouri River, mostly near the confluence of the Yellowstone River. In 1994, one young-of-the-year blue sucker, measuring 64 mm was seined downstream of the Milk River confluence (Liebelt 1996).

Yellowstone River from Missouri Confluence to Miles City (Figure 3)

Haddix and Estes (1976) reported that AC electrofishing was especially effective in sampling blue suckers in shallow water during surveys from **1973** to **1976**. Numbers were not reported.

From **1974** through **1976**, a study was conducted to evaluate the effects of altered stream flows on fish of the Yellowstone and Tongue rivers (Elser et al. 1977). Blue suckers were collected every spring in the Tongue River near it's mouth by electrofishing and gill nets. Numbers were not reported.

From **1979** to **1980**, a study was conducted to sample the aquatic organisms in tributary streams of the lower Yellowstone River basin (Morris et al. 1981). Electrofishing produced 2 blue suckers in the lower reaches of O'Fallon Creek.

In **1991**, 28 blue sucker adults were captured with trammel nets during pallid sturgeon sampling efforts in the Yellowstone River (Watson and Stewart). They were distributed throughout the study area.

Seventy five blue suckers were captured throughout the entire study area during **1992** using trammel and gill nets (Backes et al. 1992). One specimen was sampled in the Tongue River near it's mouth. The Intake diversion canal is sampled annually following the shutdown of the irrigation system. Seining and electrofishing were used to collect one blue sucker from the diversion canal.

Stewart reported catches of blue suckers in the study area using electrofishing, but with less frequency than previous years (n=12) (Stewart 1993). Size was also of concern as most specimens are very large, weighing no less than 2,000 g. To date, small blue suckers have never been observed in the Yellowstone River. Incidental catches during trammel netting for sturgeon produced 26 adults. Distribution continued to be throughout the entire study area (Backes and Gardner 1994).

Electrofishing results for **1993** were similar to the previous year. Twenty one large blue suckers were collected (Stewart 1994). Netting was markedly more successful than any previous year. Three hundred nine large blue suckers were sampled, making up 45% of the total catch (Backes et al. 1994). Stress was noticeable on blue suckers captured in nets drifted longer than 15 minutes.

In **1994** an additional 11 adult blue suckers were sampled by electrofishing during the annual Yellowstone River population survey (Stewart 1995).

In **1995**, 33 large blue suckers were sampled by electrofishing during annual fish population surveys on the Yellowstone (Stewart 1996). Blue suckers were considered common during this survey. Small blue suckers still appear to be a mystery in this area.

Sicklefin Chub

(*Macrhybopsis meeki*)

This species is also a little known member of the large-river fish community. It has received increased recognition since the mid 1990's when it was petitioned for listing as endangered species.

<u>Missouri River above Fort Peck Reservoir</u> (Figure 1)

Sicklefin chub were first reported in Montana in **1981** (Berg) in this study area and were collected by minnow seine. Prior to this the farthest known upstream distribution was the confluence with the Little Missouri River in North Dakota. Following the proposal for endangered listing, a status report (Werdon 1993a) recommended that sampling be conducted in the Wild and Scenic section of the Missouri River to update previous fish collections.

It wasn't until **1994** that sicklefin chub were specifically targeted for research in this section (Grisak 1996a). Sampling began by using a minnow seine in shallow water zones, but was largely ineffective as only 4 specimens were collected. A beam trawl was modified and techniques were developed to sample deep water zones which greatly improved catch rates. In total, 302 sicklefin chub were sampled by trawl and were the second most abundant species collected. Sicklefin catches were associated with sand substrate 81% of the time. Mean bottom velocity measured at catch sites was 0.58 m/s and was similar to velocity measured at all trawl sites. Mean depth at catch sites was 3.41m compared to 2.94m at all trawl sites. Fish exhibiting signs of reproductive readiness were observed between July 18 - August 16 when temperature was 21-22°C, suggesting a summer spawning period. Concentrations of fish exhibiting signs of reproductive readiness were observed in an area with substrate 2.5-5.0 cm diameter, mean bottom velocity of 0.58 m/s and mean depth 1.98 m. Sicklefin were aged to 4 years by reading scales.

In **1996** sicklefin chub were evaluated for electrofishing caused injury to the spine and tissue by subjecting specimens to a treatment of pulsed DC electricity (Grisak 1996b). X-ray and necropsy revealed no injury.

<u>Missouri River from Fort Peck Dam to Lake Sakakawea headwaters</u> (Figure 2)

Stewart (1982) first reported finding sicklefin chub in this section of river in **1981**. Three specimens were seined near the Nohley bridge. Collection of an additional 8 specimens in 1980-81 was reported by Gardner and Berg (1987), but it is likely that these were the same fish reported by Stewart 1982.

In **1993**, Tews reported additional collections during seining but numbers were not included.

Liebelt (1996) reported seining 31 specimens below the confluence of the Yellowstone during **1994** and **1995**. Fifty five additional sicklefin were sampled in the trawl, many of which were collected from the Yellowstone River. Albeit close to the Missouri River, this is the first documentation of the species in the Yellowstone drainage. Habitat measurements including depth, substrate and velocity were collected at trawl sites.

<u>Yellowstone River from Missouri Confluence to Miles City</u> (Figure 3)

While conducting a fish community study in this section from **1973** through **1976**, Haddix and Estes (1976) reported no collections of sicklefin chub during seining, electrofishing and trapping.

A Study investigating the aquatic organisms in select tributary streams of the lower Yellowstone River basin was conducted during **1979** and **1980** (Morris et al. 1981). Seining and electrofishing failed to sample sicklefin chub.

In **1995**, a number of sicklefin chub were sampled from the Yellowstone River as far up as Intake diversion dam (Mike Ruggles, MDFWP, personal communication, 1997), which is the farthest upstream distribution documented in the drainage.

Sturgeon Chub

(*Macrhybopsis gelida*)

The sturgeon chub is like the sicklefin chub in many regards. It too has received greater recognition since the mid 1990's when it was petitioned for listing as an endangered species. There is, however some historical data available from the Yellowstone River area and it's tributaries.

Missouri River above Fort Peck Reservoir (Figure 1)

In **1979** sturgeon chub were collected by seining in the mainstem Missouri between the Marias River confluence and the Robinson Bridge. Seining was also conducted in the Teton River and produced a few specimens (Gardner and Berg 1982). Despite not sampling in this area, Werdon (**1992**b) reported reduced distribution.

Sturgeon chub were sampled with a seine once again in **1994**, but in low abundance (n=8). A beam trawl was modified and techniques were developed to sample deepwater zones. Trawling produced 260 sturgeon chub and they were the third most abundant species sampled in the trawl (Grisak 1996a). Habitat data measured at collection sites indicated 53% association with rocky substrate, 43% sand and 4% silt. Mean depth at collection sites was 3.18 m compared to 2.94 overall. Mean bottom velocity was 0.67 m/s compared to 0.58 overall. Sturgeon chub were sampled with sicklefin chub only 32% of the time suggesting different habitat requirements. Fish exhibiting signs of reproductive readiness were observed from September 1-16 suggesting a late summer spawning period. Upstream distribution was reduced compared to past studies (Gardner and Berg 1982), but sturgeon chub were found to be more widely distributed than previously reported. These data were compiled (Gould 1994) in an effort to accurately report the distribution of sturgeon chub throughout the state of Montana.

In **1996** sturgeon chub were evaluated for injury caused by pulsed DC electrofishing (Grisak 1996b). Examination of spine and tissue by x-ray and necropsy revealed no sign of injury.

Missouri River from Fort Peck Dam to Lake Sakakawea headwaters (Figure 2)

In **1993** Tews reported sampling 47 sturgeon chub during seining and they were the second most abundant species sampled.

From **1994** to **1995**, Liebelt (1996) sampled 117 sturgeon chub with a seine. He reported wide distribution throughout the study area with greatest concentrations below the confluence of the Yellowstone River. Sturgeon chub were the second most abundant species sampled in the trawl (n=48) during

1994 and 1995. Higher densities of sturgeon chub were reported from the lower section in the Yellowstone River. Habitat measurements including depth, substrate and current velocity were collected at trawl sites.

Yellowstone River from Missouri Confluence to Miles City (Figure 3)

From **1973** to **1976**, electrofishing, trapping and seining were employed to sample the Yellowstone River fish community (Haddix and Estes 1976). Although numbers were not reported, sturgeon chub were frequently sampled by seining. Distribution was from the mouth of Sunday Creek to the town of Sidney.

From **1974** through **1976**, a study was conducted to investigate the effects of altered stream flow on the organisms of the Tongue and Yellowstone rivers (Elser et al. 1977). Fish populations were surveyed using electrofishing, gill nets, hoop nets and seines. Sturgeon chub were encountered by seining and found from the mouth of Sunday Creek to near the town of Sidney. These distribution data appear to be the same reported in Haddix and Estes (1976). Two additional specimens were sampled by electrofishing in the Tongue River near it's mouth. Analyses of stomach samples from sauger and burbot indicated sturgeon chub comprised a measurable percentage of the diet of these two species.

During **1975** through **1978**, a study investigating the ecology of the Powder River employed electrofishing, seines, hoop nets and gill nets to sample fish populations (Rehwinkel 1978). At least 106 sturgeon chub were sampled by seining the Powder, including near it's mouth.

During **1979** and **1980**, electrofishing and seining were used to inventory the aquatic organisms in select tributary streams in the lower Yellowstone basin (Morris et al. 1981). One sturgeon chub was sampled by seining near the mouth of Sears Creek.

In **1992**, one sturgeon chub was seined from the Yellowstone River, and several from the Powder River (Werdon 1992). Meristics, habitat data and sexual maturity were reported.

Stewart (1994) reported collecting 7 sturgeon chub from the Yellowstone River, between Forsyth and Intake, using boat mounted electrofishing in **1993**.

In **1994**, only 1 sturgeon chub was sampled during electrofishing efforts on the Yellowstone (Stewart 1995). Gould (1994) collected specimens from the Yellowstone and Powder rivers using seining to update statewide distribution records. Mean depth at collection sites in the Powder River ranged from 0.15 to 0.37m. Mean bottom velocity ranged from 0.27 to 0.34 m/s.

Substrate was exclusively rock and ranged from <5 to 23 cm diameter. Water temp ranged from 20-25 °C.

Despite previous collections using boat mounted electrofishing equipment, there were no sturgeon chub sampled during electrofishing efforts in **1995** (Stewart 1996).

NORTH DAKOTA

Research on the Missouri and Yellowstone rivers in North Dakota is conducted by the North Dakota Game and Fish Department and the United States Fish and Wildlife Service's Missouri River Fish and Wildlife Management Assistance Office in Bismarck. Frequently, the Montana Department of Fish Wildlife and Parks will conduct work beyond the Montana-North Dakota border. Some of the information reported in this section comes from lakes Sakakawea and Oahe population surveys.

Pallid Sturgeon

(*Scaphirhynchus albus*)

Missouri and Yellowstone Rivers above Lake Sakakawea (Figure 4)

Increased concerns of the current status and future of the pallid sturgeon in North Dakota prompted the North Dakota Game and Fish Department to impose harvest restrictions on sturgeon angling in **1985**, by prohibiting the harvest of any sturgeon greater than 36 inches total length (Rykman 1995). Following the listing of the species as Endangered, North Dakota imposed a total ban on the harvest of sturgeon (Rykman 1995).

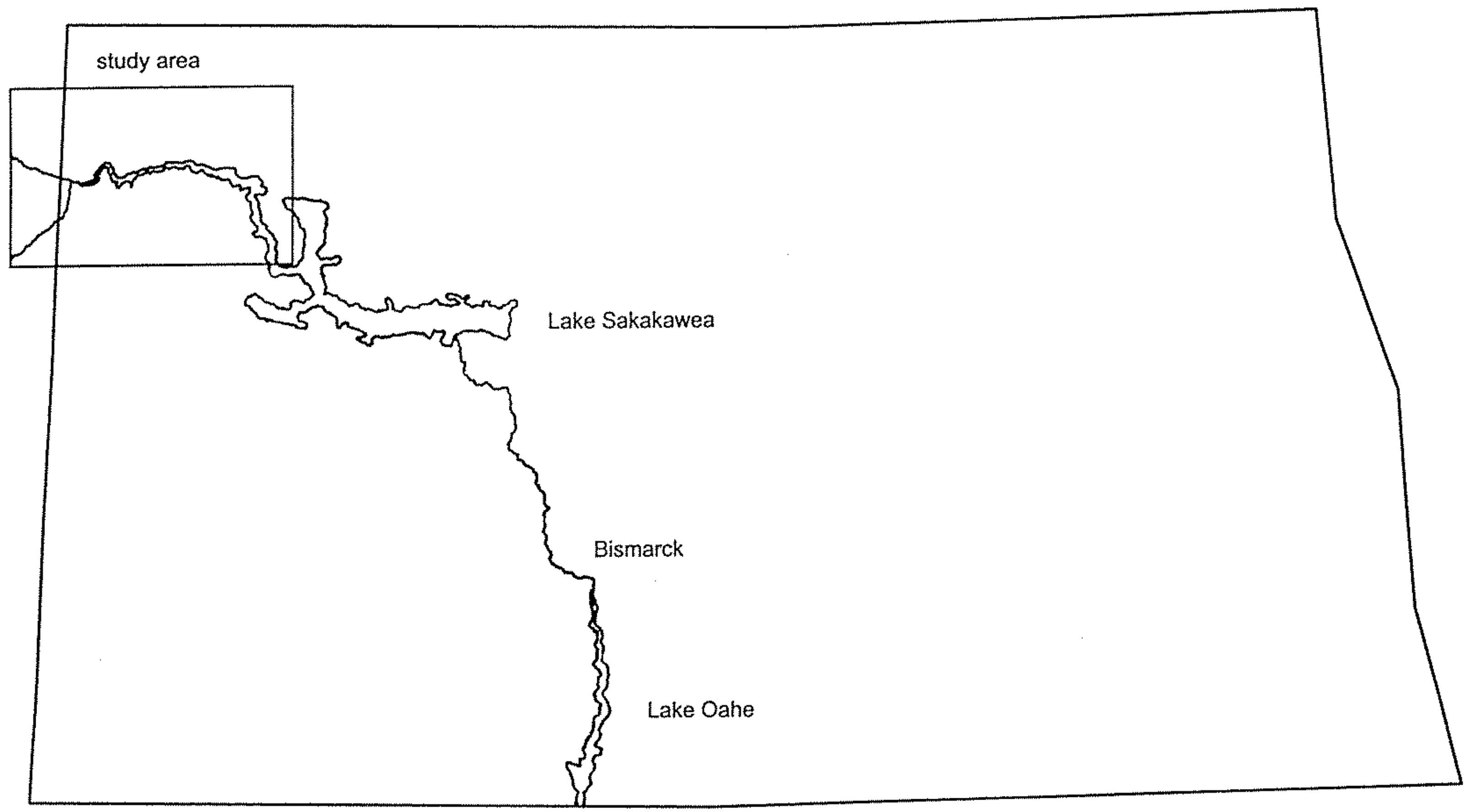


Figure 4. Missouri and Yellowstone rivers above Lake Sakakawea to Montana Border.

In **1988**, the U.S. Fish and Wildlife Service began field efforts in the Missouri River above Lake Sakakawea primarily to sample paddlefish for propagation with some incidental sampling of pallid sturgeon (Krentz 1994).

In **1991** efforts were intensified toward pallid sturgeon research in response of the endangered listing of the species in 1990.

In **1992** (Elstad et al.) field work was begun on the sturgeon abundance and habitat needs. Fish were sampled by drifting gill nets. Habitat data were collected at all sampling sites. Project objectives included collecting biological data on pallids and transporting adult fish to the Gavins Point National Fish Hatchery for artificial propagation. No pallid sturgeon were sampled during 1992.

In **1993** (Sapa) the results of a study investigating fisheries impacts to the proposed reconstruction of Highway 200 bridge over the Yellowstone River were reported. Two pallid sturgeon were sampled within a 3 km reach of the bridge by drifting gill nets. Habitat measurements at both collection sites included depths of 0.9 and 2.4 m. Velocity was 0.7 and 0.8 m/sec and water temperature was 14° C. Substrate was exclusively sand. At least 11 additional pallids were reportedly snagged by paddlefish anglers in May 1993. Two of these fish exhibited signs of reproductive readiness. High densities of pallids at this site suggests the area may be of significance for pallid spawning.

One pallid sturgeon was sampled during paddlefish tagging in this study area using 180' x 6' x 5" surface gill nets (Hendrickson et al. 1994).

Seventy three pallids have been encountered by the USFWS in the study area, 43 of which were sampled in **1994** (Krentz). Efforts were made toward documenting reproduction of pallid sturgeon by using egg mats, larval light traps and larval drift sampling. Drifting gill and trammel nets has been the most effective means of sampling adults. Captured specimens received a PIT tag and were measured for application to the hybrid character index. Gravid adults were sought for artificial reproduction. The large data base on pallid sturgeon captures has afforded the opportunity to estimate this population. The Schnabel and modified Peterson indices of population abundance provided an estimate of roughly 230 and 150 pallid sturgeon in the study area, respectively. Movement of pallids from initial capture sites showed distances from 0 to 220 miles. One individual sampled weighed 76 lbs. and is the largest fish recorded by the recovery project.

Six pallid sturgeon were encountered in **1994** during annual population surveys using 180' x 6' x 5", 180' x 6' x 3.5-5" and 125' x 6' x 0.75-2" gill nets (Hendrickson et al. 1995). A limited amount of meristic data were collected from some specimens.

Past reports of incidental snagging of pallid sturgeon during the paddlefish season prompted the implementation of a pallid sturgeon creel survey to be run concurrently with the paddlefish creel survey at Sundheim Park during the paddlefish angling season (Rykman 1995). In 1994 a questionnaire was provided to paddlefish anglers regarding the endangered species status of the pallid sturgeon. Two pallid sturgeon were incidentally snagged during the 1994 paddlefish season. One of these specimens was examined by a fisheries worker to obtain meristic data. Angler reports suggested that three additional pallids were snagged during the 1994 season.

In **1995**, an additional 9 pallids were sampled by USFWS (Krentz 1995). Four of these fish were transported to the Miles City State Fish Hatchery as brood stock. Before transfer, each specimen received an antibiotic to combat bacterial infection. This effort resulted in no pure pallid sturgeon being produced, but male pallids were spawned with female shovelnose to develop hybrids and study their characteristics in captivity (Erdahl 1995). The apparent reproductive readiness of wild pallid sturgeon suggests that spawning is physiologically possible. Furthermore, the common use of the lower Yellowstone system suggests that it may be the most suitable area for natural reproduction of wild pallid sturgeon. Two hundred eighty one different pallid sturgeon have been confirmed since 1985 in Montana and North Dakota.

One pallid sturgeon was encountered during paddlefish tagging in this study area by using 180' x 6' x 3.5-5" surface gill nets (North Dakota Game and Fish Department 1995). Some meristic data were collected from this specimen.

In **1996**, efforts were continued toward the capture of wild pallid sturgeon and development of a broodstock for propagation at the Garrison Dam National Fish Hatchery (Dryer et al. 1996). Russian scientists were consulted for information regarding sturgeon culture. Special attention was given to reduce fungal infection of specimens by using salt treatments and antibiotics. Fourteen pallids were captured and examined in the field for signs of gender and reproductive readiness. Four pallids were successfully transferred to the hatchery. One of the suspected females was misidentified, and the other did not have suitable eggs for this season. Following the unsuccessful attempt to spawn pallids, all specimens were returned to their natural environment. An additional 3 pallids were captured in the fall from the Yellowstone River and transported to the Garrison hatchery to be held over winter. The fish were to be transported to Gavins Point NFH to be spawned the next spring. Egg coloration of one female was consistent with mature ova.

Another female contracted a fungal infection, but cleared up shortly afterwards.

There were 2 pallid sturgeon sampled during the annual population survey by State personnel using 180' x 6' x 4" and 180' x 6' x 3.5-5" gill nets (North Dakota Game and Fish Department 1996). An additional pallid was reportedly caught by an angler this year.

<u>Missouri River from Garrison Dam to Bismarck</u> (Figure 5)

Despite annual population sampling by State personnel and periodic research projects, no pallid sturgeon have been reported from this section in recent years.

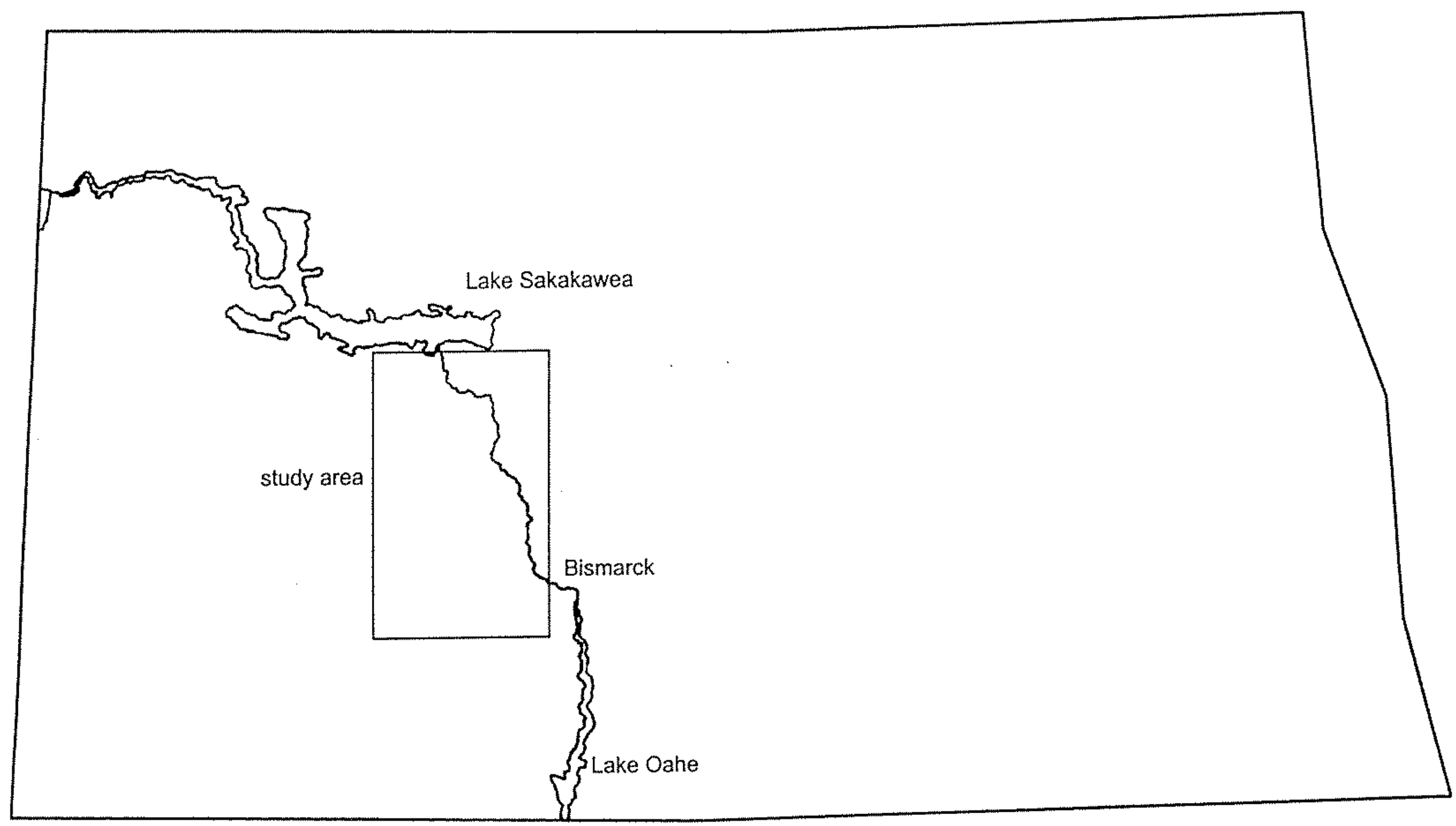


Figure 5. Missouri River from Garrison Dam to Bismarck.

Shovelnose Sturgeon

(*Scaphirhynchus platorynchus*)

<u>Missouri and Yellowstone Rivers above Lake Sakakawea</u> (Figure 4)

In **1992**, 168 shovelnose sturgeon were sampled by drifting gill nets during a sturgeon population and habitat study (Elstad et al. 1992). Habitat data included depth, substrate, water velocity, temperature and turbidity, among others. In addition to meristics, stomach contents were removed for analyses. Shovelnose diet was predominantly aquatic insects. Fish from this section are larger than those sampled in downstream sections. Higher sturgeon abundance in this section, compared to the Garrison section, is associated with increased turbidity and greater presence of sand substrate.

One shovelnose sturgeon was sampled by stationary gill nets in Lake Sakakawea (Hendrickson et al. 1993).

In **1993**, two shovelnose sturgeon were sampled with 180' x 6' x 3.5-5" gill nets during paddlefish tagging (Hendrickson et al. 1994). One additional specimen was sampled in a stationary gill net in Lake Sakakawea.

In **1995**, trawling and seining were conducted in a effort to sample for sicklefin and sturgeon chub (Everett and Scarnecchia 1996). Although numbers were not reported, shovelnose sturgeon larvae were noted as being the most abundant species sampled with the trawl in the Yellowstone River and second most abundant species sampled in the Missouri River.

One shovelnose sturgeon was sampled in stationary gill nets in Lake Sakakawea (North Dakota Game and Fish Department 1995).

One shovelnose sturgeon was sampled during the annual population survey in this section (North Dakota Game and Fish Department 1995).

In **1996**, 32 shovelnose sturgeon were transported to Garrison Dam National Fish Hatchery to continue the development of a domesticated strain of shovelnose sturgeon and perfect techniques for pallid sturgeon propagation (Dryer et al. 1996). Cooperators from many facilities and agencies participated in the project. Ovulation and spermiation were induced by injecting specimens with LH/RHa. Although not all fish responded to the treatment, the majority did. Cesarean section was used to extract ripe eggs from females which were subsequently fertilized with sperm extracted from males. Further experimentation with diet and temperature had marked effects on survival of sturgeon past the larval stage (Erdahl 1996). Two commercial diets, Biodiet and Silvercup, and one production diet from the Bozeman FTC were tested. The Bozeman diet was most effective with 70-80% of larvae surviving. Beyond the larval stage, differences in diet and temperature were not as critical in influencing survival. Overall production at this facility was approximately 12,000 shovelnose sturgeon fry which represents 83% eye-up. Six thousand were shipped to Gavins Point NFH to be raised to fingerlings for reintroduction into the upper Bighorn River. Poor survival resulted in only 335 fingerlings for release in fall 1996.

Two shovelnose were sampled during the annual population survey in this section (North Dakota Game and Fish Department 1996). A number of shovelnose were reportedly sampled in stationary gill net sets in Lake Sakakawea.

<u>Missouri River from Garrison Dam to Bismarck</u> (Figure 5)

In **1992**, this section was included in a study investigating sturgeon population and habitat (Elstad et al. 1992). Habitat data including depth, substrate, velocity and temperature were recorded. Drifting gill nets was the sampling method used. Thirty six shovelnose were sampled. Size of fish in this section was generally smaller with a narrower length distribution. This may be a function of the tail water habitat characteristic of this section.

In **1993**, 7 shovelnose sturgeon were sampled with stationary gill nets in Lake Oahe (Hendrickson et al. 1994).

A study investigating aging techniques for shovelnose sturgeon was conducted (Buckmeier 1993). Ten fish were collected from the Missouri River for analyses. Marginal pectoral fin rays, otoliths, scutes, opercula, jaw bones and cleithra were considered for aging. Marginal pectoral fin rays and the fourth scute anterior to the dorsal fin were the only structures having observable concentric rings. The study used scutes and fin rays and concluded that fin rays were the most reliable structure to age shovelnose sturgeon.

In **1993** and **1994**, a study investigating the larval fish community of this section used varying mesh sizes of 0.5 m plankton nets. No sturgeon eggs or larvae were collected (Wolf 1995).

In **1995**, trawling and seining were conducted in this section to collect chub species and no sturgeon were reported as being sampled (Everett and Scarnecchia 1996).

Shovelnose sturgeon catch rate in gill nets was 0.11 fish per hour (North Dakota Game and Fish Department 1995). An additional 2 specimens were sampled in Lake Oahe in stationary gill nets.

Two shovelnose were sampled in Lake Oahe in **1996** (North Dakota Game and Fish Department 1996). One with a 4'x 6' trap, and another with a 125' x 6' x 0.75-2" gill net.

Blue Sucker

(*Cycleptus elongatus*)

<u>Missouri and Yellowstone Rivers above Lake Sakakawea</u> (Figure 4)

In **1993**, one young of the year blue sucker was captured in a frame trap in Lake Sakakawea (Hendrickson et al. 1994).

In **1994**, blue suckers were sampled with gill nets during the annual population survey (Hendrickson et al. 1995). Numbers were not reported.

Blue suckers were sampled with gill nets during the annual population survey in **1995** and **1996** (North Dakota Game and Fish Department 1995, 1996). Again, numbers were not reported.

<u>Missouri River from Garrison Dam to Bismarck</u> (Figure 5)

In **1991**, sampling was conducted using gill nets. Twelve adult blue suckers were sampled near the mouth of the Knife River (Hendrickson et al. 1992). Female fish exhibited signs of reproductive readiness and were apparently concentrating near this tributary. Larval fish sampling is conducted annually. No young blue suckers have been recovered in the study area to date.

In **1992**, 2 adult blue suckers were sampled from the Knife River mouth and another from the Heart River (Hendrickson et al. 1993). Based on scales from 11 fish sampled in previous years fish indicated ages ranged from 5 to 9 years. Larval fish sampling was continued in an effort to document reproduction. Despite sampling other sucker species, blue sucker larvae or young of the year have not been sampled.

In **1993**, 14 blue sucker adults were sampled (Hendrickson et al. 1994). Locations included the Knife River confluence, tailrace of Garrison Dam and Hazelton boat ramp. Scales collected from 11 fish in 1993 indicated ages to be 6 to 10 years. Larval fish sampling continued to yield negative resulted for blue suckers.

An additional 7 blue suckers were sampled with stationary gill nets in Lake Oahe (Hendrickson et al. 1994).

A study investigating the larval fish community of this section using varying mesh sizes of 0.5 m plankton nets, found no blue sucker eggs or larvae (Wolf 1995).

In **1994**, a marked increase in catch rate was experienced for blue sucker adults (Hendrickson et al. 1995). Sixty seven specimens were sampled in the study area. Higher densities were observed in the summer in the upstream sections between Garrison Dam and the Knife River. Fish seemed to disperse downstream in the fall. Annual population surveying of the Missouri River mainstem has provided evidence of a measurable population of blue suckers. Blue suckers are still absent in larval samples.

In **1995**, 9 blue sucker adults were sampled in this section, with one reportedly collected at the mouth of the Knife River (North Dakota Game and Fish Department 1995). An additional 8 blue suckers were sampled in stationary gill nets in Lake Oahe.

In **1996**, a number of blue suckers were sampled in stationary gill nets in Lake Oahe (North Dakota Game and Fish Department 1996).

Sicklefin Chub

(*Macrhybopsis meeki*)

Missouri and Yellowstone Rivers above Lake Sakakawea (Figure 4)

In **1993**, data were reported from a study investigating the possible impacts to sicklefin chub resulting from the proposed reconstruction of the Highway 200 bridge crossing on the Yellowstone River (Sapa 1993). A trawl was used to sample 7 sicklefin chub from the vicinity of the construction project. As sicklefin chub occur in this area, there is a concern to minimize impacts to the river area.

In **1994**, seines and small frame traps were used to survey the fish population in the study area. Three sicklefin chub were reported (Hendrickson et al. 1995).

In **1995**, a study investigating the sicklefin chub population was initiated (Everett and Scarnecchia 1996). Trawling and seining were the principal sampling methods. Thirty four sicklefin chub were sampled from the Missouri River. Habitat data were collected at each sampling site including depth, substrate, velocity and water chemistry. Habitat types were categorized by subsection and preliminary data were reported according to sicklefin collections. Habitat associations by age class were reported for each habitat sub-type. An additional 29 were sampled from the Yellowstone River.

<u>Missouri River from Garrison Dam to Bismarck</u> (Figure 5)

In **1993**, a study investigating the larval fish community of this section was begun. Varying mesh sizes of 0.5 m plankton nets were used and no sicklefin chub eggs or larvae were collected (Wolf 1995).

In **1995**, a study investigating sicklefin chub populations was begun using trawling and seining to sample (Everett and Scarnecchia 1996). No sicklefin chub were sampled by either method.

Sturgeon Chub

(*Macrhybopsis gelida*)

Missouri and Yellowstone Rivers above Lake Sakakawea (Figure 4)

In **1993**, 10 sturgeon chub were sampled in the Yellowstone River by seining. Nine of these specimens were reported as "yearlings" (Hendrickson et al. 1994).

Data were reported from a study investigating the possible impacts to sturgeon chub resulting from the proposed reconstruction of the Highway 200 bridge crossing on the Yellowstone River (Sapa 1993). A trawl was used to sample 13 sturgeon chub from the vicinity of the construction project. As sturgeon chub occur in this area, there is a concern to minimize impacts to the river area.

In **1994**, seines and small frame traps were used to survey the fish population in the study area. Five sturgeon chub were reported, three of which were reported as "yearlings" (Hendrickson et al. 1995).

In **1995**, trawling and seining were used to sample a total of 31 sturgeon chub from this section (Everett and Scarnecchia 1996). Fifteen were sampled from the Missouri and 16 from the Yellowstone River. Habitat data including depth, substrate, velocity and water chemistry were collected at sampling sites. Habitat types were categorized by subsection and preliminary data were reported according to sicklefin collections. Habitat associations by age class were reported for each habitat sub-type. Specimens had a maximum age of 3 years. Collections were reported according to habitat types.

Missouri River from Garrison Dam to Bismarck (Figure 5)

In **1993**, a study investigating the larval fish community of this section was begun. Varying mesh sizes of 0.5 m plankton nets were used. No sturgeon chub eggs or larvae were recovered (Wolf 1995).

In **1995**, seining and trawling efforts in this section sampled no sturgeon chub (Everett and Scarnecchia 1996).

REFERENCES CITED

Backes, K.M., W.M. Gardner, D. Scarnecchia and P.A. Stewart. 1992. Lower Yellowstone River pallid sturgeon study II and Missouri River pallid sturgeon creel survey. Montana Department of Fish, Wildlife & Parks. Helena.

Backes, K. and W. Gardner. 1994. Lower Yellowstone River pallid sturgeon study III and Missouri River pallid sturgeon creel survey. Montana Department of Fish, Wildlife and Parks. Miles City.

Backes, K.M., W.M. Gardner, D. Scarnecchia and P.A. Stewart. 1994. Lower Yellowstone River pallid sturgeon study IV and Missouri River pallid sturgeon creel survey. Montana Department of Fish, Wildlife & Parks. Helena.

Berg, R.K. 1981. Fish populations of the Wild and Scenic Missouri River, Montana. Project FW-3-R, 1-a. Final Report. Montana Department of Fish, Wildlife & Parks. Helena.

Bramblett, R.G. 1996. Habitats and movements of pallid and shovelnose sturgeon in the Yellowstone and Missouri rivers, Montana and North Dakota. Doctorate Thesis. Montana State University, Bozeman.

Buckmeier, D. 1993. Questions concerning the current aging technique using marginal pectoral-fin rays in shovelnose sturgeon. Term paper-Biology 491 (submitted to Dr. Steve Kelsch). University of North Dakota, Bismarck.

Campton, D.E., A. Garcia, B. Bowen and F. Chapman. 1995. Genetic evaluation of pallid, shovelnose and Alabama sturgeon based on control region (d-loop) sequences of mitochondrial DNA. Final report. University of Florida, Department of fisheries and aquatic sciences, Gainsville. *submitted to:* U.S. Fish and Wildlife Service, Pallid Sturgeon Recovery Team. Missouri River Fish and Wildlife Management Assistance Office. Bismarck, N.D.

Clancey, P. 1989. Fort Peck pallid sturgeon study. Montana Department of Fish, Wildlife & Parks. Helena.

Clancey, P. 1990. Fort Peck pallid sturgeon study. Montana Department of Fish, Wildlife & Parks. Helena.

Clancey, P. 1991. Fort Peck pallid sturgeon study. Montana Department of Fish, Wildlife & Parks. Helena.

Dryer, M. 1996. Pallid sturgeon and shovelnose sturgeon activities conducted for propagation at Miles City Sate Fish Hatchery, Spring 1995. United States Fish and Wildlife Service, Missouri River Fish and Wildlife Management Assistance Office. Bismarck.

Dryer, M., W. King and S. Krentz. 1996. Pallid sturgeon and shovelnose sturgeon activities conducted for propagation at Garrison Dam National Fish Hatchery, 1996. United States Fish and Wildlife Service, Missouri River Fish and Wildlife Management Assistance Office. Bismarck.

Elser, A., R. McFarland and D. Schwer. 1977. The effect of altered streamflow on fish of the Yellowstone and Tongue rivers, Montana. Technical report no. 8. Yellowstone Impact Study. Montana Department of Natural Resources and Conservation, Water Resources Division. Helena.

Elstad, S., J.C. Hendrickson and G. Power. 1992. North Dakota fisheries investigations-sturgeon and their associated habitat in the Missouri and Yellowstone rivers of North Dakota. Report no. 4. North Dakota Game and Fish Department, Bismarck.

Erdahl, D. 1993. Shovelnose sturgeon reproductive study . Progress report. United States Fish and Wildlife Service, Bozeman Fish Technology Center. Montana.

Erdahl, D. 1994. Sturgeon broodstock development. Annual report. United States Fish and Wildlife Service, Bozeman Fish Technology Center. Montana.

Erdahl, D. 1995. Sturgeon broodstock development. Annual report. United States Fish and Wildlife Service, Bozeman Fish Technology Center. Montana.

Erdahl, D. 1996. Shovelnose sturgeon propagation and culture. Progress report. United States Fish and Wildlife Service, Bozeman Fish Technology Center. Montana.

Everett, S.R. and D.L. Scarnecchia. 1996. Distribution, abundance and habitat use of sturgeon chub and sicklefin chub in the Missouri and Yellowstone rivers, North Dakota. Progress report. University of Idaho Department of fish and wildlife resources, Moscow.

Gardner, W.M., and R.K. Berg. 1982. An analysis of the instream flow requirements for selected fishes in the Wild and Scenic portion of the Missouri River. Final report. Montana Department of Fish, Wildlife & Parks. Helena.

Gardner, W.M. and P.A. Stewart. 1987. The fishery of the lower Missouri River, Montana. Project FW-2-R, I-b. Final report. Montana Department of Fish, Wildlife & Parks. Helena.

Gardner, W.M. 1990a. Missouri River pallid sturgeon inventory. Project F-46-R-3, III-d. Montana Department of Fish, Wildlife & Parks. Helena.

Gardner, W.M. 1990b. Yellowstone River paddlefish spawning study. Project F-46-R-3, III-e. Montana Department of Fish, Wildlife & Parks. Helena.

Gardner, W.M. 1991a. Missouri River pallid sturgeon inventory. Project F-46-R-4, III-d. Montana Department of Fish, Wildlife & Parks. Helena.

Gardner, W.M. 1991b. Yellowstone River paddlefish spawning study. Project F-46-R-4, III-e. Montana Department of Fish, Wildlife & Parks. Helena.

Gardner, W.M. 1992a. Missouri River pallid sturgeon inventory. Project F-46-R-5, III-d. Montana Department of Fish, Wildlife & Parks. Helena.

Gardner, W.M. 1992b. Yellowstone River paddlefish spawning study. Project F-46-R-5, III-e. Montana Department of Fish, Wildlife & Parks. Helena.

Gardner, W.M. 1993a. Missouri River pallid sturgeon inventory. Project F-46-R-6, III-d. Montana Department of Fish, Wildlife & Parks. Helena.

Gardner, W.M. 1993b. Yellowstone River paddlefish spawning study. Project F-46-R-6, III-e. Montana Department of Fish, Wildlife & Parks. Helena.

Gardner, W.M. 1994a. Missouri River pallid sturgeon inventory. Project F-46-R-7, III-d. Montana Department of Fish, Wildlife & Parks. Helena.

Gardner, W.M. 1994b. Yellowstone River paddlefish spawning study. Project F-46-R-7, III-e. Montana Department of Fish, Wildlife & Parks. Helena.

Gardner, W.M. 1995a. Missouri River pallid sturgeon inventory. Project F-78-R-1. Montana Department of Fish, Wildlife & Parks. Helena.

Gardner, W.M. 1995b. Population status of the blue sucker in Montana. Montana Department of Fish, Wildlife & Parks, Lewistown.

Gardner, W.M. 1996. Missouri River pallid sturgeon inventory. Project F-78-R-2. Montana Department of Fish, Wildlife & Parks. Helena.

Gilge, K.W. 1992. Northeast Montana warmwater ecosystem investigation. Project F-46-R-5, V-e. Montana Department of Fish, Wildlife and Parks. Helena.

Gilge, K.W. and R. Needham. 1982. Inventory and survey of waters in northeast Montana. Project F-11-R-29, I-a. Montana Department of Fish, Wildlife and Parks. Helena.

Gould, W.R. 1994. Recent distribution of the sturgeon chub (*Macrhybopsis gelida*) in Montana. Montana State University, Department of Biology. Bozeman.

Grisak, G.G. 1996a. The status and distribution of the sicklefin chub in the middle Missouri River, Montana. Masters thesis. Montana State University, Bozeman.

Grisak, G.G. 1996b. Effects of two electrofishing treatments on eight warmwater fish species in Montana. Montana State University, Cooperative Fisheries Research Unit, Bozeman.

Haddix, M. and C. Estes. 1976. Lower Yellowstone River fishery study. Montana Department of Fish and Game. Helena.

Hendrickson, J.C., J.D. Lee and L. K. McGregor. 1993. North Dakota fisheries investigations-aquatic investigations of the Missouri mainstem in North Dakota. Report no. 7. North Dakota Game and Fish Department, Bismarck.

Hendrickson, J.C., J.D. Lee and L. K. McGregor. 1994. North Dakota fisheries investigations-aquatic investigations of the Missouri mainstem in North Dakota. Report no. 12. North Dakota Game and Fish Department, Bismarck.

Hendrickson, J.C., J.D. Lee and L. K. McGregor. 1995. North Dakota fisheries investigations-aquatic investigations of the Missouri mainstem in North Dakota. Report no. 16. North Dakota Game and Fish Department, Bismarck.

Krentz, S. 1994. Observations and findings of the Missouri River Fish and Wildlife Assistance Office (pallid sturgeon), confluence region of the Yellowstone and Missouri rivers. United States Fish and Wildlife Service, Fish and Wildlife Management Assistance Office. Bismarck.

Krentz, S. 1995. Missouri -Yellowstone rivers pallid sturgeon status, 1995 summary report. Draft report. United States Fish and Wildlife Service, Fish and Wildlife Management Assistance Office. Bismarck.

Liebelt, J.E. 1996. Lower Missouri River and Yellowstone River pallid sturgeon study 1994-1995. Montana Department of Fish, Wildlife & Parks. Helena.

Megargle, D.J. 1997. Temporal variation in diet and food selectivity of shovelnose sturgeon in the Missouri River above Fort Peck Reservoir, Montana. Draft Masters Thesis. Montana State University, Bozeman.

Morris, L., T. Hightower and A. Elser. 1981. An aquatic resource assessment of selected streams in the lower Yellowstone River basin. Final report. *for* Bureau of Land Management. Montana Department of Fish, Wildlife and Parks. Helena.

North Dakota Game and Fish Department. 1995. Summary of findings for Missouri River system-1995. Bismarck.

North Dakota Game and Fish Department. 1996. Summary of findings for Missouri River system-1996. Bismarck.

Power, G.J., J.C. Hendrickson, B.L. Kreft and L. K. McGregor. 1992. North Dakota fisheries investigations-aquatic investigations of the Missouri mainstem in North Dakota. Report no. 1. North Dakota Game and Fish Department, Bismarck.

Rehwinkel, B. 1978. Powder River aquatic ecology project. Final report. *for* Utah International Inc. Montana Department of Fish and Game. Miles City.

Rykman, F. 1995. Paddlefish creel survey with emphasis on incidental snagging of sturgeon. North Dakota Game and Fish Department, endangered species program. Bismarck.

Sapa, A. 1993. Pallid sturgeon seasonal use and habitat studies on the Yellowstone River within the Highway 200 bridge replacement project area. Final report. U.S. Fish and Wildlife Service. Bismarck, N.D.

Snyder, D. 1994. Morphological development and identification of pallid, shovelnose and hybrid sturgeon larvae. Contribution no. 71. Final report. Larval Fish Laboratory, Department of Fishery and Wildlife Biology, Colorado State University. Fort Collins.

Stewart, P.A. 1981. Lower Missouri River basin investigations. Project FW-2-R-10, 1-b. Montana Department of Fish, Wildlife & Parks. Helena.

Stewart, P.A. 1982. Lower Missouri River basin investigations. Project FW-2-R-11, 1-b. Montana Department of Fish, Wildlife & Parks. Helena.

Stewart, P.A. 1993. Southeast Montana warmwater streams investigations. Project F-46-R-6, III-b. Montana Department of Fish, Wildlife & Parks. Helena.

Stewart, P.A. 1994. Southeast Montana warmwater streams investigations. Project F-46-R-7, III-b. Montana Department of Fish, Wildlife & Parks. Helena.

Stewart, P.A. 1995. Southeast Montana warmwater streams investigations. Project F-78-R-1, III-b. Montana Department of Fish, Wildlife & Parks. Helena.

Stewart, P.A. 1996. Southeast Montana warmwater streams investigations. Project F-78-R-2, III-b. Montana Department of Fish, Wildlife & Parks. Helena.

Tews, A. and P. Clancey. 1993. Fort Peck pallid sturgeon study. Final Report. Montana Department of Fish, Wildlife and Parks. Helena.

Tews, A. 1994. Pallid sturgeon and shovelnose sturgeon in the Missouri River from Fort Peck Dam to Lake Sakakawea and in the Yellowstone from Intake to its mouth. Fort Peck pallid sturgeon study. Final report. Montana Department of Fish, Wildlife & Parks. Helena.

Watson, J.H. and P.A. Stewart. 1991. Lower Yellowstone River pallid sturgeon study. Montana Department of Fish, Wildlife and Parks. Helena.

Werdon, S.J. 1992. Population status and characteristics of sturgeon chub, flathead chub and longnose dace in the Missouri River basin. Masters thesis. South Dakota State University, Department of Wildlife and Fisheries Sciences. Brookings.

Werdon, S.J. 1993a. Status report on sicklefin chub, a candidate endangered species. USFWS. Ecological services division. Bismarck, ND.

Werdon, S.J. 1993b. Status report on sturgeon chub, a candidate endangered species. USFWS. Ecological services division. Bismarck, ND.

Werdon, S.J. 1993c. Draft status report on blue sucker, a candidate endangered species. USFWS. Ecological services division. Bismarck, ND.

Wolf, A. E. 1995. Evaluation of the larval fish community in the Missouri River below Garrison Dam, North Dakota. Masters Thesis. South Dakota State University, Brookings.