The Sturgeon Chub, Sicklefin Chub, Flathead Chub, W. Silvery Minnow, Plains Minnow, and Blue Sucker

Annotated Bibliography Through July 1996

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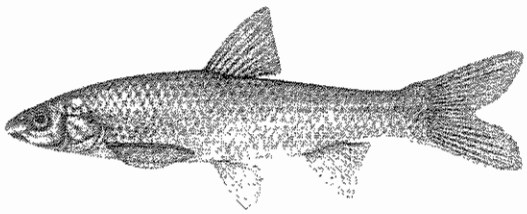
Contents



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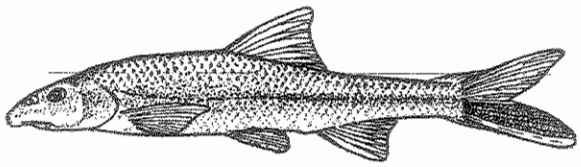

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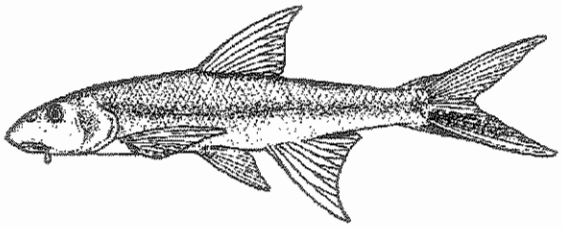
(Hybopsis gelida)



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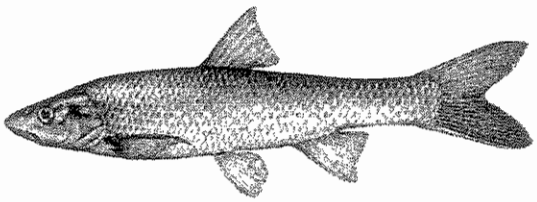
(Hybopsis meeki)



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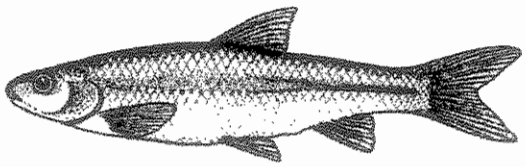

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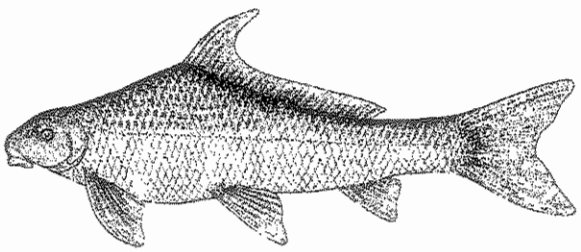

Blue Sucker
(Cycleptus elongatus)

Introduction

This bibliography annotates published and unpublished papers on the sturgeon chub (*Hybopsis gelida*), sicklefin chub (*Hybopsis meeki*), flathead chub (*Hybopsis gracilis*), western silvery minnow (*Hybognathus argyritis*), plains minnow (*Hybognathus placitus*), and blue sucker (*Cycleptus elongatus*) through July 1996. We queried the Biological Abstracts Electronic Index (BIOSIS) and the Ovid Electronic Index at Montana State University, which searches several data bases including the reader's guide and the applied technical and science index for listed published and unpublished papers. For unlisted published and unpublished materials we narrowed our efforts to locate papers and agency documents that reported research and findings on the Missouri River for the featured species. Even reports and papers that did little more than list the featured species in catch data are annotated because of the importance in just knowing when and where species of concern are captured. The citations are arranged alphabetically by author and characterized by key words to help users locate annotations keyed to species, river, state and general subject matter.

Annotations summarize the data and findings as presented when published or reported in the literature cited. Succeeding works often contradicted earlier findings as additional information about the species was learned. We are solely responsible for any errors in the citations or misinterpretations in the annotations. Users should consult the original sources for pertinent data rather than rely on the limited material contained in the annotations. Some of the annotations were gleaned from photocopies of chapters or sections of a book or large report, and where it was suspected the full report or book included material on one or more of the other featured species, it was so noted.

The Missouri River is home to 170 naturally occurring and introduced species (Hesse et al. 1989). Major changes to the Missouri River brought about by impoundments and channelization after the 1920's have transformed the historical "Big Muddy" from a dynamic, highly turbid, braided-channel river to a river "tamed" by man. Changes in water temperature, water clarity, river channel configuration, and flow patterns have resulted in major changes in fish habitat and communities throughout the river. Many native species have declined. Most notable is the pallid sturgeon, which is listed as endangered under

the Endangered Species Act. Other native fish have similarly declined in some areas of the Missouri River and as a result have gained the attention of fishery researchers and managers. Our purpose for compiling this annotated bibliography was to assist fishery managers and researchers in further investigating the status of these species and developing conservation plans where they are needed. The near extinction of the pallid sturgeon and the noted declines in population numbers of the six fish species featured should serve as a signal that the ecological health of the Missouri River has deteriorated.

The sturgeon chub and sicklefin chub are candidate species for listing and protection under the Endangered Species Act, which means they are not currently being proposed for listing but development and publication of proposed rules for such candidate taxa is anticipated. When we initiated this project, the other fish species featured in this bibliography were classified as candidates for listing, but at a lower classification level (Category-2). The Fish and Wildlife Service (Service) discontinued the designation of Category-2 species in February 1996 (Federal Register, Feb. 28, 1996, 40:7596-7613). Prior to this change in designation, Category-2 species were defined as taxa for which available data in possession of the Service indicated that proposing to list as endangered or threatened is possibly appropriate, but for which persuasive data on biological vulnerability and threat were not currently available to support proposed rules. Although the official classification has been changed to clarify the definition of candidate species, the Service remains concerned about these species. Further biological research and field study are needed to resolve their conservation status.

Literature Cited

Hesse, L. W., J. C. Schmulbach, J. M. Carr, K. D. Keenlyne, D. G. Unkenholz, J. W. Robinson, and G. E. Mestl. 1989. Missouri River fishery resources in relation to past, present, and future stresses. Pg. 352- 371. In Dodge, D. P. Proceedings of the International Large River Symposium (LARS). Canadian Special Publications Fisheries and Aquatic Science 106.

Annotated Bibliography

#1 **Bailey, R. M.** 1951. A checklist of the fishes of Iowa with keys for identification. Iowa State Conservation Commission, Des Moines. Pg. 217.

Brief physical description of the sicklefin and sturgeon chubs. Although not included in the reviewed material, this key may include information on flathead chub, blue sucker, plains minnow, and western silvery minnow.

#2 **Bailey, R. M., and M. O. Allum.** 1962. Fishes of South Dakota. Miscellaneous publication No. 119, Museum of Zoology, University of Michigan, Ann Arbor. Pg. 46-49.

Information on the habitat preferred by the sturgeon and sicklefin chubs. The maps included cover the entire northwest from Washington State to Iowa and show the sites where the two species have been collected. Although not included in the reviewed material, this key may include information on flathead chub, blue sucker, plains minnow, and western silvery minnow.

#3 **Baxter, G. T., and J. R. Simon.** 1970. Wyoming fishes. Bulletin No. 4, Wyoming Game and Fish Department, Cheyenne. Pg. 64-65.

Contains a brief physical description and distribution map for the sturgeon chub (dace). Notes the preference of these fish for gravel bottom habitat. Sturgeon chub are known for the shape of their keeled scales. The keel on the scales may help to plane the fish down next to the gravel. The fish is endangered in Wyoming and has possibly been eliminated from the Big Horn River by the construction of the Yellowtail Dam. Although not included in the reviewed portion, information on flathead chub, western silvery minnow, and plains minnow may be available in the original bulletin.

#4 **Berard, E.** 1981. Ecological investigations of the Missouri Mainstem Reservoirs in North Dakota. North Dakota Game & Fish Department, Dingell-Johnson Division, Project F-2-R-27.

The objective of the study was to document data on the biological and chemical status of Sakakawea and Oahe Lakes in relation to fisheries management. Fish population information gathered includes species composition, relative abundance, population trends, vertical distribution, age and growth of scaled species, and reproductive success. The primary emphasis of the report is on game fish management (e.g. walleye, sauger, etc.) and endangered species (e.g. pallid sturgeon).

Flathead chub were caught in the 1979 study, but not in the 1980 study. (The report mistakenly calls them "fathead chub," but the Latin name is correct.) Flathead chub have been caught during ten of the annual surveys since 1956. Plains minnows were caught during both the 1979 and 1980 studies, and have been sampled in seven of the annual surveys since 1956.

#5 **Berg, R. K.** 1981. Fish populations of the wild and scenic Missouri River, Montana. Montana Department of Fish, Wildlife and Parks. 242 pp.

The long range objective of this study was to emulate inventory procedures developed on the Upper Yellowstone by Berg in 1975 and use resulting data to make recommendations for aquatic resource management on the Wild and Scenic section of the middle Missouri River. The report focuses on game fish such as paddlefish and sauger. Boom suspended electrofishing units, mobile electrofishing units, baited hoop nets, frame traps, seines, and gill nets were all used to capture adult fish. The baited hoop nets were used primarily for the trapping of channel catfish. The seines were the most successful method used to capture the smaller minnow family fish.

The inventory took place from 1976 to 1979 on 11 sections of the middle Missouri River. Flathead chub, western silvery minnow, and blue sucker were trapped in every section surveyed from 1976 to 1979. Sturgeon chub were only found along the Judith Landing, Cow Island, and Robinson Bridge sections. Sicklefin chub were found only in the Cow Island, Robinson Bridge, and Turkey Joe sections.

The spawning migrations of several species were also monitored during the survey. Of the six species concerned in this bibliography, three were monitored during this spawning inventory. The flathead chub spawned from mid-June until late July. The western silvery minnow spawned from early June until late July. The blue sucker spawned from late May until early July. Electrofishing surveys of blue suckers indicate that these fish travel as far as 196 km during their spawning migration. The age distribution of blue suckers in 1978 and 1979 had 24.3% of the fish aged at 11 years. The ages of all blue suckers sampled ranged from 6 to 17 years. The 49.1% of the blue suckers sampled fell between the ages of 11 and 14 years.

The ecological concerns identified in this inventory include: potential hydropower developments between Morony Dam and Fort Benton, oil and natural gas developments, saline seepage, dewatering during irrigation, and excessive sediment loading from agriculture and logging.

#6 **Bich, J. P., and C. G. Scalet.** 1977. Fishes of the Little Missouri River, South Dakota. Proceedings of the South Dakota Academy of Science 56:163-177.

Both fish population and physical river information is included in the report. The researchers used seines to collect fish at 25 sites along the Little Missouri. All collections occurred during May, June, and July of 1976. Mesh size of the seines varied from 3.2 mm in shallower portions to 19.1 mm in faster, deeper sections. A representative sample of each species was preserved and placed in the Collection of Fishes at South Dakota State University. Standard water chemistry information including dissolved oxygen, carbon dioxide, pH, alkalinity, hardness, temperature, turbidity (Secchi disc), substrate, velocity, stream width, and stream depth were collected at each site. Researchers used Hach kits for the chemical tests. A physical description of each collection site is included.

The fish species were classified as rare, uncommon, common, or abundant based on numerical counts from the seines. This survey was the first recording for the sturgeon chub in the Little Missouri in South Dakota. Not surprisingly, the sturgeon chub is classified as rare (<0.1%). The plains minnow was abundant, making up 10.2% of all fish collected. The sicklefin chub had been collected on this portion of the river in previous surveys, but was not found during this survey. A significant flood event occurred during the study and the authors address its potential effects in the

discussion. A table of species collected provides information on previous surveys along the same section for 1929, 1955, 1962, 1970, and 1971.

#7 **Bouc, K.** 1990. Obscure and imperiled. Nebraskaland. April edition. Pg. 8-13.

A popular article that describes the endangered species classification and the currently listed or threatened species in Nebraska. Both the sturgeon and sicklefin chubs are noted by the author as fish that are not classified, but are in danger because of habitat loss.

#8 **Branson, B. A.** 1963. The olfactory apparatus of *Hybopis gelida* (Girard) and *Hybopsis aestivalis* (Girard) (Pisces: Cyprinidae). Journal of Morphology 113:215-229.

Eight specimens of sturgeon chubs were collected from the Kansas River near Linwood, Kansas. These specimens were sectioned into 10 micron widths in three planes, decalcified and stained to allow examination of the head. The anterior nostril is smaller than the posterior and opens by way of a tubular nasal flap. A constant flow of water moves through the olfactory receptors and the heavily ciliated chamber helps to move the water along. The water flows from the anterior nostril, over the olfactory lamellae, and out the posterior nostril. The anterior and posterior regions are not divided. The olfactory rosette is circular and large. There are also compound lamellae in the anterior and posterior regions. Olfactory hair bearing cells are present as long, thick polarized sensory cells. The direct nervous connections of the sensory cells are not myelinated and could not be traced. However, they do join up with ganglia that in turn connect to the three first order olfactory nerves. All of these adaptations place the sturgeon chub in Teichmann's first category in which eyes and olfactory organs are about equal in importance to the species. The sturgeon chub is not a very plastic species ecologically speaking, and its high level of adaptation attests to this.

#9 **Branson, B. A.** 1966. Histological observations on the sturgeon chub, *Hybopsis gelida* (Cyprinidae). Copeia 1966:872-876.

Eight specimens were collected from the Kansas River near St. Lawrence. These specimens were sectioned into 10 micron widths and stained to allow examination of the grooves in the head. The ventral surface of the fish is flattened and the scales above the midlateral line all have longitudinal keels. These shapes help to hold the fish close to the bottom in its preferred fast-flowing habitat. Goblet cells are nearly lacking on the outer surface of the rugosities, but are abundant in the lining of the space. Taste buds are abundant within the buccal cavity and in all regions of the ventral surface. There are large, clear cells that extend from the compactum to two-thirds of the rugosities that may function as "alarm substance cells." The rugosities may offer frictional resistance against the sand. The author notes the similarity between these rugosities and the hold fasts of Indian sisorids.

#10 **Brown, C. J. D.** 1971. Fishes of Montana. Big Sky Books, Endowment and Research Foundation at Montana State University, Bozeman. Pg. 92 and 95.

A list of Montana fishes compiled from 800 collections with 75,000 specimens. The fish families represented are listed in addition to the individual species. Each species is followed by a code to note from which drainage it came. This reference lists the taxonomic names for the blue sucker, plains minnow, flathead chub, and sturgeon chub.

#11 **Bryan, J. D., L. G. Hill, and W. H. Neill.** 1984. Interdependence of acute temperature preference and respiration in the plains minnow. Transactions of the American Fisheries Society 113(5):557-562.

Although the temperature preferences of fishes in air-saturated water have been studied intensively, very little is known about temperature preferences in oxygen-depleted waters. *Hybognathus placitus* acclimated near 21°C and selected 30°C in a horizontal temperature gradient when dissolved oxygen was maintained at 5 to 9 mg/L. But, when dissolved oxygen was lowered, the acute preferred temperature (APT) declined to 17°C at 2 mg/L. In oxygen deficient water, the plains minnow prefers the highest temperature (less than 30°C) at which it can operate within the zone of respiratory independence.

#12 **Buchanan, T. M.** 1976. An evaluation of the effects of dredging within the Arkansas River navigation system - the effects upon the fish populations. Final Report. Westark Community College. Fort Smith, Arkansas. Pg. 29-30.

The blue sucker is listed as species #47 with an accompanying map #48. The blue sucker is difficult to capture because of its preference for turbid, deep, fast waters. These fish are often caught accidentally in the spring by commercial fishermen, although there is no current market for the fish. The population in the Arkansas River is one of the largest and most stable in the entire range of the species. However, it is not abundant in any part of the State and has declined in numbers due to habitat loss.

#13 **Burr, B. M., and M. L. Warren, Jr.** 1986. A distributional atlas of Kentucky fishes. Scientific and Technical Series No. 4, Kentucky Nature Preserve Commission. Pg. 92 and 95.

The sicklefin chub is found only in the extreme western part of Kentucky, in the Mississippi and in the Ohio Rivers. The Ohio River record is unsubstantiated. Attempts to collect these fish in the Mississippi have been unsuccessful. Adults prefer wide, shallow, gravelly channels. The sicklefin chub is restricted to the ends of sandy islands or open channels of turbid rivers over sand. Both species are recommended for special concern status.

#14 **Churchill, E. P., and W. H. Over.** 1938. Fishes of South Dakota. South Dakota Department of Game, Fish, and Parks, Pierre. Pg.55.

The authors give a brief physical description of the sturgeon chub, although they did not use its common name at the time. No spawning or other life history information was available.

#15 **Cross, F. B.** 1953. Occurrence of the sturgeon chub, *Hybopsis gelida* (Girard) in Kansas. Transactions of the Kansas Academy of Science 56(1):90-91.

Recounts the history of collections of the sturgeon chub in Kansas. First collection occurred in 1884. The sturgeon chub is distinguished by its keeled scales. It is similar to the sicklefin and speckled chubs, but has eyes larger than the former and smaller than the latter. The speckled chub also has irregularly-placed spots as its only pigment, while the sturgeon chub is more evenly pigmented.

#16 **Cross, F. B.** 1967. Handbook of fishes of Kansas. Museum of Natural History Miscellaneous Publication No. 45. University of Kansas, Lawrence. Pg.167-169.

Dichotomous key to fishes of Kansas. Includes a description of the blue sucker and a map of its distribution. The blue sucker is found in strong currents over bedrock or rubble substrate and is considered a good eating fish. The adults prefer deeper, faster channels, while the juveniles are often found in less turbulent riffles. The author notes the decline of the fish in the upper Mississippi is due to pollution (silt) and dams that block spawning migration. Declines in the lower Kansas River are attributed to natural flooding (1903) and renovation of the river channel.

#17 **Cross, F. B., and R. E. Moss.** 1987. Historic changes in fish communities and aquatic habitats in plains streams of Kansas. Pages 155-165 in W.J. Mathews and D.C. Heins, editors. Community and evolutionary ecology of North American stream fishes. University of Oklahoma Press, Norman. Pg.155-156.

The geologic history of the great plains, including its submersion beneath the pre-Cretaceous seas and current existence within the rainshadow of the Rocky Mountains, has contributed to low species richness in its rivers. The aridity and storm patterns of the great plains also contribute to its high erosibility. The large amounts of sediment washed into rivers gives them their characteristic turbidity and has pressured local fish to adapt. The author suggests three habitat types that exist in the great plains; channels of fluctuating, shallow streams with shifting sandbeds; clear brooks, ponds, and marshes sustained by seeps and springs and residual pools of highly intermittent streams. The sicklefin and sturgeon chubs inhabit the first habitat type and are considered diagnostic fishes.

#18 **Cunningham, G. R., R. D. Olson, and S. M. Hickey.** 1994. Fish specimens from the White River in the South Unit of Badlands National Park. Badlands National Park.

A listing of the fish caught during a single day survey of the White River. Also includes a description of each site that yielded sturgeon chub during 1994. Included with each site description are the types of other fish caught, the method used, and comments. Flathead chub were always collected along with the sturgeon chub. Some plains and western silvery minnows were also collected.

#19 **Davis, B. J., and R. J. Miller.** 1967. Brain patterns in minnows of the genus *Hybopsis* in relation to feeding habits and habitat. Copeia 1967(1):1-39.

Specimens were obtained through gifts and loans from museums and personal field collections. Sixteen measurements of the brains of all specimens were taken using a calibrated Whipple disc mounted on a dissecting scope. The brains of each species are diagrammed in the article. Barbels were also mounted, cross-sectioned, and examined for taste buds. Serial sections of the body surface and buccopharyngeal cavity were also examined for taste buds. Five regions were numerically compared between species as to taste bud density. The five regions are tip of snout anterior to the nasal rosette, snout containing the anterior lamellae and lips, snout immediately posterior to the nasal rosette (posterior to retina), region behind the retina but anterior to the corpus cerebellum, and immediately behind the anterior extreme of the corpus.

The analysis of the data used the length of the brain as the independent variable and all other measurements as dependents. Means were compared between species and T values were determined using the inverse Doolittle method.

The data for the sturgeon and sicklefin chubs begins on page 27. Both species inhabit turbid streams and have more external taste buds than fish that live in clearer water. The sturgeon chub is found over gravel bottoms and the sicklefin chub over sandy bottoms. Both species have widely separated, reduced optical lobes. The cerebellum is well developed, especially in the sturgeon chub. This development is associated with life in faster waters. In the sturgeon chub, the facial lobe is expanded laterally, while in the sicklefin chub the same lobe is more spherical. Cutaneous taste buds are more developed in this subgenus to complement the reduction in optical senses. The density of taste buds declines posteriad in the sicklefin chub, while it remains constant in the sturgeon chub. Judging by the number and arrangement of taste buds, the sturgeon chub seems better adapted to the turbid waters that both species prefer. The sturgeon chub is better at finding food because of its high density of cutaneous taste buds and longer barbels. However, its food sorting mechanism is less efficient than that of the sicklefin. This difference in sorting ability may explain the sturgeon chub's preference for gravelly bottoms and the sicklefin's preference for sandy ones.

#20 **Dimmick, W. W.** 1993. A molecular perspective on the phylogenetic relationships of the barbeled minnows, historically assigned to the genus *Hybopsis* (Cyprinidae: Cypriniformes). Molecular Phylogenetics and Evolution 2(3):173-184.

Allozyme products of 32 gene loci were compared for the North American cyprinid fishes. The fishes of concern for this bibliography are: *Macrhybopsis aestivalis*, *M. gelida*, and *M. meeki*. Selected members of the *Campostoma*, *Cyprinella*, *Erimystax*, *Hybopsis*, *Nocomis*, *Platigobio*, and *Phenocabious* genuses were also tested. Triose-phosphate isomerase was found to be duplicated in all species. The genus *Macrhybopsis* was expanded to include *Macrhybopsis aestivalis*. *M. gelida* was identified as the sister to *M. meeki* and *M. aestivalis* as the sister to the former two species.

#21 **Eddy, S., and J. C. Underhill.** 1978. How to know the freshwater fishes. The pictured key nature series. Wm. C. Brown Co. Publishers, Dubuque. Pg. 72.

Dichotomous key that includes the sicklefin and sturgeon chubs. Although not included in the reviewed material, this key may include information on blue sucker, plains minnow, western silvery minnow, and flathead chub.

#22 **Eddy, S., and A. C. Hodson.** 1982. Taxonomic keys to the common animals of the north central states. Burgess Publishing Company, Minneapolis, Minnesota. Pg. 113-114.

Dichotomous key that includes the sicklefin, flathead, and sturgeon chubs. Includes line drawings. Although not included in the reviewed material, this key may include information on the blue sucker, plains minnow, and the western silvery minnow.

#23 **Elser, A. A., M. W. Gorges, and L. M. Morris.** 1980. Distribution of fishes in southeastern Montana. Montana Department of Fish, Wildlife, and Parks, U.S. Department of the Interior, and Bureau of Land Management.

The sturgeon chub is rare in Montana and has been collected mainly in the Yellowstone and Powder Rivers. The sturgeon chub prefers gravelly substrate. The fish is widely distributed but not common within this large range. Although not included in the

reviewed material, this report may include information on blue sucker, plains minnow, western silvery minnow, sicklefin chub, and flathead chub.

#24 **Elstad, S., J. C. Hendrickson, and G. Power.** 1992. Sturgeon and their associated habitat in the Missouri and Yellowstone Rivers of North Dakota. Report number 4. North Dakota Game and Fish Department, Bismarck.

Eleven blue suckers were caught during this survey between May and October of 1992. The majority of the report focuses on the pallid sturgeon.

#25 **Etnier, D. A., and W. C. Starnes.** 1993. The fishes of Tennessee. The University of Tennessee Press, Knoxville. Pg. 194-195.

Includes a physical description of both the sicklefin and sturgeon chubs. The sturgeon chub is restricted to the main channels of the Missouri and Mississippi Rivers. Many cutaneous taste buds, keeled scales, dorsal fin coloration, and small eyes are all adaptations for its preferred habitat of turbid, fast waters. A map of the species' distribution is provided. Both chubs are common within the Missouri and Mississippi Rivers.

#26 **Everett, S. R., and D. L. Scarnecchia.** 1996. Progress Report: Distribution, abundance and habitat use of sturgeon chub and sicklefin chub in the Missouri and Yellowstone Rivers, North Dakota. Department of Fish and Wildlife Resources. University of Idaho, Moscow.

The objectives of this study are to gather information on the distribution, abundance, relative density, and habitat use of the sicklefin and sturgeon chubs that will aid in their management. The researchers also gathered data on age-specific microhabitat and macrohabitat use during the summer and fall. The data collected were used to develop a qualitative model for predicting the presence of both species based on habitat characteristics. Three sections with different flow regimes and habitat were studied: a section of the Yellowstone from the Montana border to the confluence with the Missouri, the section of the Missouri from Wilton, North Dakota, to the mouth of the Heart River; and the section of the Missouri from the Montana border east to the Hwy. 85 bridge west of Williston, North Dakota. Both the Williston and Yellowstone sections have high turbidity, few revetment banks, and no major shoreline development. The Yellowstone section is completely free-flowing, but the Williston section is controlled by Fort Peck Dam above the confluence of the two rivers. The last section, the Bismarck section, is controlled by the Garrison Dam and has low turbidity, lots of shoreline development, and many revetment banks.

Each section was sampled using a benthic trawl or a seine at each of the following habitat types; main channel, border channel, side channel, sandbar, and backwater. Each section had different numbers of site types. Sicklefin and sturgeon chubs made up 12.5% of the total catch in the Williston section and 13% in the Yellowstone section. In both sections, sicklefin chub were caught more frequently than sturgeon chub and flathead chub and goldeneye were the most commonly caught species. Only four fish were caught in the Bismarck section, none of which were chubs.

Sturgeon chubs were caught most often in the main channel (61.3%), followed by sandbars (19.4%), border channels (16.1%), and side channels (3.2%). Sicklefin chubs were caught most often in the main channel (63.4%), followed by border channels (22.2%), sandbars (9.5%), and side channels (4.8%). No chub were found in backwaters or revetments. Habitat preference data are still being analyzed.

#27 **Fisher, H. J.** 1962. Some fishes of the lower Missouri River. The American Midland Naturalist 68(2):424-429.

The actual survey took place from April through October 1945. Eleven stations were sampled along the Lower Missouri River from the Iowa border to the river's confluence with the Mississippi. Most of the seining was done near the banks. Twenty-three sturgeon chubs were collected, making this fish one of the rarer ones captured. Twenty-one of these were caught at station #8. Sixty-six sicklefin chubs were also collected. Twenty-six of these were collected at station #2. A map of the stations and river is included, but no description of the water conditions or sites is provided.

#28 **Gale, L. R.** 1985. The status and distribution of commercial and forage fish in the Missouri River and their utilization of selected habitats. Missouri Department of Conservation.

Primary habitat surveyed was sand islands within the Missouri River. Seining was the sampling method chosen and the entire perimeter of each sand island was seined when possible. Larger fish were identified and released and smaller fish were taken back to the lab for identification. The researchers used Shannon and Weaver's equation to calculate species diversity indexes. Diversity was highest at Petite Saline Island and, in general, catch rates were highest in summer and fall. Fish species were considered common if they comprised between 1 and 10% of the total catch. The western silvery minnow was common in this survey, comprising 1.9% of the total catch. This species of fish was collected at every seining, except in June and July.

The plains minnow was the most abundant species, comprising 24% of the total catch, and occurred in all collections at each island. The catch rate was highest in July of 1983 (54%).

Sturgeon and sicklefin chubs were common in this survey, comprising 1.5% of the total catch. The researchers feel that the chubs' rare status is still justified because of its extirpation from previously occupied habitat in the Mississippi River.

#29 **Gardner, B.** 1994. Monthly activity report - September & August 1994 Pallid Sturgeon Study. Montana Department of Fish, Wildlife, and Parks.

Trawl sampling of the Missouri River yielded sicklefin and sturgeon chubs as the first and second most common species collected. A total of 84 sicklefin and 58 sturgeon chubs, along with 137 young-of-the-year of both species had been collected by this date. The section trawled included the area from Cow Island to Nichols Coulee.

Drift netting yielded 21 blue suckers and lower numbers of flathead chub. Flathead chub collected by beach seining was the second most common species. Over 50 percent of the flathead chubs were caught in the section from Wolf Point to Redwater River. The beach seines also caught 29 sicklefin chubs, 3 sturgeon chubs, and 1 young-of-the-year blue sucker.

#30 **Gelwicks, G. T., K. Graham, D. Galot, and G. D. Novinger.** 1996. Final report: Status survey for sicklefin chub, sturgeon chub, and flathead chub in the Missouri River, Missouri. Missouri Department of Conservation.

The objective of this survey was to determine the abundance and distribution of sicklefin and sturgeon chubs in the Missouri River between the Iowa border and St. Louis. Thirteen sites were seined and sicklefin chub were collected at all sites. Sturgeon chub were collected at 11 of the 13 sites. The sites were chosen to allow comparisons with historical surveys. All samples were taken in the late summer to early fall of 1994. Daily river flow data were also taken at local gaging stations and is summarized. Sicklefin chub had extended their range upstream as compared to a 1985 study. Sicklefin chub were present at the head, channel side, bank side, and between bars in the river. They were collected most frequently over sand and gravel substrates where bottom velocities ranged between 0.15 to 0.19 m/s or 0.30 to 0.349 m/s.

Sturgeon chub had also extended their range upstream as compared to a 1985 study. They were collected most frequently from the chute side and bank side of channel bars. Sturgeon chub were found over silt, sand, gravel, and flooded vegetation, but most commonly over gravel where bottom velocities ranged from 0.25 to 0.399 m/s.

Only one flathead chub was collected in 1994. The 1985 survey reported flathead chub at all but three of the thirteen sites. The single fish in 1994 may represent a significant reduction in the fish's range.

The author also collected plains and western silvery minnows during the survey and found their numbers to be declining. The author planned to resample the sites in the fall of 1995 using seines and a bottom trawl.

#31 **Girard, C. F.** 1856. Researches upon the cyprinoid fishes inhabiting the freshwaters of the United States of America, west of the Mississippi Valley, from specimens in the museum of the Smithsonian Institution. Proceedings of the Academy of Natural Sciences, Philadelphia 8:165-213.

Lists the sturgeon chub as *Pogonichthys communis*. The short entry describes the fish and notes its collection from the Milk River, Montana, in 1855.

#32 **Gould, G., and J. Schmulbach.** 1973. Final Report - Missouri River environmental inventory. Relative abundance and distribution of fishes in the Missouri River, Gavins Point Dam to Rule, Nebraska. Missouri Department of Environmental Resources.

Summarizes past surveys of the Missouri River and proposes to add to these studies by measuring the current relative abundance. The 300 mile stretch of the Missouri was divided into five sections based on natural and man-made divisions, such as dams. Electrofishing, seining, gill netting, drift netting, trap netting, poisoning with rotenone and angling were used in the year-long survey. The unit of effort was standardized to attempt to make the methods consistent for analysis. Larger fish were returned to the river after scale samples were taken. Smaller fish and minnows were preserved in formalin and examined in the lab. Blue suckers made up 1.8% of the catch in section I, an unchannelized section. Blue suckers made up 0.9% of the catch in sections II, III and IV; all channelized sections. Blue suckers seemed to prefer tailwaters and sandbars as habitat, although some were found in the main channel and tributaries. Blue suckers and plains minnows were classified as "common" by the authors. Out of the entire survey, about 65% of all fish caught came from the unchannelized sections. A large portion of the report is devoted to methods descriptions.

#33 **Gould, W. R.** 1981. First records of the rainbow smelt (*Osmeridae*), sicklefin chub (*Cyprinidae*), and white bass *(Perichthyidae*) from Montana. Proceedings of the Montana Academy of Science 40:9-10.

Documents William Gardner as the first person to collect sicklefin chub in Montana. He collected the fish on the middle Missouri in 1979. Specimens were placed in the collections of Montana State University in Bozeman.

#34 **Gould, W. R.** 1994. The recent distribution of sturgeon chub (*Macrhybopsis gelida*) in Montana. Montana State University, Bozeman.

Montana Fish, Wildlife, and Parks contracted this survey to update information from a 1993 United States Fish & Wildlife survey. Seining sites were chosen along the Yellowstone and Missouri Rivers based on previous sturgeon chub collections and identified likely habitat. Of the 26 sites, 20 were located on the Yellowstone and 6 were on the Missouri. Only 4 of the 26 sites produced sturgeon chub, and all 4 sites were on the Powder River. The flathead chub was the most common species taken with the sturgeon chub. The productive sites varied in depth from 0.5 to 1.2 ft, the water temperature varied from 68° to 77°F, the water velocity at the bottom depth varied from 0.9 to 1.1ft/s and the channel width varied from 20 to 118 ft. In recent collections, chub habitat in both Montana and Wyoming shared the following characteristics: rock and gravel substrates, high turbidity, no vegetation and depths of less than 0.6 m. Bottom water velocities are probably more important to sturgeon chub as they are bottom feeders. The wider channels had faster velocities. Turbidity at all sites was greater than 1,000 JTU. The author hypothesizes that the chub were not collected in some of the established chub habitat in side channels because of lower water levels in 1994. The author suggests that more complete information on sturgeon chub could be obtained by collecting chub during routine sampling and sharing the data and collected fish with Montana State University's permanent collection. He also suggests night electrofishing and sampling in lower velocity riffles.

#35 **Gould, W. R.** 1994. The current status of sturgeon chub *Macrhybopsis gelida* in Montana. Montana State University, Bozeman.

Reviews the history and threatened status of the sturgeon chub. Recent collections, including the author's, have found that the sturgeon chub may not be as limited in numbers as was thought. In total, sturgeon chub have been found over 650 km in three Montana rivers within the last 2 years. Studies in 1993 and 1994 found sturgeon chub at sites 144 km lower in the Yellowstone and over an additional 135 km of the Missouri than previously documented.

Dam building and low flows are still the major threat to the species. The author feels that despite these threats the species is relatively secure in Montana.

#36 **Grisak, G. G.** 1996. The status and distribution of the sicklefin chub in the middle Missouri River, Montana. Masters Thesis, Montana State University, Bozeman.

A trawling technique used to sample deeper waters significantly improved sampling success. A 2 m by 0.5 m frame was attached to a 5.5 m long net. The net was 3.8 cm mesh on the outer chafing portion and 3.2 mm mesh was used as a liner. The net was equipped with a rockhopper to facilitate trawling over rocky bottoms. Seining only produced four sicklefin chubs, while the deep water method produced 298. The distribution range above Fort Peck Reservoir was 83.7 km spanning from Cow Island to

near C.K. Creek. Habitat variables in successful sicklefin chub catch sites in deep-water zones were mean depth of 3.41 m, mean bottom velocity of 0.58 m/s, and substrate composition of 70% sand, 2% silt, 13% rock, and 15% mixed material. Sicklefin chub sampled ranged from 1 to 4 years in age. Twenty-two gravid females and 11 ripe males were sampled between July 18 and August 16. Probable spawning habitat had water depth of 1.98 m, bottom velocity of 0.58 m/s and rock 2.54-5.05 cm diameter. The youngest reproductively mature chubs were age 2. Condition factors range from 0.243 to 0.964. Annual monitoring of this population should be conducted by trawling at Knox Bottoms (RM 146.5), Sand Creek (RM 158.9), and Sevenmile Creek (RM 173.5). The findings of this study suggest that additional information on the sicklefin chub should be gathered before listing the fish as an endangered species in the middle Missouri River.

#37 **Grisak, G. G.** 1994. Sicklefin project summary. Montana Department of Fish, Wildlife, and Parks. Fort Benton.

Methods used included seining and trawling along a 93 mile section of the Missouri River. Trawling was much more successful as a collection method. Seining sites were categorized by habitat type and water velocity. Most seine samples were located in main channel border and pool habitat types. Sicklefin chub and sturgeon chub scales were collected and aged. The range for the sicklefin chub is 49 miles, spanning from RM 128 (Cow Island) to RM 177 (Nichols Coulee). Core habitat for the sicklefin chub includes the stretch from Upper Two-Calf area to Peggy's Bottoms (34 mi). The range for the sturgeon chub is 84 miles, spanning from RM 93 (Iron City Island) to RM 177 (Nichols Coulee). The sturgeon chub is distributed throughout the entire section, with the area of highest concentration in the Cow Island to Upper Two-Calf area (16 mi.).

Follow-up work will include more seining and trawling in the upper and lower regions, with possible statistical analysis of the trawling data.

#38 **Guillory, V.** 1979. Distributional notes on some lower Mississippi River fishes. Florida Scientist 42:248-250.

Specimens of sturgeon and sicklefin chubs were collected for the first time on the Mississippi in Louisiana. These collections extend the fishes' previous ranges by 1125 and 642 km, respectively.

#39 **Haddix, M. H., and C. C. Estes.** 1976. Lower Yellowstone River fishery study. Final Report. Montana Department of Fish, Wildlife, and Parks.

The data table provides catch records for July 1974 to October 1975. Plains minnows were collected in backwater locations 4 times out of 13 collections and in main channel areas 5 times out of 13 collections. Sturgeon chub were collected twice in backwaters and four times in the main channel.

#40 **Hankinson, T. L.** 1929. Fishes of North Dakota. Papers of the Michigan Academy of Science Arts and Letters. University of Michigan, Ann Arbor.

Physical description of the sicklefin and sturgeon chubs. Although not included in the reviewed material, this key may contain information on the blue sucker, plains minnow, western silvery minnow, and the flathead chub.

#41 **Harlan, J. R., and E. B. Speaker with J. Mayhew.** 1987. Iowa fish and fishing (5th ed). Iowa Department of Natural Resources, Des Moines. Pg. 79.

Very brief description of the sicklefin and sturgeon chubs and their distributions in Iowa. The sturgeon chub is classified as extremely rare. The author's only comment is that the sicklefin chub is limited to the Missouri River in Iowa.

#42 **Hendrickson, J. C., J. D. Lee, and L. McGregor.** 1995. Aquatic investigations of the Missouri River system in North Dakota, report number 16. North Dakota Game and Fish Department, Bismarck.

Sixty-seven blue suckers were caught in May - August. In May, 90% of the blue suckers caught were above river mile 1372. As the summer progressed, more were caught in downstream sections. Most of the blue suckers caught were 6 years or older and some were as old as 10 years. The length-weight regression equation is:
LogW = -4.361 + 2.732 (Log L).

#43 **Hendrickson, J. C., J. D. Lee, and L. McGregor.** 1994. Aquatic investigations of the Missouri River system in North Dakota, report number 12. North Dakota Game and Fish Department, Bismarck.

A list of species found in the Missouri/Yellowstone Rivers above Lake Sakakawea and above Lake Oahe. Plains minnow, sturgeon chub, and flathead chub were all sampled at the site above Lake Sakakawea. Blue suckers had been caught in similar surveys above Lake Sakakawea in the past, but were not caught in 1991, 1992, or 1993. Plains minnow, western silvery minnow, blue sucker, sicklefin chub, and flathead chub were sampled within Lake Sakakawea. Plains minnow, western silvery minnow, and blue sucker were sampled at the site above Lake Oahe. Plains minnow, western silvery minnow, flathead chub, and blue sucker were sampled within Lake Oahe.

#44 **Hendrickson, J. C., J. D. Lee, and L. McGregor.** 1993. Aquatic investigations of the Missouri River system in North Dakota, report number 7. North Dakota Game and Fish Department, Bismarck.

A list of species found in the Missouri/Yellowstone Rivers above Lake Oahe. Plains minnow, western silvery minnow, blue sucker, sicklefin chub, and flathead chub were all sampled within Lake Oahe. Two blue suckers were caught in the mouth of the Knife River and one was caught in the mouth of the Heart River.

#45 **Herzog, D.** 1995. LTRMP fisheries annual report. Missouri Department of Conservation, Cape Girardeau.

A catch record for sicklefin chub and summary of methods used on the open river at Cape Girardeau for the years 1991 to 1994. In 1991, 57 sicklefin chubs were sampled with a trawl, 16 with a seine, and 27 by electrofishing. In 1992, 19 sicklefin chubs were sampled with a trawl, 18 with a seine, and 9 by electrofishing. In 1993, 1 sicklefin chub was sampled with a trawl, none with a seine, and 5 by electrofishing. In 1994, 2 sicklefin chub were sampled with a trawl, 3 with a seine, and 15 by electrofishing.

#46 **Hesse, L. W., J. C. Schmulbach, J. M. Carr, K. D. Keenlyne, D. G. Unkenholz, J. W. Robinson, and G. E. Mestl.** 1989. Missouri River fishery resources in relation to past, present, and future stresses. Pg. 352- 371. In Dodge, D. P. Proceedings of the International Large River Symposium (LARS). Canadian Special Publications Fisheries and Aquatic Science 106.

Nearly one-third of the Missouri River has been impounded, one-third channelized, and the hydrologic cycle, including temporal flow volume and sediment transport, has been altered on the remainder. The changes in basin and floodplain physiography and channel morphology have reduced commercial fish harvest by more than 80% and are implicated in the demise of native species. The plains minnow is distributed within the Missouri River in Missouri, Kansas, Nebraska, Wyoming, South Dakota, North Dakota, and Montana. The sturgeon chub is distributed within the Missouri River in Missouri, Iowa, Kansas, Nebraska, Wyoming, South Dakota, North Dakota, and Montana. The flathead chub is distributed within the Missouri River in Missouri, Iowa, Kansas, Nebraska, Wyoming, South Dakota, North Dakota, and Montana. The sicklefin chub is distributed within the Missouri River in Missouri, Iowa, Kansas, Nebraska, South Dakota, North Dakota, and Montana. The sicklefin chub is considered endangered or a species of special concern in Missouri, Kansas, North Dakota, and South Dakota. The sturgeon chub is considered endangered or a species of special concern in Missouri, Kansas, North Dakota, and South Dakota. The blue sucker is distributed within the Missouri River in Missouri, Iowa, Kansas, Nebraska, South Dakota, North Dakota, and Montana. The blue sucker is considered a threatened species in Kansas and North Dakota.

Suggested solutions to the degradation of fish habitat include: a holistic management plan, acquisition of data on minimum flow requirements to maintain or reestablish natural channel morphology, creation of fish bypass structures around dams, a solution to degradation/aggradation imbalances through mechanical sediment moving measures, modifications of release patterns to mimic natural flows, development of structural modifications to recreate lost habitat, a moratorium on the stocking of non-native species of fishes and innovation of means to pay for needed mitigation.

#47 **Hesse, L. W.** 1993. The status of Nebraska fishes in the Missouri River. Unpublished Report, Federal Aid in Sport Fish Restoration, Dingell-Johnson Project F-75-R-11, Nebraska Game and Parks Commission, Norfolk.

Short life histories are provided for the sicklefin chub, sturgeon chub, plains minnow, and western silvery minnow. Samples were collected using 15.2 m X 1.8 m seines. Fish were preserved in the field in formalin and transported to the lab for examination. Although seining effort was difficult to standardize, the catch-per-unit effort for this 1986-1993 survey was only 60% of CPU in a similar survey in 1970-1975. Sicklefin and sturgeon chubs appear to have been extirpated from the Missouri River in Nebraska upstream of Lewis and Clark Lake. Plains and western silvery minnows represented less than 1% of the total catch and should be considered very rare in the lower channelized reach and the reach above Lewis and Clark Lake. Plains and western silvery minnow abundance is down 98% in comparison to 1970 levels. No sicklefin or sturgeon chubs were collected in either of the unchannelized portions sampled. The author suggests the establishment of a flooding corridor from Fort Randall Dam downstream to increase the influx of organic matter and off-channel habitat. The water released must be mixed to prevent artificial stimulation of the fishes' reproductive cycles, and spring and early summer pulse releases must be maintained to mimic natural reproductive cues.

#48 **Hesse, L. W.** 1994. The status of Nebraska fishes in the Missouri River, selected chubs and minnows. sicklefin chub, sturgeon chub, flathead chub, silver chub, speckled chub, plains minnow, and western silvery minnow. Transactions of the Nebraska Academy of Sciences (21).

A status report based on sampling completed between 1971 and 1993. The sicklefin chub is described as a minnow with reduced eyes, many taste organs on its fins and skin, a preference for sandy bottoms with moderate current, and a food sorting adaptation for its habitat. The sicklefin chub feeds mainly on detritus and insect larvae and spawns in the spring. The sturgeon chub is described as preferring gravel bottoms with strong current, having highly developed cutaneous sense organs like the sicklefin chub, and a shape that helps it hold itself close to the bottom despite the strong currents. The sturgeon chub feeds mainly on aquatic insects and spawns in the summer. Its historical range has recently been much reduced.

The plains minnow is described as living in the margin of the stream channel. It is herbivorous and gets most of its food in shallow sandbar habitat. Unfortunately, this type of habitat is almost gone, and the plains minnow is having trouble surviving. The range and status of the minnow is not well established, but in early surveys (Cross 1967) the species was abundant.

The western silvery minnow is often found in backwaters or protected areas, although it has been seen in schools with plains minnows. The western silvery minnow feeds on decaying plant material, diatoms, algae, and fungi. The numbers of western silvery minnow were shown to be declining from 1978-1983.

All of the species studied have declined, some by as much as 98%. The sturgeon and sicklefin chubs face a real threat of extinction. All of the species' decreasing numbers have contributed to the declines in larger predatory fish such as the burbot, sauger, and catfish. The author recommends establishing a flood plain corridor from Fort Randall Dam downstream and restoring the natural level of sediment in the rivers in order to provide cover for the fish. He also recommends planning releases to mimic natural flows and mixing the released water to prevent temperature miscues for the fishes' reproductive cycles.

#49 **Hesse, L. W., G. E. Mestl, and J. W. Robinson.** 1993. Status of selected fishes in the Missouri River in Nebraska with recommendations for their recovery. Biological Report 19. Nebraska Game and Parks Commission, Norfolk.

The increased impoundment and channelization of the Missouri River has lead to the degradation of necessary habitat for several fish species. The species addressed in this report include: blue sucker, sturgeon chub, plains minnow, western silvery minnow, flathead chub and sicklefin chub. Detailed information is provided on the morphometry and hydrology of the river. Difficulties arise in the management of the river because of the state's management of the water and the wildlife agencies' management of the fish do not always coincide. The authors suggest the creation of a Missouri drainage basin management agency that would coordinate control of the entire river system. They also suggest developing minimal controlled release plans, similar to those done in Montana, for the entire basin. All mainstem dams need a fish bypass system to allow movement through the system and channel bed degradation must be addressed and repaired. By releasing sediments from reservoirs, the authors feel the habitat would improve and the life of the reservoirs would be extended. Release schedules must mimic those in nature to rejuvenate the stream and cue reproductive behavior. The authors also suggest the redistribution of funds from projects designed to maintain navigable

channels between Sioux City and the mouth, to other projects such as the ones listed above.

#50 **Hilohowskyj, C. P., M. M. Coburn, and T. M. Cavender.** 1989. Comparisons of pharyngeal filtering apparatus in seven species of the herbivorous cyprinid genus *Hybognathus* (Pisces:Cyprinidae). Copeia 1989 (1):172-83.

In all seven species of the herbivorous cyprinid genus *Hybognathus*, pharyngeal taste buds are arranged in a pattern that suggests a filtering apparatus. The dorsal pharynx has a patch of small papillae that grade into larger posterior buds. Ventrally, prominent transverse ridges cross the first, second, and third gill arches; joining the anterior gill rakers to those on the posterior border of the arch. Proximally, the ridges merge into V-shaped flaps covering the basibranchials. The major comb, the largest, is associated with the first arch and has marginal and surface papillae. The minor comb, the smallest, is associated with the second arch and has marginal papillae. Proximal gill rakers of the second arch, located between the major and minor combs, have rows of papillae, and merge into a central, random patch of papillae. None of the other 40 nearctic cyprinid species surveyed has comparable pharyngeal modifications. Six counted variables and one measurement, major comb width, were used to make intra- and interspecific comparisons. *Hybognathus argyritis* (western silvery minnow) is most similar to *H. nuchalis*, which had the highest values for counted variables. *Hybognathus placita* (plains minnow) is most similar to *H. amurus*. Discriminant analysis classified 92.02% of specimens correctly, indicating that the variation observed in these structures is probably species specific.

#51 **Holton, G.** 1980. The riddle of existence: fishes of "special concern." Montana Outdoors 11:2-6, 26.

Notes the limited distribution of the sturgeon chub in the Mississippi drainage basin. Sturgeon chub were first sampled on the Milk River in 1855. Dr. G.T. Baxter of the University of Wyoming believes the sturgeon chub to be more common than was formerly thought, but that care must be exercised in order to prevent its decline.

The first sicklefin chub collected in Montana was in 1979 by R. Berg and B. Gardner on the Missouri River between Cow Island and Fort Peck Reservoir. Because of its specialization for the silty waters, this species' survival may be threatened by the impoundments of the Missouri .

#52 **Hunter, C.** 1991. A sucker called blue. Montana Outdoors, September/October, pg. 2-5.

A popular article that describes the physical distinguishing characteristics of the blue sucker and gives a little history on the population in Montana. Research done in Kansas showed that the suckers preferred smooth substrate with fast current (3 fps) for habitat and were awkward in their movements over rough substrate or in slower currents. Their habitat also dictates their food (macroinvertebrates). The author notes that although the blue sucker is considered a species of special concern by the American Fisheries Society (AFS), it is not given this classification by the Montana Chapter of the AFS or the Montana Fish, Wildlife, and Parks. Young blue suckers are rarely collected despite the apparently healthy adult populations in some rivers. The author suggests that more research is needed to determine why the surveys miss these juvenile fish or why there are so few.

#53 **Jenkins, R. E.** 1979. *Hybopsis gelida* Girard. Page 185 in D.S. Lee, C.R. Gilbert, C.H. Holcutt, R.E. Jenkins, D.E. McAllister, and J.R. Stauffer, editors. Atlas of North American freshwater fishes. North Carolina State Museum of Natural History, Raleigh.

Description of the physical characteristics, nomenclature, and distribution for the sturgeon chub. A map with the points of collection marked is provided.

#54 **Jenkins, R. E.** 1979. *Hybopsis meeki* Girard. Page 191 in D.S. Lee, C.R. Gilbert, C.H. Holcutt, R.E. Jenkins, D.E. McAllister, and J.R. Stauffer, editors. Atlas of North American freshwater fishes. North Carolina State Museum of Natural History, Raleigh.

Description of the physical characteristics, nomenclature, and distribution for the sicklefin chub. A map with the points of collection marked is provided.

#55 **Johnson, B., J. Lott, W. Nelson-Stastny, and J. Riis.** 1996. Annual fish population and sport fish harvest surveys on Lake Oahe, South Dakota, 1995. South Dakota Department of Game, Fish, and Parks, Wildlife Division, Annual Report No. 96-12.

The annual fish survey's purpose is to evaluate management's ability to provide angling opportunities in the future. The survey measures species' composition, relative abundance, age and condition, recruitment, survival rates and population size structure. Angler effort and harvest are also quantified. A map of the study area with locations for all survey methods is provided. No flathead chub were caught during the 1995 survey. During the years 1991 to 1995, only 1994 produced any flathead chub. In 1994, trace (value <0.05 per seine haul) numbers of flathead chub were collected. The majority of the report concerns the gamefish in the lake such as walleye and sauger.

#56 **Johnson, B., J. Lott, W. Nelson-Stastny, and J. Riis.** 1995. Annual fish population and sport fish harvest surveys on Lake Oahe, South Dakota, 1994. South Dakota Department of Game, Fish, and Parks, Wildlife Division, Annual Report No. 95-7.

The annual fish survey's purpose is to evaluate management's ability to provide angling opportunities in the future. The survey measures species' composition, relative abundance, age and condition, recruitment, survival rates, and population size structure. Angler effort and harvest are also quantified. A map of the study area with locations for all survey methods is provided. In 1994, trace (value <0.05 per seine haul) numbers of flathead chub were collected. The majority of the report concerns the gamefish in the lake such as walleye and sauger.

#57 **Johnson, B., D. Fielder, J. Riis, C. Stone, D. Warnick, and G. Wickstrom.** 1989. Annual fish population surveys on South Dakota Missouri River Reservoirs. South Dakota Department of Game, Fish, and Parks.

The reservoirs are a large supplier of income for South Dakota, providing $21.4 million in revenue. The annual fish survey's purpose is to evaluate management's ability to provide angling opportunities in the future. The survey measures species' composition, relative abundance, age and condition, recruitment, survival rates, and population size structure. A map of the study area with locations for all survey methods is provided. The area extends from Lake Oahe to Lewis and Clark Lake. Gill nets and seines were the

primary methods of collection. Sampling methods were adapted to catch certain species. Blue suckers were found in small numbers in Lake Oahe. Blue suckers had not been caught at all in Lake Oahe in previous surveys. Most of the information describes walleye, sauger, smelt, and paddlefish results.

#58 **Johnson, R. E.** 1942. The distribution of Nebraska fishes. Ph.D. Dissertation, University of Michigan, Ann Arbor.

Short description of the range, habitat, and distribution of the sturgeon and sicklefin chubs in Nebraska.

#59 **Jordan, D. S., and B. W. Evermann.** 1896. The fishes of North and Middle America, Parts I-IV. Bulletin of the U.S. National Museum 47:1-10.

Contains a dichotomous key and short descriptions of members of the genus *Hybopsis*.

#60 **Jordan, D. S., and C. Gilbert.** 1882. Synopsis of the fishes of North America. Proceedings of the U.S. National Museum 4:216-217.

Describes *Ceratichthys gelidus* (sturgeon chub) and notes its collection on the Milk River in Montana.

#61 **Jordan, D. S., and S. E. Meek.** 1885. List of fishes collected in Iowa and Missouri in August 1884, with description of three new species. Proceedings of the U.S. National Museum 8:1-17.

Lists the sturgeon chub, sicklefin chub, and plains minnow.

#62 **Kansas Academy of Science.** 1973. Rare, endangered, and extirpated species in Kansas. 76(2):96-106

A listing of classified species in Kansas. Sicklefin chub are listed as being a peripheral species in Kansas. A peripheral species was defined as a species with limited numbers in Kansas, because Kansas is at the edge of its range. These species are not considered rare or endangered in their total range, but are noted because they may be at risk within Kansas because of low numbers. The suggestion for helping the sicklefin chub is to preserve portions of the Missouri River.

The blue sucker is listed as rare in Kansas, but not rare nationally. A rare species is one that has declined in Kansas during the last 100 years. These species must meet one of the following criteria: rarity is due to specialized habitat; current management may not prevent the decline of the species; or environmental deterioration may have caused, or be causing, the decline of the species. The recommendations for the blue sucker are to control siltation and organic pollution and to maintain long, unobstructed channels.

#63 **Kelsch, S. W.** 1993. Survey of the fishes of the Little Missouri River from Marmarth to Medora, North Dakota. Department of Biology, University of North Dakota, Grand Forks.

The Little Missouri is characterized by high turbidity, intermittent flow, shifting sediments, and limited aquatic vegetation. The sicklefin chub has not been collected here since 1955. Samples were collected at 24 sites at 8 km intervals using 3 and 6 m seines during an 8-day period in July 1993. The author recorded the species and length of each specimen, standard water chemistry, and flow data at each site. All specimens were preserved in 40% isopropyl and placed in the collection of the University of South Dakota.

The weather during this study was unusually wet, with 2 days of precipitation in excess of one-half inch. In general, both catch numbers and diversity were low. The plains minnow was the second most common species found, but the author was unsure about identifying those less than 35 mm in length. Multiple age groups of plains minnows was evidence of successful reproduction.

The dissolved oxygen levels averaged near 7.5 mg/L, with water temperatures of 17 to 22 degrees Celsius. Turbidity was very high, with Secchi disc readings of 0.5 to 2.0 cm. The author feels that the high flow levels may explain the absence of several previously collected species in the study area. The three most prevalent species in the study, including the plains minnow, are adapted to high flow and turbidity. The absence of the sturgeon chub is notable because of its status as a species of special concern. The author suggests that the impounding of the Missouri River by Garrison Dam may have brought about the final exodus of the sturgeon chub.

#64 **Kelsch, S. W.** 1994. Lotic fish community structure following transition from severe drought to high discharge. Journal of Freshwater Ecology 9(4):331-341.

A survey of the Little Missouri River conducted in the very wet summer (July) of 1993. Water velocities were high (0.4 to 0.87 m/s) and water temperatures, levels and discharges fluctuated dramatically in response to rainfall. Only 13 species were collected in the 190 m reach. The fish community was different and less diverse than in the past. Ten species previously collected were absent and six species collected had not been collected before. The sturgeon chub was not collected, even though it was common in the Little Missouri in the 1970's.

#65 **Klutho, M. A.** 1983. Seasonal, daily, and spatial variation of shoreline fishes in the Mississippi River at Grand Tower, Illinois. Masters Thesis, Southern Illinois University, Carbondale.

Specimens of western silvery minnow, plains minnow, sicklefin chub, flathead chub, and sturgeon chub were collected. The western silvery minnow and sturgeon chub were rare. The sicklefin chub, flathead chub, and plains minnow were common. The sicklefin chub was significantly associated with high water levels, low water temperatures, and sand substrate. The sicklefin chub was the only species whose collection was strongly associated with a time of day (1400 hrs). The flathead chub was significantly associated with sand substrate, moderate current, and time of year (February and June peaks).

#66 **Kreil, R.** 1986. Rare fishes of North Dakota. North Dakota Outdoors 48(10):14.

A description of habitat associations and adaptations of the sicklefin and sturgeon chubs is provided. The sicklefin chub is listed as endangered in North Dakota by the Endangered Species Committee of the North Dakota Chapter of the Wildlife Society. The same committee lists the sturgeon chub as threatened. Both species are class II, which means that they are slated for further study before protection is granted.

#67 **LeSueur, C. A.** 1817. A new genus of fishes, of the order Abdominales, proposed under the name of *Catostomus*; and the characters of this genus, with those of its species, indicated. Transactions of the Academy of Natural Sciences. October 1817. Pg.102-111.

An early description of the blue sucker from the Ohio River. Of interest because at the time several other species were grouped into a genus with the blue sucker. It is now the sole member of its genus, *Cycleptus*. The entry provides a detailed physical description of a single preserved (dried) specimen. A full page plate is included. The individual was 2 feet in length with a 3-inch long head from snout to eye.

#68 **McInery, M. G.** 1988. A collection of young-of-the-year blue suckers. Transactions of the Wisconsin Academy of Sciences, Arts and Letters 76:69-70.

Ten young-of-the-year blue suckers (*Cycleptus elongatus*) were collected in July 1979 and June 1980 from intake screens of a steam-electric station located on the east shore of Navigation Pool 9 (river mile 678.5) of the Mississippi River. These blue suckers probably hatched in early May and may have been reared in the tailrace below Lock and Dam No. 8.

#69 **Mestl, G. E., and L. W. Hesse.** 1991. Compendium of fisheries data from the Missouri River, Nebraska. Nebraska Game and Parks Division. Project F-75-R-8, Job No. 1.

A report on the results of a large collection effort to quantify the types and numbers of fish in the Missouri River. The number of flathead chubs is of concern, as in 1990 there were none collected. See table #4. Blue sucker larvae were collected in 1990. Most of the report is focused on game fish such as walleye and paddlefish. Most of the information on fish concerned in this bibliography is in the form of catch records with little or no interpretation.

#70 **Metcalf, A. L.** 1966. Fishes of the Kansas River system in relation to zoogeography of the Great Plains. University of Kansas, Museum of Natural History 17(3):23-189.

A short description of the habitat, distribution, and zoogeography of the sicklefin and sturgeon chubs. Although not included in the reviewed material, this reference may have information on the blue sucker, the plains minnow, or the western silvery minnow.

#71 **Michaletz, P., B. Johnson, J. Riis, C. Stone, D. Unkenholz, and D. Warnick.** 1986. Annual fisheries surveys on the Missouri River Reservoirs, 1981-1985. South Dakota Department of Game, Fish, and Parks. Progress Report No. 86-11.

The reservoirs are a large supplier of income for South Dakota, providing $21.4 million in revenue. The annual fish survey's purpose is to evaluate management's ability to provide angling opportunities in the future. The survey measures species' composition, relative abundance, age and condition, recruitment, survival rates and population size structure. A map of the study area with locations for all survey methods is provided. The area extends from Lake Oahe to Lewis and Clark Lake. Gill nets and seines were the primary methods of collection. Sampling methods were adapted to catch certain species. Blue suckers were caught in Lake Oahe in the 1982 surveys. Most information describes walleye, sauger, smelt and paddlefish results.

#72 **Miller, R. J., and H. W. Robison.** 1973. The fishes of Oklahoma. Oklahoma State University Press. Stillwater. Pg. 120-121.

A short, physical description of the blue sucker as a streamlined fish with a long, falcate dorsal fin. The mouth is inferior and small with papillose lips. Scales are tiny with more than 50 in the lateral line. Its preferred habitat is the deep, fast currents of turbid rivers and some lake channels. It is presumed to be bottom feeding, although exactly what it eats is unknown. Blue suckers are a good eating fish and were harvested commercially for a short time.

#73 **Miller, R. R.** 1972. Threatened freshwater fishes of North America. Transactions of the American Fisheries Society 101(2):239-252.

The sturgeon, flathead, and sicklefin chubs are listed as part of a table of threatened freshwater fish of the United States. No additional information on the fish is given.

#74 **Montana Fish and Game Department.** 1963. Missouri River fish population study. Job Completion Report. Project No. F-11-R-10, Job No. III.

The purpose of the survey was to capture sauger in the Missouri River between Morony Dam and Fort Peck Reservoir. Only 173 sauger were captured, tagged, and released. Twenty-three blue suckers were collected during the survey with an average weight of 5.67 pounds and an average length of 26.6 inches. Units are not specified in the tables, but appear to be pounds and inches. The authors recommend that more intensive effort be applied to researching the importance of tributaries to this section of the Missouri to the population of sauger.

#75 **Montana Department of Fish, Wildlife, & Parks.** 1980. Lower Missouri River basin investigations planning inventory, fisheries. Job Progress Report. Project No. FW-2-R-9, Job No. I-b.

The study period spanned from July 1, 1979, to June 30, 1980, and covered the Missouri River from Fort Peck Dam to North Dakota. A total of 3,067 fish were sampled, including 1,606 game fish. Flathead chub were one of the most abundant non-game species collected. The objectives of the survey were to inventory fish species on the river and collect data on important factors for fish survival such as tributary stream flows. Other data collected included spawning area surveys, fish collection method evaluation, sampling of larval and young-of-the-year game fish, and tagging game fish. Methods used for collection were: gill netting, electrofishing, baited hoop nets, and frame trap nets. The report focuses mostly on the game fish and the data on the flathead chub is limited to numbers caught.

#76 **Montana Department of Fish, Wildlife, & Parks.** 1981. Lower Missouri River basin investigations planning inventory, fisheries. Job Progress Report. Project No. FW-2-R-10, Job No. I-b.

The study period spanned from July 1, 1980, to June 30, 1981, and covered the Missouri River from Fort Peck Dam to North Dakota. A total of 4,510 fish were sampled, including 2,378 game fish. In 1980, streamflow was low and fewer larval fish were caught. Flathead chub made up only 0.3 percent of the catch in gill nets for 1981 (only 3 individuals were caught). The flathead chub was noticeably less abundant upstream of Sand Creek than in previous years. The objectives and methods for this

1981 survey were the same as the 1979 survey (see above). The report focuses mostly on the game fish, and the data on the flathead chub is limited to numbers caught.

#77 **Montana Department of Fish, Wildlife, & Parks.** 1982. Lower Missouri River Basin Investigations Planning Inventory. Fisheries. Job Progress Report. Project No. FW-2-R-11, Job No. I-b.

The study period spanned from July 1, 1981, to June 30, 1982, and covered the Missouri River from Fort Peck Dam to North Dakota. A total of 1830 fish were sampled, including 183 game fish. Another low streamflow year was 1981. Flows were maintained by releases from Fort Peck Reservoir. This year a larger effort was put into sampling non-game fish with electrofishing and sicklefin chub were found for the first time. A large concentration of blue suckers was found just downstream from the Milk River. The overall distribution of blue suckers was very uneven. Flathead chub were abundant in downstream sections. A total of 115 flathead chub were caught using electrofishing. The flathead chub was less abundant upstream of Sand Creek. The objectives and methods for this 1982 survey were the same as the 1979 survey (see above). Flathead chub were caught primarily in the gill nets. The report focuses mostly on the game fish and the data on the flathead chub is limited to numbers caught.

#78 **Moore, G. A.** 1950. The cutaneous sense organs of barbeled minnows adapted to life in the muddy waters of the Great Plains region. Transactions of the American Microscopy Society 69:69-95.

The paper provides a quantitative and qualitative description of the taste buds and lateral line function in fishes adapted to silty waters. Fish were examined under a microscope and compared to close relatives that live in clear waters. The sicklefin chub has taste buds on its fins (excepting the caudal). Some of the chemical sensing ability of the fishes is used to select habitat. The sicklefin chub was pointed out for its extremely reduced eye, often covered with a flap of skin. The genus *Macryhybopsis* has the most highly developed cutaneous sense organs of any North American cyprinids. Taste buds protrude from the skin all over the fish's body with a concentration near the head. Taste buds are found on the anterior margin of all fins, except the caudal. The sensory organ counts for the sturgeon chub were higher than those for the sicklefin. This is counter intuitive, since the sicklefin has reduced eyes and the sturgeon chub has large, well developed eyes in comparison. The author wonders if the sicklefin chub might be preadapted to burrow or cave life.

#79 **Morris, J., L. Morris, and L. Witt.** 1974. The fishes of Nebraska. Nebraska Game and Parks Commission, Lincoln.

Contains a chart of uncommon species for Nebraska. The sturgeon chub and sicklefin chub are listed. Although not included in the reviewed material, this reference may have information on blue sucker, plains minnow, or western silvery minnow.

#80 **Morris, L. A.** 1960. The distribution of fish in the Platte River, Nebraska. M.A. Thesis, University of Missouri, Columbia.

The material provided for this review was limited to tables of relative abundance of fishes. *Hybopsis meeki* (sicklefin chub) was rare. *Hybognathus placita* (plains minnow) was listed as occurring in the Platte River, but was not caught during this survey.

#81 **Moss, R. E., J. W. Scanlan, and C. S. Anderson.** 1983. Observations on the natural history of the blue sucker (*Cycleptus elongatus* Le Seur) in the Neosho River. The American Midland Naturalist 109(1):15-22.

Populations of blue suckers were sampled by electrofishing during the spring and summer of 1976 and 1977. Spawning occurred in May in deep riffles with cobble and bedrock substrates. Water temperatures at spawning were 20-23°C. By August, juveniles averaged 125 mm in length. Mature females reached greater maximum lengths, weights, and age than males. Comparative charts are provided. Condition coefficients varied slightly with time of year. The few juveniles captured occupied slower and shallower habitats than adults. Laboratory experiments confirmed a preference for smooth substrates and swift current for adults. Adults and young ate mostly invertebrate larvae and plant material. A listing of food items by volume and occurrence is provided. Blue suckers seemed to be limited by their habitat preference, particularly during spawning. Pollution and siltation are cited as possible causes for this limitation.

#82 **Nebraska Game & Parks Commission.** 1990. Missouri River ecology. Federal aid in fish restoration. Dingell-Johnson Project F-75-R-7.

Main author for this survey is Larry W. Hesse. Most of the report focuses on the status of the commercial catfish fishery within the State. The plains minnow, flathead chub and blue sucker are all listed as species for the Missouri River, but no catch data are provided.

#83 **Nebraska Game & Parks Commission.** 1991. Missouri River ecology. Federal aid in fish restoration. Dingell-Johnson Project F-75-R-8.

The majority of this report focuses on the status of channel catfish in Nebraska. Commercial harvesting is discussed in relation to fish population management. Plains minnow, silvery minnow, and blue sucker are noted in collection tables, but are not discussed in the text of the report.

#84 **Nelson, W. P.** 1962. Report of fisheries investigations during the 9th year of impoundment of Fort Randall Reservoir, South Dakota. Dingell-Johnson Project F-1-R-11.

Two blue suckers were caught during the survey. No other information is given about the species.

#85 **O'Donnell, D. J.** 1935. Annotated list of the fishes of Illinois. Illinois Natural History Survey. Bulletin 20(5):473-500.

The sturgeon chub is listed as newly discovered in Illinois. Several specimens were taken from the Mississippi at Chester in February of 1930. (This is the entire text of the entry.)

#86 **Omaha Public Power District.** 1977. The effects of entrainment and impingement at the Fort Calhoun station on the fisheries of the channelized Missouri River. Environmental Series Bulletin No. 3.

Two blue suckers were entrained in the Fort Calhoun Station between January and December of 1975. One was alive and one was dead when found; 22 juvenile blue suckers were caught in North Slough near the station on June 10 of the same year.

#87 **Omaha Public Power District.** 1982. The Nebraska city station fisheries monitoring program. Environmental Series Bulletin No. 6.

Seven sicklefin chubs and two sturgeon chubs were impinged during diurnal and nocturnal sampling at Nebraska City Station between May of 1979 and May of 1982. Flathead chub and blue sucker were also caught during electrofishing and seining surveys. Very detailed catch records are provided for the entire sampling period.

#88 **Page, L. M., and B. M. Burr.** 1991. A field guide to freshwater fishes of North America north of Mexico. The Peterson Field Guide Series. Houghton Mifflin Company, Boston.

Includes short descriptions of the physical characteristics, range, habitat, and similar species for the flathead chub, sicklefin chub, and sturgeon chub. Also has comparative line drawings of each species. Although not included in the reviewed materials, this reference may have information on the plains minnow, western silvery minnow, or blue sucker.

#89 **Personius, R. G., and S. Eddy.** 1955. Fishes of the Little Missouri River. Copeia 7:41-43.

Completed before the final opening of Garrison Dam, this survey's purpose was to establish pre-dam species diversity estimates. The sicklefin chub collected in this survey was the first ever found in the Little Missouri. The sicklefin specimens were taken near the mouth. No sturgeon chub were found, despite its presence during a 1926 survey. Flathead chub were also absent.

#90 **Peterka, J. J.** 1993. Survey of fishes in the Little Missouri and Knife Rivers, and in Spring Creek in southwestern North Dakota, 1993. North Dakota State University, Fargo.

Seining was used to collect fish on several tributaries of the Little Missouri and Knife Rivers. Each sampling site is described in detail within the paper. A map showing the locations of each site is included. Western silvery minnows were only sampled on the Little Missouri River. Western silvery minnows were found to be uncommon at site 1, just North of Medora; site 6, at Rockeman Ranch; and site 7, in the north unit of Theodore Roosevelt Park. Western silvery minnows were found to be common on one sampling day at site 5, at Nelson Ranch. Plains minnows were found to be abundant or common at 9 out of 12 sampling sites on the upper portion of the Little Missouri River.

#91 **Peters, E.J., and R.S. Holland.** 1994. Biological and economic analyses of the fish communities in the Platte River: Modifications and tests of habitat suitability criteria for fishes in the Platte River. Federal Aid in Fish Restoration Project No. F-78-R Study III: Job III-2. University of Nebraska, Lincoln.

The objective of this study was to evaluate current habitat suitability criteria and develop habitat suitability criteria for additional species. Abundance of western silvery minnows decreased dramatically from 1987 to 1993. From 1987 to 1989, the authors collected 848 specimens from 123 grids within the study area. From 1990 to 1993, they only collected 4 specimens from 4 grids. Habitat use for all years is concentrated in water less than 30 cm in depth with current velocities between 10 and 40 cm/s over sand substrate with no cover. However, areas with cover and either gravel or silt substrate had high suitability values. The authors recommend that new criteria focus on shallower, slower current conditions and greater importance given to combined cover.

Plains minnows also showed a decline in numbers. From 1987 to 1989, the authors collected 1,346 specimens from 247 grids within the study area. From 1990 to 1993, they collected 505 specimens from 142 grids. Plains minnows used habitats with higher velocity values than expected, given the suitability criteria. They also preferred sandy substrate with little or no cover. Plains minnows were found in depths up to 90 cm, although suitability criteria suggested depths of 11 to 50 cm as best. The higher values found for depth and velocity suggest that plains minnows use shorelines stabilized with rip-rap.

Only one sturgeon chub has been collected by the authors since 1987 and habitat suitability criteria appears to be similar to that of the speckled chub. Speckled chub prefer sandy bottomed, turbid, fast water.

Flathead chub use habitat with depths of 10 to 50 cm, with velocities of 11 to 40 cm/s over sand substrate with no cover. The values gathered in this survey suggest that a broadening of the habitat suitability values would be appropriate.

#92 **Peters, E. J., R. S. Holland, M. A. Callam, and D. L. Bunnell.** 1989. Platte River suitability criteria - habitat utilization, preference and suitability index criteria for fish and aquatic invertebrates in the Lower Platte River. Nebraska Technical Series No. 17, Nebraska Game and Parks Commission, Lincoln.

The study focussed on channel catfish and potential forage fish for the catfish. Only one sturgeon chub was collected. The fish was collected at mile 60 on the Platte River in 21 cm of water flowing at 47 cm/s. The substrate was sand. The specimen (ZM-3656) is catalogued in the University of Nebraska State Museum.

#93 **Pflieger, W. L.** 1971. A distributional study of Missouri fishes. University of Kansas Publications, Museum of Natural History, Lawrence 20(3):225-570.

The sturgeon chub occurs only in the Missouri and lower Mississippi Rivers. This chub inhabits the main channels of silty rivers where sand is the principal substrate. The sicklefin chub's distribution is similar to that of the sturgeon chub, but the sicklefin is far more abundant. The sicklefin increases in abundance towards the mouth of the Missouri. In Missouri, its habitat is not notably different from the sturgeon chub. Flathead chub are found over firm, sandy substrate with fast currents. The flathead chub in Mill Creek is morphologically intermediate between the two subspecies of *Hybopsis gracilis*. Maps for the distribution of all three fishes are provided.

#94 **Pflieger, W. L.** 1975. The fishes of Missouri. Missouri Department of Conservation, Jefferson City. Pg. 138-141.

Provides life history, distribution, and habitat information only for the flathead chub, sturgeon chub, and sicklefin chub. Distribution information is limited to Missouri.

#95 **Pflieger, W. L., and T. B. Grace.** 1983. Changes in the fish fauna of the lower Missouri River, 1940-1983. Pages 166-177 In Matthews, W.J. and D. C. Heins, Community and evolutionary ecology of North American stream fishes. University of Oklahoma Press.

A study of the Missouri River's fish populations after channelization changed the river from a braided, slow, turbid flow pattern to a swift, deep, narrow channel with lower turbidity. Data from surveys completed in 1885 and 1892, both by Meek, established prechannelization population estimates. In the surveys for this study, completed between 1945 and 1983, the author found that the sicklefin and sturgeon chub populations had not declined despite their apparent specialization for life in the river before the human made changes. The plains minnow and the western silvery minnow both showed a substantial decline. The plains minnow, flathead chub, and western silvery minnow made up 93.4% of the smaller fishes in the earliest survey. Their proportion was 61.9% in 1963 and 72.3% in 1982. River environment changes are described, including the history of reservoir development, channel rerouting and subsequent flow changes. Sampling methods included seining, hoop netting, and electrofishing the river in three sections from the Iowa-Missouri border to the mouth (885 km). Sampling was conducted primarily in 1945, 1963, and 1982. No electrofishing was done in 1945.

Some fish showed a markedly different abundance in the three sections. Plains minnows were more common in the upper section, while two chub species were more common in the lower section. The discussion section outlines the possible reasons for the changes in species abundance and diversity. Although some species increased in numbers while others decreased, the overall fish diversity in the river increased over the survey period. The author suggests introductions and migration from tributaries as explanations for this trend.

#96 **Pitlo, J. Jr., A. Van Vooren, and J. Rasmussen.** 1995. Distribution and relative abundance of upper Mississippi River fishes. Upper Mississippi River Conservation Committee, Rock Island, Illinois.

Species collected along the Mississippi from St. Anthony Falls at St. Paul, MN, to the Ohio River at Cairo are listed. A detailed description of the portions of the river and definitions of terms used in the article is provided. The blue sucker has increased in numbers and is now listed as occasional. Both sicklefin and sturgeon chubs are listed as rare. A table with all species found and the site where they were sampled is provided.

#97 **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 number 1. North Dakota Game and Fish Department, Bismarck.

Twelve blue suckers were caught in a gill net near the mouth of the Knife River between May and July of 1991. These fish ranged from 600-735 mm and 1650-3050 g. The females were gravid and appeared to be ready to spawn. No blue sucker young-of-the-year were sampled. Western silvery minnows were also caught and made up 7% of the total catch in the small frame nets.

#98 **Rehwinkel, B. J.** 1978. Montana Department of Fish and Game Powder River aquatic ecology project, 1975-1978. Final Report. Prepared for Utah International, Inc. 81pp.

Utah International was preparing to develop the coal reserves in the area near the Powder River in Montana and had applied for a permit to use Powder River water in their plant. The objectives of this study were to inventory the fish populations, sample the aquatic invertebrates, and measure the physical characteristics of the Powder River. Electrofishing was used to collect the game fish species. All stationary net methods were found to be unsatisfactory for fish trapping on the Powder River because of their tendency to trap silt and sediment. A map is provided with all of the sampling sites marked.

Flathead chub were the most common fish caught in the fall of 1975, comprising between 81.5% and 100% of the total catch at each of the seven stations. Sturgeon chub comprised between 1.7% and 8.6% of the total catch at 6 of the 7 stations.

Flathead chub were the most common fish caught again in the summer of 1976, comprising between 35.6% and 90.4% of the total catch at each of the seven stations. Sturgeon chub comprised between 0.6% and 5.9% of the total catch at 4 of the 7 stations. No sturgeon chub were caught at 3 of the 7 stations. Members of the genus *Hybognathus* comprised between 1.0% and 57.6% of the total catch and were caught at all 7 stations.

Three tributaries of the Powder River were also sampled during the summer of 1976. Flathead chub were the most abundant species in seining samples in Mizpah Creek. The Little Powder River was also seined, but only one flathead chub was sampled. The most common fish sampled from the Little Powder River was the plains minnow, which made up 69.5% of the total catch. Clear Creek, a tributary in Wyoming, was sampled and yielded 14 flathead chubs. The focus of the survey was the number of channel catfish, sauger, shovelnose sturgeon and other larger game fish species.

#99 **Reigh, R. C.** 1978. REAP Reports: Fishes of the western tributaries of the Missouri River in North Dakota. REAP Reports No. 79-2:43-47.

Short listing of historic collection records for sturgeon chub and sicklefin chub, along with maps showing sampling points. Both fish were collected on the Yellowstone River, as well as on the Missouri and the Little Missouri. The sicklefin chub was collected at the mouth of the Little Missouri River prior to the impoundment of Lake Sakakawea.

#100 **Reigh, R. C., and D. S. Elsen.** 1979. Status of the sturgeon chub (*Hybopsis gelida*) and sicklefin chub (*Hybopsis meeki*) in North Dakota. Prairie Naturalist 11(2):49-52.

Describes both species and notes the keeled scales and small eyes of the sturgeon chub. The eyes of the sicklefin chub are also small, and may be covered with a flap of skin. Both species are dorsoventrally compressed to allow them to stick near the bottom. Many of the authors' questions about the feeding and reproductive habits of the sturgeon chub are answered in later publications. See Stewart's 1981 work in this bibliography. The sicklefin chub was only collected at the mouth of the Yellowstone in North Dakota. However, its preference for strong currents in large rivers makes its collection difficult. The sicklefin chub prefers sandy bottoms, which may also explain its low numbers in the upper portions of rivers in North Dakota.

#101 **Reno, H. W.** 1969. Cephalic lateral-line systems of the cyprinid genus *Hybopsis*. Copeia 1969 (4):736-772.

An in-depth study of the lateral line systems of 23 species of *Hybopsis* including *meeki*, *gracilis*, and *gelida*. Methods included pore counts of both complete and incomplete canals, with an emphasis on the canals in the heads. Heads were fixed in 10% formalin, decalcified, dehydrated, set in Tissuemat and sectioned to 10 micron thicknesses. Once sectioned, the samples were stained and mounted on slides where the canals were measured quantitatively and qualitatively. The heads were divided into six sections from the anterior to the posterior. The following data were recorded for each canal: number of pores, maximum pore diameter, maximum and minimum height of the neuromasts, maximum and minimum lengths of the portions of each canal and the number of sense hairs per cell and their lengths. Similar counts were made for superficial neuromasts.

The majority of the paper concerns species other than those of interest. Pages 757 to 759 contain information on the three *Hybopsis* species concerned in this bibliography. The author concludes that the lateral line system in *Hybopsis* is highly plastic and can adapt to the environment. The changes were not classified as genotypic or phenotypic in origin. Not all lateral line systems were adaptable. The shape of specific canals, completeness of canals, and position of bony portions are stable attributes. The author suggests that the more stable characteristics are better suited for phylogenetic sorting. The article has a substantial bibliography.

#102 **Riis, J., and B. Johnson.** 1996. Annual fish population and angler use and harvest surveys on Lake Sharpe, South Dakota, 1995. South Dakota Department of Game, Fish and Parks, Wildlife Division. In-Press.

The annual fish survey's purpose is to evaluate management's ability to provide angling opportunities in the future. The survey measures species' composition, relative abundance, age and condition, recruitment, survival rates and population size structure. Angler effort and harvest are also quantified. A map of the study area with locations for all survey methods is provided. No blue suckers were caught during the 1995 survey. During the years 1991 to 1995, only 1993 produced any blue suckers. The mean catch-per-unit of effort for 1993 was 0.1 for blue suckers. The majority of the report concerns game fish such as walleye and sauger.

#103 **Riis, J., and B. Johnson.** 1995. Annual fish population and angler use and harvest surveys on Lake Sharpe, South Dakota, 1994. South Dakota Department of Game, Fish and Parks, Wildlife Division, Annual Report No. 95-5.

The annual fish survey's purpose is to evaluate management's ability to provide angling opportunities in the future. The survey measures species' composition, relative abundance, age and condition, recruitment, survival rates and population size structure. Angler effort and harvest are also quantified. A map of the study area with locations for all survey methods is provided. No blue suckers were caught during the 1994 survey. During the years 1991 to 1995, only 1993 produced any blue suckers. The mean catch-per-unit of effort for 1993 was 0.1 for blue suckers. The majority of the report concerns game fish such as walleye and sauger.

#104 **Riis, J., D. Fielder, B. Johnson, C. Stone, D. Unkenholz, and G. Wickstrom.** 1988. Annual fisheries survey on the Missouri River reservoir, 1986-1987. South Dakota Department of Game, Fish, and Parks. Progress Report No. 88-3.

The reservoirs are a large supplier of income for South Dakota, providing $10 million per year in angling revenues. The annual fish survey's purpose is to evaluate management to provide angling opportunities in the future. The survey measures species composition, relative abundance, age and condition, recruitment, survival rates and population size structure. A map of the study area with locations and survey methods is provided. The area extends from Lake Oahe to Lewis and Clark Lake. Gill nets and seines were the primary methods of collection. Sampling methods were adapted to catch certain species. Blue suckers were found in trace amounts in Lake Oahe in 1982. Blue suckers were not caught in Lake Oahe during the five following surveys (1983-1987). The majority of information in the report describes walleye, sauger, smelt and paddlefish results.

#105 **Robison, H. W., and T. M. Buchanan.** 1988. Fishes of Arkansas. The University of Arkansas Press, Fayettville. Pg. 185-188.

Contains short, physical descriptions and distribution maps for the sturgeon chub, flathead chub and sicklefin chub. Information on distribution is specific to Arkansas. Although not included in the reviewed material, this reference may have information on plains minnow or western silvery minnow.

#106 **Ross, S. T., and W. M. Brenneman.** 1991. Distribution of freshwater fishes in Mississippi, April 1, 1985, to September 30, 1991. Mississippi Department of Wildlife, Fisheries, and Parks; Bureau of Fisheries and Wildlife, Jackson.

This survey includes the historic record of the collection of one sicklefin chub from the lower Mississippi River near Vicksburg in 1973. The author describes this specimen as the only known sicklefin chub ever collected that far south; however, reference #38 appears to contradict this statement.

#107 **Rowe, J. W.** 1992. The sturgeon chub and the brook silverside in the Platte River of Nebraska. Prairie Naturalist 24(4):281-282.

Notes that several recent surveys have failed to collect sturgeon chub in the Platte River, beginning with a 1973 survey completed by the Nebraska Game and Parks Commission. In 1987, a single adult was collected in an extensive survey of the lower Platte, and only a few other specimens have been collected since.

#108 **Rupprecht, R. J., and L. A. Jahn.** 1980. Biological notes on blue suckers in the Mississippi River. Transactions of the American Fisheries Society 109:323-326.

The blue sucker is an uncommon and little known species inhabiting the U.S. The species was once commercially important. In 1894 and 1899, over 900,000 kg of blue suckers were caught in pool 20, a 33.6 km section of the Mississippi that borders Illinois, Iowa and Missouri. After locks and dam 19 were constructed in 1910, the catch dropped to 320,000 kg. The reduction in velocity below the dam was the major cause for the decline. This study was conducted to add to the information on the blue sucker's natural history.

Condition factors increased with fish size and varied among months (March-October) and between years (1977-1978). Fin rays were a better age determiner than scales after age VII. Fin rays were removed from the left pectoral fin as close to the body as possible. The largest blue sucker collected was age X (scales) or XIII (fin rays) and 817 mm long. Males generally reached sexual maturity at age IV and females at age VI. Males had nuptial tubercles in April, but no ripe females were found. For six females aged VI-IX, the fecundity to length relationship (Y= number of 1 mm eggs) was Y= -375,100 + 771.5 L. The fish ate mostly Tricoptera and Diptera larvae and pupae, and lesser numbers of Ephemeroptera larvae and amphipods. All sampling was done with electroshocking over rocky substrate.

#109 **Schmidt, T. R.** 1994. Phylogenetic relationships of the genus *Hybognathus* (Teleostei: Cyprinidae). Copeia 1994 (3):622-630.

A study of the phylogeny of seven *Hybognathus* species including the western silvery minnow *(Hybognathus argyritis)* and the plains minnow *(H. placitus)*. The author places both of the listed species in a clade together with three of the other seven species because of their shared characteristics. Namely, the sagittal blade on the first pterygiophore of the anal fin is reduced. A phylogenetic map is provided along with the results. Several skeletal diagrams accompany the descriptions for each species.

#110 **Schrenkeisen, R. et al.** 1938. Field book of freshwater fishes of North America. G.P. Putnam's Sons. New York. Pg 143.

A physical description of the "keel scaled minnow" also known as the sturgeon chub. Listed as common in the Missouri River basin. Although not included in the reviewed material, this reference may have information on the sicklefin chub, flathead chub, blue sucker, the plains minnow, or the western silvery minnow.

#111 **Smith, P. W.** 1979. The fishes of Illinois. University of Illinois Press, Urbana, 314 pp.

Provides information on the taxonomy, physical description, ecology and distribution. Fishes listed are the sicklefin, flathead and sturgeon chub.

#112 **Sprague, J.** 1964. Progress and job completion report. Dingell-Johnson Division, Project F-2-R-11. North Dakota Game and Fish Department.

One blue sucker was caught during the survey of Garrison Reservoir.

#113 **Sprague, J. W.** 1959. Report of fisheries investigations during the 4th year of impoundment of Gavins Point Reservoir, South Dakota. South Dakota Department of Game, Fish, and Parks, Dingell-Johnson Project F-1-R-8.

Seven blue suckers were netted ranging from 17.7 to 27.0 inches in length. The author calculated a growth history for the blue sucker from six of the fish caught. Blue suckers are uncommon in the reservoir and of little importance to the fishery.

#114 **Stasiak, R. H.** 1990. Population status of sicklefin chub (*Hybopsis meeki*) and sturgeon chub (*Hybopsis gelida*) in the Missouri River of Nebraska in 1989. Final Report. U.S. Army Corps of Engineers Contract OWF/05-132-00101. 16 pp.

Sampling conducted from July to October of 1989 collected no sturgeon or sicklefin chubs in the region of the Missouri River from Sioux City to Rulo. Fifty-five collections were made using a 7 m by 1.5 m, 6.3 mm seine. Four or five hauls were taken at the most favorable habitats at each site. A full list of all specimens caught is provided in the text, along with a river mile location and date for each collection. Thirteen flathead chub, known to associate with sicklefin chub, were collected. Over 3,000 other fish were also collected, so the absence of the sicklefin and sturgeon chubs appear to be a cause for concern. The spotfin shiner, a species less tolerant of turbidity, has also increased in numbers in the same stretch of river, indicating that turbidity has decreased. Since both chubs prefer turbid waters, the decrease in turbidity may be another reason why they were absent. The survey concludes by recommending official protection of both species.

#115 **Stewart, D. D.** 1980. A preliminary study of the biology of the sturgeon chub (*Hybopsis gelida*) in the Powder River in Wyoming. Proceedings of the 15th Annual Meeting of the Colorado-Wyoming Chapter of the American Fisheries Society.

A summary of the author's Masters Thesis (see below). Notes that the keel of the sturgeon chub's scales is epidermal in nature and is not part of the scale itself. The author emphasizes the sturgeon chub's need for turbid waters by pointing out its disappearance from the water above Salt Creek, the major source of the suspended load in the Powder River.

#116 **Stewart, D. D.** 1980. The sturgeon chub. Wyoming Wildlife 44(3):20-21,35.

A short popular article that summarizes the author's methods and findings from his masters thesis. See below.

#117 **Stewart, D. D.** 1981. The biology of the sturgeon chub (*Hybopsis gelida* Girard) in Wyoming. M.S. Thesis, University of Wyoming, Laramie.

Includes a general literature review of several of the references in this bibliography. All work was done on the Powder and Bighorn Rivers in Wyoming. No sturgeon chub were found in the Bighorn. The most successful collection method was seining with the current, using a 4.75 m, 4 mm mesh seine. Baited minnow traps were unsuccessful for sturgeon chub, but very successful for flathead chub (avg. 68 fish /24 h set). The flathead chub seemed to prefer dog food as bait. Although electrofishing was attempted, the high conductivity of the Powder River resulted in a lack of success with that method. Water velocity at 0.6 depth was also recorded at seining sites.

The Powder River is turbid with high fluctuations in flow. The substrate is composed of rock, cobble, gravel, mud and sand. The tributary, Salt Creek, appears to be a major source of the suspended load and the water runs clearer above its confluence. No sturgeon chub were collected above Salt Creek on the Powder River. Large portions of the river basin are likely to be developed for coal. This industry will require large diversions of water.

The preferred habitat for the chub was rocky riffles with turbid, fast moving water. In general, the larger the fish, the larger the substrate particles. All young-of-the-year chubs were collected over sandy bottoms. Specifically, the fish prefer water of 3 to 20 inches, moving at 1.1 to 2.95 feet per second. Flathead chub and plains minnows were commonly found in association with the sturgeon chub. No apparent predators were collected in the seine hauls.

The sturgeon chub reaches adult size at the end of its 2nd year. Apparent maximum age is 4 years. Reproductive maturity is reached at age 2 years. Reproductive activity occurs in June, during the highest flows. The author was not successful in collecting many young-of-the-year fish and speculates that they are either inhabiting a different niche or are few in number. They are insectivorous, with pharyngeal teeth grinding the prey before it enters the stomach. The fish tend to stick close to the bottom using their pectoral fins to help hold them in place as they feed. Taste buds on the pectorals may also be useful in finding prey.

#118 **Stone, C., D. Fielder, B. Johnson, J. Riis, D. Unkenholz, and G. Wickstrom.** 1989. Annual fisheries surveys on the Missouri River reservoirs. South Dakota Department of Game, Fish, and Parks. Progress Report No. 89-11

The annual fish survey's purpose is to evaluate management's ability to provide angling opportunities in the future. The survey measures species' composition, relative abundance, age and condition, recruitment, survival rates and population size structure. A map of the study area with locations of survey methods is provided. The area extends from Lake Oahe to Lewis and Clark Lake. Gill nets and seines were the primary methods of collection. Sampling methods were adapted to catch certain species. Small numbers of blue suckers were found in Lake Oahe in 1985 and 1988. The majority of information in the report describes walleye, sauger, smelt, and paddlefish results.

#119 **Summerfelt, R. C.** 1967. Fishes of the Smoky Hill River, Kansas. Transactions of the Kansas Academy of Science 70(1):102-111.

Three sturgeon chub were collected in a turbid, gravel bottomed section of the river on May 9, 1964. No further collections of sturgeon chub were made during the rest of the study. The author presumes that the sturgeon chub must be rare in the Smoky Hill River.

#120 **Tabor, V. M.** 1993. Declining fishes characteristic of the central great plains. U.S. Fish and Wildlife Service, Manhattan, Kansas.

The natural habitat types in rivers of the Great Plains are: 1) shallow, sandy bottomed streams with highly fluctuating flows, 2) clear streams and marshes sustained by groundwater, and 3) intermittent streams with residual pools. Impoundments, agricultural development, stream channelization, groundwater withdrawal, and stream diversion have all contributed to the destruction of these habitats. In Kansas, the flathead chub was one of the most abundant minnows present in the 1950's. By the 1960's, its numbers had declined catastrophically. Flathead chub were last captured in the Missouri River and the Kansas River in Kansas in 1969. Flathead chub are currently listed as endangered in Kansas, but F.B. Cross considers them extirpated.

In Missouri, the flathead chub has declined from making up 31% of all small fishes caught in the mainstem of the Missouri River in 1945 to 1.1% in 1978-1983. Flathead chub are currently listed as endangered in Missouri.

In Nebraska, the flathead chub made up only 2% of all fishes caught in a survey of the channelized portion of the Missouri in 1971-1975 and only 0.003% in a similar survey completed in 1990. Flathead chub are currently not listed as endangered in Nebraska.

The plains minnow historically was found in almost all drainages in Kansas. Now the species only persists in the Cimarron, Salt Fork of the Arkansas and Medicine Rivers.

Even in these rivers, numbers are dwindling. Only a single specimen was captured in a survey of the Cimarron in 1991. No specimens have been found in the Kansas River since 1980, despite frequent sampling. The western silvery minnow is often grouped together with the plains minnow because of morphological and habitat similarities. Both species have declined in Nebraska on the channelized portion of the Missouri from 28% of the total catch in 1975 to 1.6% in 1990.

The author notes that most of these species appear to have more stable populations in areas outside of the Great Plains, but he cautions that their extirpation in the Great Plains should still be considered a severe problem. He recommends land use changes as a possible remedy for the extreme decline in these species.

#121 **Taylor, C. M., and Miller, R. J.** 1990. Reproductive ecology and population structure of the plains minnow, *Hybognathus placitus*, (Pisces: Cyprinidae), in central Oklahoma. American Midland Naturalist 123:32-39.

The paper described the reproductive biology and population structure during a 2-year survey in the Cimarron River, Oklahoma. Monthly changes in gonadal weight and mean ovum diameter revealed that *H. placitus*' spawning season was prolonged, beginning in spring and ending in late summer. Two peaks of reproductive activity, one in May and the second in mid-summer, occurred both years. Spawning in both years coincided with high or receding flows. Most male and female *H. placitus* began to mature sexually at 45-50 mm SL. The sex ratio did not differ meaningfully from 1:1, males and females were similarly sized. Numbers of mature ova were correlated with standard length and weight, ranging from 417 to 4134 for females 51 to 87 mm SL. Length-frequency distributions revealed that *H. placitus* was short-lived, with most individuals reproducing and dying in their second summer.

#122 **Tews, A.** 1993. 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. Montana Department of Fish, Wildlife and Parks. Fort Peck pallid sturgeon study. U. S. Army Corps of Engineers, Omaha.

Samples of sicklefin chub, sturgeon chub, and blue suckers were collected incidentally during the sturgeon study. Seining was the predominant method of collection. Sturgeon chub were the second most common species found in the study. Forty-seven sturgeon chub were sampled from kilometers 3-82 on the Yellowstone in 18 seine hauls. The author suggests that the perceived rarity of this fish may be due to insufficient sampling. Blue suckers were the fifth most common species and were found most frequently below the confluence and in the upper reaches of the Yellowstone and the Missouri Rivers. Catch rates for blue suckers peaked in October. More than 80% of all blue suckers caught were in excess of 550 mm. Only one sicklefin chub was collected during this study.

The diversity of native species found above the Missouri-Yellowstone confluence may indicate that the fish populations below Fort Peck, although impacted, may be in better shape than those found below other Missouri River dams. The report includes several charts of flow data and catch rates.

#123 **University of Kansas.** 1982. Report on the impacts of commercial dredging on the fishery of the lower Kansas River. Kansas City Corps of Engineers, DACW 41-79-C-0075. University of Kansas Department of Biological Sciences.

Excerpts from the report included a record of three sturgeon chubs captured in habitats that were later destroyed by dredging. The dredging is thought to increase pressure on the sturgeon chub by deepening and slowing flows and increasing siltation.

#124 **U.S. Fish and Wildlife Service.** 1993. Draft status report on blue sucker (*Cycleptus elongatus*) a candidate endangered or threatened species. U.S. Fish and Wildlife Service, North Dakota Field Office, Bismarck.

The blue sucker is listed by the U.S. Fish and Wildlife Service as category 2, meaning that the fish is to be considered in environmental planning, but does not have protected status. A list of states and their individual status classifications for the blue sucker is provided (the fish also occurs in Mexico, but no information is given). Out of a total of 23 states, 8 list the status as "unknown" and 6 give the fish no classification. A listing of known collection sites for each state is provided. The fish's distinguishing characteristics are its blue color and long, slender, caudal peduncle. It is the only member of its genus. Blue suckers prefer swift, turbid rivers common in the plains states. It is associated with sicklefin and flathead chubs in terms of habitat. Blue suckers mature sexually at 3 to 4 years of age. Spawning occurs in April or May and appears to be influenced by water temperature and flows. Blue suckers have been aged up to 17 years. Demographic information is provided for known populations. The following topics are listed as having little or no information available: population ecology, survival rate, reproductive success, hybridization, and interspecific competition. Legislation has allowed the damming of significant portions of the Missouri River and its tributaries. The resulting changes in flow rates and turbidity have had a negative effect on blue sucker populations. The report recommends that irrigation be controlled to provide in-stream flows and that further research be conducted to expand knowledge of exact population status.

#125 **U.S. Fish and Wildlife Service.** 1993. Status report on Sicklefin Chub (*Macrhybopsis meeki*) a candidate endangered species. U.S. Fish and Wildlife Service, North Dakota Field Office, Bismarck.

The sicklefin chub is listed as category 2, meaning that the fish is to be considered in environmental planning, but does not have protected status. The primary distinguishing characteristics for this fish are the dorsal fin's sickle shape and the longer length of the pectoral fins. The eyes of this fish are covered with a flap of skin and the optical lobe is reduced. Sicklefin chubs have a large number of sensory cells in the fins and skin which compensate for the loss in vision. They are of scientific interest because of their adaptation to silty river environments. The current confirmed range of the fish includes portions of the Missouri River in Missouri, North Dakota, and Nebraska; the Mississippi River in Missouri; and the Yellowstone River in North Dakota. Because specimens were not found during surveys in 1980 and 1990, the sicklefin chub is assumed extirpated in the following rivers: the Missouri in Iowa; portions of the Missouri River in Missouri, Nebraska, South Dakota, and Kansas; and White Earth Creek in North Dakota. There are also many segments of the fish's previous range where its status is unknown because of a lack of study. The report includes names and dates for each of the rivers where sicklefin chub have been collected in the past. Overall reproductive success is likely to be low because of low densities and isolated populations; however, young-of-the-year were collected in the lower Missouri in 1990. These young-of-the-year have a preference for sand or fine gravel substrate. Sicklefin chub were reportably preyed upon by sauger in the Upper Missouri River. Because of low population densities, isolation of populations is a potential genetic threat. With the exception of the lower Missouri, collections of sicklefin chub have been so rare that the fish may be in danger of extinction.

Recommendations for the support of this fish include: regulating dam releases to mimic natural flow patterns and establishing instream flow rights to prevent water depletion.

#126 **U.S. Fish and Wildlife Service.** 1993. Pallid sturgeon use and habitat studies on the Yellowstone River within the Highway 200 bridge replacement project area. Spring use 1993 and final report. U.S. Fish and Wildlife Service, Bismarck, North Dakota.

The sicklefin chub, sturgeon chub, paddlefish, and blue sucker (all candidates for the threatened or endangered species list) are known to occur within the bridge project area. During the survey, 7 sicklefin chubs, 13 sturgeon chubs and 12 paddlefish were collected in the project area. No blue suckers were collected during the survey. The authors were most concerned about possible interruptions of spawning migrations during construction. They recommended that the bridge construction period should avoid the peak spawning times between March and mid-July. The authors also recommend that the gravel areas be minimally disturbed and that existing bridge structures be incorporated into the new bridge to avoid disturbance and minimize dredging.

#127 **U.S. Fish and Wildlife Service.** 1993. Status report on sturgeon chub *(Macrhybopsis gelida)*,a candidate endangered species. U.S. Fish and Wildlife Service, North Dakota Field Office, Bismarck.

The sturgeon chub is listed as category 2, meaning that the fish is to be considered in environmental planning, but does not have protected status. The primary distinguishing characteristic of the sturgeon chub is the epidermal keels. These fish are of scientific interest because of their adaptation to silty river environments. The current confirmed range of the fish includes the Powder River in Montana and Wyoming, the Missouri River in Missouri and Nebraska, and the Platte River in Nebraska. Because specimens were not found during surveys in 1980 and 1990, the sturgeon chub is assumed extirpated in the following rivers; the Missouri in Iowa, Kansas, and Missouri; the Little Missouri in North and South Dakota; the Tongue River in Montana; the Kansas River in Kansas; several creeks and rivers in Nebraska and in portions of the Powder River in Wyoming. Sturgeon chub require turbid, free-flowing water and are quickly eliminated when turbidity declines. The report includes names and dates for each of the rivers where sturgeon chub have been collected in the past. Overall, reproductive success is likely to be low because of low densities and possible hybridization with speckled chub. Reproduction has not been documented within the Missouri River main stem. However, young-of-the-year were collected in the lower Missouri in 1990. Threats to the species include the control of the Missouri via dams, the introduction of piscivorous fishes, pollution from industry and gravel extraction. Three years of drought may have eliminated the sturgeon chub from the tributaries of the Missouri in its historic range. Collections of sturgeon chub have been so rare in most of its range that the fish may be in danger of extinction in all areas except the Powder River. Recommendations for the protection of this fish include: decreasing the water use for coal mining, regulating dam releases to mimic natural flow patterns, establishing instream flow rights to prevent water depletion from agriculture and decreasing the stocking of piscivorous fishes.

#128 **Van Eeckhout, G.** 1974. Movement, reproduction, and ecological relationship of channel catfish, *Ictalurus punctatus* (Rafinesque), in the Little Missouri River, North Dakota, 1972-1973. M.S. Thesis. University of North Dakota, Grand Forks.

The sturgeon chub and the plains minnow are listed as incidental catches during a channel catfish study.

#129 **Wenke, T. L.** 1992. Kansas River collections (Raw Data). Kansas Department of Fish and Game.

Collected 2 western silvery minnows, 1 blue sucker and 3 sturgeon chub.

#130 **Wenke, T. L.** 1992. Missouri River collections (Raw Data). Kansas Department of Fish and Game.

Collected 1 plains (or silvery) minnow at mile 483. Collected 1 sturgeon chub at mile 435.5 and 3 at mile 426. Collected 2 plains (or silvery) minnows at mile 426 and 1 at mile 427. Downstream from Leavenworth, KS, collected 1 sturgeon chub and 11 plains (or silvery) minnows. Upstream and downstream from Atchison, KS: collected 4 sturgeon chubs and 1 blue sucker. The author was not sure in his identification of the plains minnows.

#131 **Wenke, T. L., G. W. Ernsting, and M. E. Eberle.** 1993. Survey of river fishes at Fort Riley Military Reservation in Kansas. Prairie Naturalist 25(4):317-323.

This reference is included mainly because this survey failed to collect any sturgeon chubs or plains minnows in regions where they had been collected previously. The authors felt that the dams in the river had altered the habitat by lowering the turbidity level and changed (lowered) peak discharge timing. The timing of peak discharge is associated with the spawning of both the sturgeon chub and the plains minnow. The sturgeon chub's preference for loose substrate is also undermined by the lowering of flows. Low flows do not scour the channel and tend to pack the sand. Other species that were collected in large numbers were more adapted to low turbidity levels, emphasizing the changes in the river.

#132 **Werdon, S. J.** 1992. Population status and characteristics of *Macrhybopsis gelida*, *Platygobio gracilis* and *Rhinichthys cataractae* in the Missouri River Basin. Masters Thesis. South Dakota State University, Brookings.

Population status of the sturgeon chub was determined by resampling historic sampling sites along the Missouri River. Sturgeon chub were found only in the Powder River, with the exception of one individual found in the Yellowstone. The author compared physical characteristics of each species, both among populations and between populations. Both morphometric and meristic data were collected for each population. Her results do not point to any hybridization of the sturgeon chub. This lack of hybridization is probably due to a lack of the main hybridizer (*M. aestivalis*) in the habitats surveyed. No species exhibited latitudinal meristic clines, perhaps because the rivers were all near the same latitude. The flathead chub was far more abundant and more widely distributed than the sturgeon chub. However, its range has declined from its historical numbers. Flathead chub appear to prefer sandy substrate in comparison with the gravel substrate preferred by the sturgeon chub. Also, the larger eyes of the flathead chub make it a better sight feeder and may allow it to do well in less turbid waters. The author includes summarized historical collection numbers to compare with her survey results.

#133 **Wickstrom, G., D. Fielder, B. Johnson, J. Riis, C. Stone, and D. Warnick.** 1990. Annual fish population surveys on South Dakota Missouri River reservoirs. South Dakota Department of Game, Fish, and Parks. Annual Report No. 91-14.

The reservoirs are a large supplier of income for South Dakota, providing $21.4 million in revenue. The annual fish survey's purpose is to evaluate management to provide angling opportunities in the future. The survey measures species' composition, relative abundance, age and condition, recruitment, survival rates and population size structure. A map of the study area with locations of survey methods is provided. The area extends from Lake Oahe to Lewis and Clark Lake. Gill nets and seines were the primary methods of collection. Sampling methods were adapted to catch certain species. Blue suckers were found in low numbers in Lake Oahe. Blue suckers were not captured at all in Lake Oahe during the three previous surveys. The majority of information in the report describes walleye, sauger, smelt and paddlefish results. Walleye catches were much lower in than in previous years.

#134 **Winston, M. R.** 1995. Co-occurrence of morphologically similar species in stream fishes. The American Naturalist 145:527-545.

The hypothesis that very similar species were less likely to co-occur than dissimilar species was investigated. A total of 219 assemblages of stream fishes from the Red River basin in Texas, Oklahoma, and Arkansas were assessed for morphological and phylogenetic similarities between parapatric and sympatric pairs of cyprinid minnows. A significantly lower number of morphologically similar species than dissimilar species coexisted in the test sites. However, phylogenetic relatedness was not a factor in the coexistence of minnow pairs. It was concluded that interspecific competition was the most likely explanation for the assemblies in the Red River Basin. One of the minnow pairs examined included the plains minnow.

#135 **Yeager, B. L., and K. J. Semmens.** 1987. Early development of the blue sucker, *Cycleptus elongatus*. Copeia 1987(2):312-316.

Blue sucker eggs were collected from adult fish during the first week of March 1981 on the Alabama River. The eggs were then fertilized and cultured. The resulting larvae were examined for morphometric and meristic characteristics at different stages of development. Only the taxonomically significant characteristics are described in the article. Each stage is summarized in great detail. A chart breaks down the stages and the most significant developments.

Keyword index:

Sturgeon Chub (*Hybopsis gelida*)

Classification, taxonomy:	1, 10, 21, 22, 40, 53, 59, 60, 88, 105, 110, 111
Distribution, range:	2, 3, 13, 23, 25, 26, 27, 28, 30, 34, 37, 38, 41, 43, 46, 51, 53, 58, 85, 88, 93, 94, 99, 107, 127
Food habits:	19, 48
Genetics, Phylogeny:	20
Habitat:	2, 9, 13, 17, 18, 23, 25, 26, 34, 48, 58, 65, 66, 70, 88, 91, 93, 94, 116, 117, 123, 127, 131
Hybridization:	132
Identification:	3, 14, 15, 21, 22, 40, 59, 60, 105, 110, 116
Impoundments:	35, 48, 49, 87, 95, 131
Life History:	47, 126
Management status:	3, 6, 7, 13, 30, 34, 35, 46, 49, 73, 79, 96, 100, 114, 117, 126, 132
Morphometrics and meristics:	132
Physiology:	8, 9, 19, 66, 78, 100, 101
Records of occurrence:	5, 6, 15, 17, 18, 27, 28, 29, 31, 35, 39, 43, 51, 53, 60, 61, 64, 65, 85, 87, 89, 91, 92, 93, 95, 98, 99, 107, 114, 119, 122, 126, 127, 128, 129, 130, 131, 132
Reproduction:	48, 126, 127
Sampling methods:	28, 32, 34, 37, 47, 114, 116, 117, 122

Sicklefin Chub (*Hybopsis meeki*)

Classification, taxonomy:	1, 10, 21, 22, 40, 54, 59, 88, 105, 110, 111
Distribution, range:	2, 3, 13, 23, 25, 26, 27, 28, 30, 34, 36, 37, 38, 41, 43,44, 46, 51, 54, 58, 62, 63, 75, 88, 93, 94, 99, 106
Food habits:	19, 48
Genetics, Phylogeny:	20
Habitat:	2, 9, 13, 17, 23, 25, 26, 34, 48, 58, 65, 66, 70, 88, 91, 93, 94, 126
Identification:	3, 15, 21, 22, 40, 59, 105, 110, 125
Impoundments:	35, 48, 49, 87, 95, 125
Life History:	47, 125, 126
Management status:	3, 7, 13, 30, 34, 35, 36, 46, 49, 62, 63, 73, 79, 80, 82, 96, 100, 114, 125, 126, 132
Physiology:	8, 9, 19, 66, 78, 100, 101
Records of occurrence:	5, 6, 17, 27, 28, 29, 33, 35, 43, 44, 51, 54, 61, 63, 65, 69, 87, 89, 91, 93, 95, 99, 114, 122, 126
Reproduction:	36, 48, 126
Sampling methods:	28, 32, 34, 37, 45, 47, 63, 75, 77, 114, 122

Flathead Chub (*Hybopsis gracilis*)

Classification, taxonomy:	10, 21, 22, 40, 59
Distribution, range:	26, 28, 30, 43, 44, 55, 56, 58, 88, 93, 94, 132
Habitat:	18, 26, 34, 58, 65, 70, 88, 91, 93, 94, 95, 120, 132
Identification:	21, 22, 40, 59, 105, 110
Impoundments:	49
Larvae:	76
Management status:	30, 49, 73, 79, 114, 120
Morphometrics and meristics:	132
Physiology:	101
Records of occurrence:	4, 5, 18, 29, 34, 44, 55, 56, 65, 76, 77, 87, 89, 93, 95, 98,114, 132
Reproduction:	5, 76
Sampling methods:	28, 76, 77, 95, 114

Plains Minnow (*Hybognathus placita*)

Classification, taxonomy:	10, 21, 22, 88
Development, growth:	121
Distribution, range:	2, 3, 10, 23, 46, 70, 80, 82, 120
Food habits:	48
Genetics, Phylogeny:	109, 134
Habitat:	48, 91, 95, 117
Identification:	1, 2, 3, 21, 22, 40, 88, 105, 110
Impoundments:	47, 49, 95
Life History:	47, 121
Management status:	6, 28, 47, 48, 49, 65, 95, 120
Physiology:	11, 50
Records of occurrence:	6, 18, 30, 32, 39, 43, 44, 61, 63, 65, 83, 90, 95, 98,117, 128, 130, 131
Reproduction:	48, 49, 63, 121
Sampling methods:	5, 28, 30, 32

Western Silvery Minnow (*Hybognathus argyritis*)

Classification, taxonomy:	10, 21, 22, 88
Distribution, range:	23, 28, 70, 79, 120
Food habits:	48
Genetics, Phylogeny:	109
Habitat:	48, 91, 95, 120
Identification:	1, 2, 3, 21, 22, 40, 88, 105, 110
Impoundments:	47, 49, 95
Life History:	5, 47
Management status:	47, 48, 49, 65, 91, 95, 120
Physiology:	50
Records of occurrence:	5, 18, 28, 30, 43, 44, 48, 65, 83, 90, 91, 95, 97, 120, 129, 130
Reproduction:	5, 48, 49
Sampling methods:	5, 30, 90

Rivers:

States:

Oklahoma:	72, 124
North Dakota:	26, 40, 42, 43, 44, 63, 66, 90, 92, 97, 100, 109, 110, 112, 114, 125, 126
South Dakota:	2, 6, 14, 18, 55, 56, 57, 71, 84, 102, 103, 104, 113, 115, 118, 132
Wyoming:	3, 34, 98,114, 115, 117