STATUS OF LAKE STURGEON

IN LAKE SUPERIOR

prepared for the
Lake Superior Technical Committee

by

the Lake Sturgeon Subcommittee

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INTRODUCTION

In 1980, the *Joint Strategic Plan for Management of Great Lakes Fisheries* (SGLFMP) was developed under the auspices of the Great Lakes Fishery Commission. Signed by all agencies responsible for managing Great Lakes fisheries, SGLFMP defined a common goal shared by the agencies responsible for managing Great Lakes fisheries and outlined a strategy to achieve the goal. SGLFMP commits signatory agencies to plan for the restoration and maintenance of desirable fish communities using a strategy of consensus. As part of the strategic procedures outlined in SGLFMP, lake committees, comprised of representatives of all agencies with fisheries management authority, were to define objectives for the desired state of the fish community in each Great Lake. Lake committees were developed and coordinated under the forum of the Great Lakes Fishery Commission. *Fish Community Objectives for Lake Superior* (Busiahn 1990) is a product of this process.

In order to reach the desired state of the fish community in Lake Superior, agencies responsible for fisheries management agreed that depleted stocks of lake sturgeon *Acipenser fulvescens*, "should be re-established by management of habitat for spawning and rearing via habitat inventory, protection and rejuvenation or replacement of degraded habitat" (Busiahn 1990). Management agencies also recognized that "these stocks require protection from over-harvest through regulation and enforcement," and that "depleted stocks may be replaced or enhanced by stocking of appropriate life stages" (Busiahn 1990).

Consistent with the fish community objectives for Lake Superior, the Lake Superior Work Group of the Binational Program to Restore and Protect the Lake Superior Basin has suggested that population levels of lake sturgeon may be useful as a potential indicator of ecosystem health (Ecosystem Principles and Objectives for Lake Superior, Discussion Paper, 1994). The objective for aquatic communities (developed by the Lake Superior Work Group) states that "Lake Superior should sustain diverse, healthy, reproducing and self-regulating aquatic communities closely representative of historical conditions", and that "native aquatic species associations will be recognized as key elements of a healthy Lake Superior ecosystem".

Development of realistic restoration goals and management strategies, designed to re-establish or enhance Lake Superior lake sturgeon stocks, requires a thorough understanding of their past and present status throughout the basin. This report provides a description of the past and current status of lake sturgeon in Lake Superior and will be used to refine the fish community objective for lake sturgeon and develop a restoration plan for this species.

HISTORY

The earliest references to lake sturgeon in Lake Superior came from 17 th Century explorers. One of the first accounts was made by Pierre Esprit Radisson in 1660 who witnessed over 1,000 sturgeon being dried at a village on the south shore of Lake Superior (Adams 1961). In 1670, Father Dablon commented that sturgeon were so plentiful in the St. Louis River, Minnesota, that a night's fishing with a single net could provide from 30 to 40 sturgeon (Thwaites 1899). About a century later, in the summer of 1765, Alexander Henry the Elder stopped at an Ojibwa village at the mouth of the Ontonagon River, Michigan, and reported the sturgeon so abundant that a month's subsistence for a regiment could be taken in a few hours (Henry 1969). The Pigeon River, Minnesota; Bad River, Wisconsin; Sturgeon, Pine and Tahquamenon Rivers, Michigan; and the Big Pic and Goulais Rivers, Ontario, also were noted as tributaries associated with spawning runs of lake sturgeon (Goodyear et al. 1982) as were the Wolf and Nipigon Rivers, Ontario, (Ed Iwachewski, Ontario Ministry of Natural Resources, Lake Superior Programs Office, 1194 Dawson Road, Thunder Bay, Ontario P7B 5E3, personal communication) (Figure 1 and Table 1).

Table 1. Lake Superior tributaries for which there is documented historical evidence of spawning by lake sturgeon.

MINNESOTA	Pigeon River	
MINNESOTA/WISCONSIN	St. Louis River	
WISCONSIN	Bad River	
MICHIGAN	Montreal River	
	Ontonagon River	
	Sturgeon River	
ONTARIO	Batchawana River	Kaministiquia River
	Big Pic River	Michipicoten River
	Black Sturgeon River	Nipigon River
	Goulais River	White River
	Gravel River	Wolf River
	Harmony River	

Baker (1980) notes that lake sturgeon were observed in the Waiska River, Michigan, in the 1970's. Lake sturgeon have also been observed in the Iron River, Michigan, and Amnicon River, Wisconsin but use for spawning has not been confirmed (U.S. Fish and Wildlife Service, Marquette Biological Station, 1924 Industrial Parkway, Marquette, Michigan, unpublished data). In 1993, two juvenile lake sturgeon were captured in the Iron River, Wisconsin (U.S. Fish and Wildlife Service, Fishery Resources Office, 2800 Lake Shore Drive East, Suite B, Ashland, WI 54806, unpublished data). A 19 th century fishing study along the Canadian shore identified lake sturgeon fisheries at the Michipicoten, Pic, and Kaministiquia rivers (Goodier 1984). The Batchawana, Harmony, and Willow Rivers, Ontario, also contained lake sturgeon (Goodier 1982) but no documented spawning (Figure 1). What is known about historical distribution is limited but based on historical levels of distribution more Lake Superior tributaries than those listed in Table 1 may have been used by lake sturgeon for spawning.

Prior to the early 1800's, Native Americans were the principal harvesters of lake sturgeon. Native Americans in the Great Lakes region valued the lake sturgeon for food, oil and leather (Holzkamm and Wilson 1988). Schoolcraft (1970) noted that some Native Americans relied upon lake sturgeon almost entirely for their subsistence. Ojibwa peoples utilized nooses, hooks, weirs, spears, and nets to harvest lake sturgeon.

Lake sturgeon populations likely began to decline prior to the first records of commercial catch (1880's) due to the combined affects of pollution from sawmills, log drives on spawning tributaries, and incidental catch in the commercial fishery for other species. Lake sturgeon, which had little commercial value prior to 1855, were regarded as a nuisance because they damaged or destroyed commercial nets. Many lake sturgeon captured in the commercial fishery were buried as fertilizer, used as hog feed, or simply stacked on the beach to rot (Harkness and Dymond 1961).

A lake sturgeon processing plant began operation in 1860 in Sandusky, Ohio (Harkness and Dymond 1961). Spurred by market demands, other major processing facilities soon sprang up throughout the Great Lakes as the commercial price for whole fish rose from $0.25 for each fish to $0.50/kg (Baker 1980). Caviar and smoked sturgeon were found to be highly palatable. The head and entrails were rendered for their oil and isinglass was made from sturgeon swim bladders (Harkness and Dymond 1961). Gillnets, pound nets and set lines were the primary means of capture (Smith and Snell 1889; Koelz 1926).

The reported commercial harvest of lake sturgeon from U.S. and Canadian waters of Lake Superior was greatest in 1885 when harvest was estimated at 102,000 kg (Baldwin et al. 1979)(Figure 2). By 1923, the harvest decreased to 13,000 kg. From 1924 to 1994, the annual Lake Superior harvest ranged from 1,000 to 6,000 kg (Baldwin et al. 1979). From the peak harvest of about 102,000 kg in 1885, lake sturgeon yields for all of Lake Superior declined at a rate of about 9% per year through 1950 (Lawrie and Rahrer 1973). Goodier (1982) reported that Black Bay, Ontario, produced an average of 25,000 kg of lake sturgeon annually between 1886 and 1890.

Even as the commercial fishery for sturgeon collapsed, other man-induced environmental changes stifled the recovery of this species. In the late 1920's, hydroelectric dams were constructed on several lake sturgeon spawning tributaries. These dams blocked spawning migrations and manipulated flow regimes. From 1880 to 1930, the combined effects of exploitation, pollution, and barriers were responsible for the further decline in lake sturgeon abundance. Pollution associated with industrial development limited the food supply and buried spawning beds (Harkness and Dymond 1961). The biological characteristics of this species (e.g. slow growth, late maturity, and infrequent spawning) contributed to the lack of recovery of the fishery (Harkness and Dymond 1961).

By the 1920's, the lake sturgeon fishery was in such dire straits that management agencies began imposing restrictions on the commercial harvest of lake sturgeon. Commercial fishing for lake sturgeon was prohibited in Michigan waters from 1928-1950 and has been closed since 1970. Wisconsin and Minnesota waters were closed in 1928 and Ontario closed its waters to commercial fishing for lake sturgeon in 1990. On December 30, 1982, following a petition to list lake sturgeon as a threatened or endangered species under the Endangered Species Act of 1973, the U.S. Fish and Wildlife Service (Service) recognized lake sturgeon as a Category 2 (C2)candidate species for listing under the Act. This designation placed lake sturgeon in a category of species for which there is insufficient information to make a listing decision. On July 19, 1995, the Director of the Service redefined the term 'candidate species' to mean only those species for which the Service has sufficient information indicating that listing under the Endangered Species Act may be appropriate. Those species formely known as 'Category 2' (C2) candidate will no longer have a particular name or categorization, nor will they be manintained on a formal list by the Service. In Canada, lake sturgeon are not classified as rare, threatened, or endangered, although it is recognized that many stocks have been depleted or extirpated (Houston 1987). Current commercial, tribal, and sport fishing regulations for Lake Superior are listed in Table 2.

Table 2. Sport and commercial fishing regulations for lake sturgeon in Lake Superior by jurisdiction.

	FISHERY	
GOVERNMENT OR AGENCY	SPORT	COMMERCIAL
Minnesota	Possession Prohibited	Possession Prohibited
Grand Portage Indian Reservation	No regulations	No Regulations
Fond du Lac Indian Reservation	Ceded Territory-One fish per year, open year round.	No Regulations
Michigan *	127 cm minimum size limit July 1-April 30. One fish per season.	Possession Prohibited Mandatory reporting of incidental catches.
COTFMA Bay Mills Indian Community, Sault Ste. Marie Tribe, and Grand Traverse Band.	No Sport Regulations. Sturgeon treated as protected by tribal wardens.	May not be sold. If alive, must be released. If dead, permitted for home use.
Keweenaw Bay Indian Community *	127 cm minimum size limit July 1-April 30. Two fish per season.	Fishing for sturgeon is prohibited. Home use of dead sturgeon is permitted.
Wisconsin	127 cm minimum size limit. Open year round, One fish per year. Mandatory registration.	Possession Prohibited
Bad River Band of Lake Superior Chippewa	No Regulations	No Regulations
Red Cliff Band of Lake Superior Chippewa	Regulations for Lake Superior tributaries only: 114 cm minimum size limit, June 1-March 1. One fish per person per year. Mandatory registration.	May not be sold to non-Indians. Home use permitted
Province of Ontario	Open Season except December 24. One fish per day. No size limit.	Possession Prohibited

* Sturgeon River, Baraga County, Michigan, closed to all fishing (April 1-July 30) from Prickett spillway dam to 0.8 km downstream.

Source: Regulations compiled by K. Gebhardt, Bay Mills Indian Community.

The collapse of the lake sturgeon fishery led to early attempts at artificial propagation in the Detroit River between 1883 and 1887 (Baker 1980). The greatest difficulty in hatchery culture was poor success in securing ripe males and females. Fungal growth on their gelatinous egg mass, and the inability of fish culturists to identify a suitable food for fry, were additional culture problems. These initial attempts at lake sturgeon culture were abandoned by the early 1900's (Baker 1980).

BIOLOGY

Lake sturgeon are indigenous to the Mississippi River, Laurentian Great Lakes, and the Hudson-James Bay watersheds (Harkness and Dymond 1961; Houston 1987). They are the only species of sturgeon endemic to the Great Lakes basin.

The largest of all freshwater fish in the Great Lakes basin, lake sturgeon are benthivores, feeding on molluscs, crayfish, insect larvae and nymphs, fish eggs, amphipods, leeches, other invertebrates, and algae (Scott and Crossman 1973; Becker 1983). Lake sturgeon are long-lived reaching ages of 100 to 150 years. Habitats utilized by lake sturgeon closely overlap with those of white and longnose suckers, which are probably its greatest competitors for food (Scott and Crossman 1973).

Lake sturgeon generally migrate from lakes into spawning tributaries prior to or shortly after the rivers are free of ice to areas of rapids or the base of falls that prevent further migration (Scott and Crossman 1973). In the lower Great Lakes and some inland lakes, where suitable spawning streams are limited or not available, lake sturgeon spawn over rocky shorelines or near islands (Scott and Crossman 1973; Becker 1983). Except for parasitic lampreys, which are known to attack and possibly kill lake sturgeon (Scott and Crossman 1973, Vladykov 1985), predation on lake sturgeon is limited by the sharp scutes of the young and large size of adults. Eggs and newly-hatched larval lake sturgeon may be preyed upon by other benthic or piscivorus fishes.

Genetics

Currently, there is no scientific information regarding the genetic variability within and between populations of lake sturgeon in Lake Superior, and limited knowledge of most Great Lakes populations. Genetic analysis supports the hypothesis that lake sturgeon belonging to one glacial race used colonization routes from the Mississippian glacial refugia to recolonize their contemporary range of distribution in the Great Lakes (Moira Ferguson, Department of Zoology and Institute of Ichthyology, University of Guelph, Ontario, Canada, N1G 2W1, personal communication). Recently, the genetic status of lake sturgeon from Lake Erie was compared to populations from Lake St. Clair, and the Wolf River and Menominee Rivers, Wisconsin, using protein electrophoresis (Porter et al. 1995). Results of this investigation indicate that a unique phenotype exists in the Lake Erie population. Porter et al. (1995) caution against augmenting the existing Lake Erie lake sturgeon population through the use of introduced stocks, noting the possibility that stocking might actually accelerate the loss of lake sturgeon from Lake Erie through intergression of genetically different strains.

POPULATION CHARACTERISTICS

Unique to Lake Superior is the presence of two, self-sustaining populations, in the Bad River, Wisconsin, and the Sturgeon River, Michigan. Additional self-sustaining populations likely exist, but documentation is limited.

Distribution/movements

Self sustaining populations of lake sturgeon in Lake Superior are currently found in the Sturgeon River, Michigan; Bad River, Wisconsin; and the Kaministiquia, Michipicoten, Pic, Goulais, and Black Sturgeon Rivers, Ontario. One adult lake sturgeon was captured in the lower Ontonagon River, Michigan, in the fall of 1993 (Michigan Department of Natural Resources, P.O. Box 440, Baraga, MI 49908, unpublished data). There is little documentation on the use of the Tahquamenon River by lake sturgeon, yet fish occasionally taken in Whitefish Bay by tribal members of the Bay Mills Indian Community may be products of this system (Ken Gebhardt, Bay Mills Indian Community, Route 1, Box 313, Brimley, MI 49715, personal communication). Lake sturgeon have been observed in the Iron River, Michigan, and Amnicon River, Wisconsin (USFWS, Marquette Biological Station, 1924 Industrial Parkway, Marquette, Michigan 49855, unpublished data), and captured in the Iron River, Wisconsin (U.S. Fish and Wildlife Service, Ashland Fishery Resources Office, 2800 Lake Shore Drive East, Ashland, WI, 54806, unpublished data) (Table 3).

Table 3. Lake Superior tributaries for which there is current documentation of spawning by lake sturgeon.

WISCONSIN -	Bad River
MICHIGAN -	Sturgeon River
ONTARIO -	Big Pic River
	Black Sturgeon River
	Goulais River
	Gravel River
	Kaministiquia River
	Michipicoten River
	Nipigon River

From 1983 to 1994, 688,190 fry and 127,710 fingerling lake sturgeon were stocked in the St. Louis River, MN (Table 4). These fish were the progeny of adult lake sturgeon from Lake Winnebago, Wisconsin. The Wisconsin Department of Natural Resources (WIDNR) stocked lake sturgeon fingerlings in July and August at 50-75 mm total length, and the Minnesota Department of Natural Resources (MNDNR) stocked in September or early October at 125-200 mm total length. Coded wire tags were injected into the snout cartilage of all year-classes of fingerlings stocked by the MNDNR and the 1991 cohort were also tagged under the sixth dorsal scute posterior of the head (MNDNR, Duluth Area Fisheries, 5351 North Shore Drive, Duluth, MN 55804).

Results of assessments conducted by the MNDNR and WIDNR since 1988 indicate an increasing population of introduced lake sturgeon in the St. Louis Bay, Minnesota, and along the south shore of Lake Superior. Lake sturgeon appear to reside within St. Louis Bay from the time of stocking until age four or five when they migrate to the south shore of Lake Superior (MNDNR, Duluth Area Fisheries, 5351 North Shore Drive, Duluth, MN 55804; WIDNR, Box 589, Bayfield, WI 54814, unpublished data).

Prior to 1985, lake sturgeon catches in WIDNR assessment nets were predominantly from the area near the mouth of the Bad River and Chequamegon Bay. From 1985 through 1991, lake sturgeon have increased in abundance and mean length annually in waters between Superior, Wisconsin, and the western Apostle Islands (Figures 3 and 4) (Schram 1994). This increase appears to be in direct

Table 4. Records of lake sturgeon stocked in the St. Louis Bay by the Minnesota and Wisconsin Department of Natural Resources, 1983-1994.

YEAR	MINNESOTA		WISCONSIN		TOTAL	
	FRY	FINGERLING	FRY	FINGERLING	FRY	FINGERLING
1983			102,000	2,659	102,000	2,659
1984			162,000	18,000	162,000	18,000
1985		4,909	59,000	2,745	59,000	7,654
1986		420				420
1987						
1988		18,210		6,050		24,260
1989		7,150	50,000	100	50,000	7,250
1990		10,282	24,400		24,400	10,282
1991		5,336	96,280	4,500	96,280	9,836
1992	36,580			13,499	36,580	13,499
1993			7,380	19,333	7,380	19,333
1994			150,550	14,517	150,550	14,517
TOTAL	36,580	46,307	651,610	81,403	688,190	127,710

Source: MNDNR and WIDNR data, compiled by MNDNR response to the stocking program in the St. Louis River. After leaving the St. Louis River, stocked lake sturgeon moved eastward along the south shore. Tag returns indicate these fish stay west of the Apostle Islands (Schram 1994).

Lake sturgeon marked in Chequamegon Bay, Wisconsin, have generally been recaptured in the same area and in or near the Bad River (Schram 1994). Results of a 1995 telemetry study demonstrated that lake sturgeon spawning in the Bad River moved into Lake Superior and nearby Chequamegon Bay shortly after spawning (USFWS, Fishery Resources Office, 2800 Lake Shore Drive East, Ashland, WI 54806, unpublished data). From these data we infer that lake sturgeon spawning in the Bad River utilize Chequamegon Bay as a home area when they are immature or not spawning.

Since the mid-1980's, one lake sturgeon marked in Chequamegon Bay, and one marked in Frog Bay, Wisconsin (near the Apostle Islands), were recaptured spawning in the Sturgeon River, Michigan (Schram 1994; Auer 1995). Another lake sturgeon marked in Chequamegaon Bay was recaptured in Misery Bay, Michigan (Schram 1994). One lake sturgeon marked in the Sturgeon River was recaptured in the lower Bad River, indicating that some degree of mixing occurs in Lake Superior between fish that spawn in these two tributaries (USFWS, Fishery Resources Office, 2800 Lake Shore Drive East, Ashland, WI 54806, unpublished data).

Adult lake sturgeon migrate upstream 69 km in the Sturgeon River, Michigan (Auer 1995), and 42 km in the Bad River, Wisconsin (USFWS, Fishery Resources Office, 2800 Lake Shore Drive East, Ashland, WI 54806, unpublished data). Results of telemetry studies and tag return information indicate that after spawning in the Sturgeon River, Michigan, adult lake sturgeon move downstream first into Portage Lake, then disperse east or west into Lake Superior (Auer 1995). Marked adult fish have been recaptured by commercial fishers 170 km to the west of the north entry to Portage Canal, and up to 165 km east of the south entry to Portage Canal near Munising, Michigan (Auer 1995). Marked lake sturgeon have also been recaptured by commercial fishers near Marquette, Michigan, and in lower Keweenaw Bay, Michigan. From 1987 through 1994, Native Americans reported 15 incidental catches in gillnets, state licensed commercial fishers reported 12 incidental catches in trap nets, and sport fishers reported 7 catches with hook and line (Auer 1995).

Juvenile habitat/movements

In 1994, 19 juvenile lake sturgeon, 21-86 cm total length, were captured in the lower Bad River, Wisconsin, in bottom trawls (N=3) or near the mouth of the Bad

River in Lake Superior in gillnets (N=16)(Slade and Mattes 1995). Using the data on age presented by Schram (1994), these fish could range between one to nine years. Most juveniles (58%) were captured within 200 m of the river mouth in water less than 6.1 m deep. Substrate samples at capture locations varied from 99% sand in Lake Superior to 70% silt and 30% detritus in the lower Bad River. Lake sturgeon were captured during June, July, and September, indicating that juvenile lake sturgeon utilize this area throughout the open water season, and that some juveniles move to the lower Bad River and Lake Superior at an early age. Surface temperature ranged from 13.5 to 19°C.

In August and September 1994, 18 juvenile lake sturgeon, 29-77 cm total length, were captured in gillnets in Portage and Torch Lakes, Michigan, within 16 km of the mouth of the Sturgeon River (Slade 1995). Capture depths ranged from 7.0 to 14.6 m with a mean depth of 11.8 m. Bottom substrate was similar at each location where lake sturgeon were captured, consisting of at least 95% silt. Bottom water temperature ranged from 18 to 18.5°C at locations where lake sturgeon were captured. Using the data on age presented in Figures 6 and 7, five or six age groups were represented. Age one and two lake sturgeon comprised 67% of the sample, indicating that some juvenile lake sturgeon move out of the Sturgeon River at an early age.

In July and August 1987, 24 lake sturgeon, mean age of 5.1 years and mean total length of 46 cm, were captured in the lower 47 km of the Kaministiquia River (Cullis et al. 1987). The majority of these fish (N=22) were captured between 10 and 20 km upstream from the mouth. This area is characterized by deep pools (maximum depth=8 m), slow flow, substrate consisting primarily of silt and sand, and an average depth of 2.5 m. Monthly surface temperature ranged from 18 to 24°C.

Spawning habitat/temperature

Lake sturgeon in the Sturgeon River, Michigan, and Bad River, Wisconsin, have been observed spawning over substrate consisting primarily of sandstone bedrock, rubble, and cobble. Adult lake sturgeon have been captured in both the Bad and Sturgeon Rivers at temperatures of 7 to 20°C (Auer 1995; Slade and Rose 1994). Spawning has been observed at temperatures of 10 to 18°C in the Bad River (Slade and Rose 1994), and 9.5 to 19°C in the Sturgeon River (Auer 1995).

The MNDNR developed spawning habitat suitability indices for the St. Louis River downstream from the Fond du Lac Dam. These indices indicate adequate substrate, depth, and water velocity for lake sturgeon spawning (MNDNR, Duluth Area Fisheries, 5351 North Shore Drive, Duluth, MN 55804, unpublished data).

Abundance

Assessment data of stocked lake sturgeon in St.Louis Bay, MN indicate a relatively stable population of juveniles less than 635 mm long. Yearly summer assessment gillnet catch-per-unit-effort (CPUE) from 1990 to 1994 was 2.9, 2.5, 3.3, 3.0 and 5.8 lake sturgeon per lift, respectively (Table 5)(MNDNR, Duluth Area Fisheries, 5351 North Shore Drive, Duluth, MN 55804, unpublished data).

Table 5. Statistics for lake sturgeon captured in the St. Louis Bay, MN from 1990-1994.

	1990	1991	1992	1993	1994
Sample Size [1]	86	80	54	107	79
Mean Length (mm)	410	416	450	435	411
Percent with Tags [2]	50%	65%	61%	49%	44%
CPUE [3]	2.9(22)	2.5(22)	3.3(21)	3.0(21)	5.8(13)

[1] Sample size indicates all sturgeon captured during summer population assessments using standard experimental gill nets and those sturgeon captured in fall special assessment using 3 panel, 48 m, 3.18 to 5.08 cm mesh nets.
[2] Coded wire tags
[3] Effort measured in net nights. One net night equals 76.25 m of experimental gillnet with five, 15.25 m panels of 1.91, 2.54, 3.18, 3.81 and 5.08 cm bar multifilament nylon gillnets. Number of net nights in parentheses.
Source: MNDNR

The population of lake sturgeon which utilize the Sturgeon River for spawning is one of the largest populations in Michigan. Combining eight years of tag/recapture information, an estimate of the adult population stands at approximately 1000-1200 individuals (Auer 1995).

During the spawning migrations of 1992 and 1995, 34 and 36 lake sturgeon were captured in the Bad River, Wisconsin (Slade and Rose 1994; USFWS, Fishery Resources Office, 2800 Lake Shore Drive, Ashland, WI 54806, unpublished data). In both years, numerous untagged lake sturgeon were observed near the lower rapids, resulting in a conservative estimate of at least 50 spawning fish during each of these two years. Anecdotal information suggests that an unknown number of lake sturgeon spawn in the White River, a tributary of the Bad River.

Age and growth

Ages of spawning fish were estimated for 11 fish captured in the Sturgeon River, Michigan, in 1987 (Auer 1995). Five females 145-161 cm total length were 31 to 36 years old, and six males 122-152 cm total length were 22 to 33 years old. The length-frequency distribution of all fish captured for eight years (1987-1994) in the Sturgeon River (recaptures not included) is presented in Figure 5.

During the 1987 and 1988 spawning migrations in the Bad River, Wisconsin, 8 adult males were 8 to 21 years old (average 16 years) and 86-138 cm total length, and 3 females were 22 to 24 years old (average 23 years) and 133-140 cm total length (average 137 cm) (Shively and Kmiecik 1989). In 1992, 16 adult males were 89-183 cm total length (average 113 cm) and 4 adult females were 122-183 cm total length (average 156 cm). An additional 9 adult fish of undetermined sex were 94-144 cm total length (average 118 cm) (Slade and Rose 1994). Also in the Bad River in 1995, 20 adult males were 113-141 cm total length (average 128 cm) and 16 adult females were 135-161 cm total length (average 148 cm) (USFWS, Fishery Resources Office, 2800 Lake Shore Drive East, Ashland, WI 54806, unpublished data). Average total length of lake sturgeon captured near the spawning grounds in the Sturgeon and Bad Rivers between 1987 and 1995 varied, with Bad River fish shorter in total length (Table 6).

Growth of lake sturgeon captured in western Lake Superior was slow based on 198 aged fish and annual individual growth rates determined from the recapture of 14 tagged fish (Table 7)(Schram 1994). Growth is faster in younger fish and gradually slows as age and size increases. Lake sturgeon ranged in age from 4 to 42 years (Figure 6).

In the St. Louis River, Minnesota, mean length of known age lake sturgeon of the 1991 cohort sampled at age one, two, and three was 32.0, 34.0 and 38.6 cm, respectively (Figure 7) (MNDNR, Duluth Area Fisheries, 5351 North Shore Drive, Duluth, MN 55804, unpublished data).

Table 6. Combined 1987 to 1995 total length (cm) of spring run lake sturgeon captured in the Bad River, Wisconsin and Sturgeon River, Michigan.

Year	Sex	Range in Total Length	Average	n
BAD RIVER, WISCONSIN				
1987-1995	Male	86.4-182.9	120.8	49
	Female	121.9-182.9	146.8	31
	Undetermined	94.2-142.2	123.1	11
STURGEON RIVER, MICHIGAN				
1987-1995	Male	99-159	134.5	508
	Female	131-183.5	153.4	248
	Undetermined	91-162.6	132.2	87

Age at maturity

Age at maturity for Lake Superior lake sturgeon has not been documented. However, inferences can be made based on fish captured during their spawning migration in the Bad River in 1987, 1988, 1992, and 1995, and in the Sturgeon River from 1987 through 1994. Assuming lake sturgeon captured during the spring in the Bad River, Wisconsin, are mature spawners, their size can be correlated to age at maturity. Mature males (N=44) ranged from 86-183 cm total length (average 120 cm) and mature females (N=23) ranged from 122-183 cm total length (average 148 cm). Age at maturity was estimated based on aging data presented in Figure 6. Males first matured at about 9 years and females at about 20 years. Mean age of all spawning males is 19 years and all spawning females 30 years. Applying the data on age of lake sturgeon captured in Chequamegon Bay and presented in Figure 6 to lake sturgeon captured in the Sturgeon River, males first matured at age 14 and females at age 20. Mean age of all males (N=374) would be 22 years, and mean age of all females (N=206) would be 30 years.

Table 7. Growth of lake sturgeon from Lake Superior based on Wisconsin DNR tag and recapture data (Schram 1994).

Initial Tag Length (cm)	Recapture Length (cm)	Years between Capture	Growth (cm/year)
53.3	68.6	2	7.6
69.9	89.7	4	5.0
83.6	92.5	4	2.2
84.6	98.0	3	4.5
101.1	108.0	2	3.5
101.6	102.9	1	1.3
111.0	112.0	1	1.0
117.3	119.4	3	0.7
120.7	120.9	2	0.1
124.5	129.5	3	1.7
125.0	130.6	1	5.6
131.3	133.4	1	2.1
137.9	139.2	1	1.3
139.4	139.7	2	0.15

Source: Schram 1994

Recruitment

Natural recruitment of wild fish has been documented in four Lake Superior tributaries. In 1988, 1992, and 1993, age 0 lake sturgeon were captured in the Sturgeon River (Auer 1995), and in 1994, 18 juveniles 29-77 cm total length (average 43 cm) were captured in Portage and Torch Lakes, Michigan (Slade 1995), a probable nursery area for lake sturgeon produced in the Sturgeon River. In the fall of 1992, three juvenile lake sturgeon 16-20 cm total length (average 17.5 cm) were captured in the lower Bad River (Slade and Rose 1994). In the lower Bad River and nearshore waters of Lake Superior, 19 juvenile lake sturgeon 21-86 cm total length (average 53 cm) were captured in 1994 (Slade and Rose 1994, Slade and Mattes 1995). Figure 6 indicates some level of recruitment occurring over the past 40 years from the Bad River. Two juvenile lake sturgeon, total length 6 and 8 cm were captured in the Kaministiquia River in 1994 (Bruce Thacker, Ontario Ministry of Natural Resources, Lake Superior Management Unit, 435 James St. S., Suite 221, Thunder Bay, Ontario, P7E 6S8, personal communication). In 1995, larval lake sturgeon were observed and collected in the Pic River, Ontario (Robert Young, Department of Fisheries and Oceans, Sea Lamprey Control Centre, 1 Canal Drive, Sault Ste. Marie, Ontario, personal communication). Juvenile lake sturgeon in Whitefish Bay may be recruiting from the nearby Tahquamenon or Goulais Rivers (Figure 1).

In the St. Louis River, Minnesota, the percentage of microtagged lake sturgeon captured in assessment nets ranged from 44 to 65%, indicating probable recruitment from stocked fry as well as microtagged fingerlings or tag loss (Figure 8) (MNDNR, Duluth Area Fisheries, 5351 North Shore Drive, Duluth, MN 55804, unpublished data).

Propagation

Few attempts have been made to propagate Lake Superior lake sturgeon. The Bad River Band of Lake Superior Chippewa successfully reared and stocked 1,500 fingerlings in the Bad River in 1988. Other attempts to capture and rear Bad River lake sturgeon between 1989 and 1992 were largely unsuccessful (Joe Dan Rose Jr., Bad River Natural Resources Department, P.O. Box 39, Odanah, Wisconsin, personal communication 54861).

Fish culturists in Michigan and Wisconsin have developed the technology for gamete collection and rearing of lake sturgeon (Folz et al. 1983; Anderson 1984; Czeskleba et al. 1985). The Wild Rose State Fish Hatchery, Wisconsin, and several federal hatcheries, currently rear or are capable of rearing lake sturgeon. These facilities could potentially rear fish for restoration efforts in Lake Superior.

Harvest

Lake sturgeon can currently be legally harvested by state licensed sport anglers, and tribal subsistence and commercial fishers (Table 2). In Wisconsin, state licensed harvest has been monitored through mandatory registration since 1983. The bag limit is one fish per angler annually. In 1991, the minimum size limit for state licensed anglers increased from 101.6 cm to 127.0 cm total length. Anglers must acquire a tag prior to fishing for lake sturgeon and register legally caught fish with the WIDNR. Registered angler catches peaked at 14 fish in 1988 in Lake Superior, but has remained at 2 or less since the larger size limit went into effect (Table 8).

A 1989 survey of Ontario waters of Lake Superior revealed that lake sturgeon were harvested commercially in 22 districts (Ed Iwachewski, Ontario Ministry of Natural Resources, Lake Superior Programs Office, 1194 Dawson Road, Thunder Bay, Ontario P7B 5E3, personal communication). The reported commercial catch of lake sturgeon for the Ontario waters of Lake Superior are 72, 28, 0, 6, 5, 22, and 16 kgs (round weight) for the years 1988 to 1994, respectively.

Table 8. Wisconsin sport and tribal home use lake sturgeon harvest from Lake Superior, 1983-1993.

Year	Sport Harvest	No.≥ 127cm	Mean Size cm	Mean Weight kg	Red Cliff kg	Bad River
1983	2	2	140	Unknown	18	Unknown
1984	3	1	120	Unknown	Unknown	Unknown
1985	5	3	132	Unknown	25	Unknown
1986	4	1	123	12.7	86	Unknown
1987	0	0			Unknown	Unknown
1988	14	8	126	13.9	Unknown	Unknown
1989	11	2	118	12.7	13.6	Unknown
1990	7	2	127	15.2	Unknown	Unknown
1991	2	2	142	20.2	Unknown	Unknown
1992	0	0			Unknown	Unknown
1993	1	1	163	25	Unknown	Unknown

Source: Schram 1994

The Michigan Department of Natural Resource's (MIDNR) draft Lake Sturgeon Management Plan (editors Whelan and Hay-Chmielewski, in review), prohibits spearing in the state while allowing a catch and release sport fishery in designated areas only, until assessments of current stocks can be made.

ASSESSMENT TECHNIQUES

The primary sampling gear used to assess lake sturgeon populations in Lake Superior and its tributaries is the gillnet. Mortality of lake sturgeon captured in assessment gillnets is estimated to be less than 5% when nets are lifted daily (MNDNR, Duluth Area Fisheries, 5351 North Shore Drive, Duluth, MN 55804, unpublished data). The WIDNR developed gillnet selectivity indices that can be used to estimate the most efficient mesh size to fish for various sizes of lake sturgeon (Appendix A). Management agencies, researchers, and commercial fishers also capture lake sturgeon in trap nets and bottom trawls, with electrofishers and larval nets, and with dip nets at barriers. Although the observed mortality of lake sturgeon in gillnets is minimal, mortality of non-target fishes remains a concern. In 1995, the MIDNR, Michigan Technological University, Keweenaw Bay Indian Community, and the USFWS tested the feasibility of using trap nets to capture juvenile lake sturgeon near the Sturgeon River, Michigan. Preliminary results indicate that trap nets were not successful at capturing lake sturgeon in locations where they had previously been captured with gillnets (USFWS, Fishery Resources Office, 2800 Lake Shore Drive East, Ashland, WI 54806, unpublished data).

IMPEDIMENTS TO REHABILITATION

Rochard et al. (1990) listed three major impediments to the restoration of sturgeons worldwide: 1) fishing; 2) physical obstacles for migrating fish; and 3) physical impacts on spawning and nursery areas, including alterations to substrates, water flow, and pollution. Additional impediments to the rehabilitation of lake sturgeon in Lake Superior, include: the lack of information regarding abundance of the species and its life history, the potential loss of genetic stocks unique to Lake Superior waters, and likely predation on lake sturgeon by sea lampreys.

<u>Effects of fishing</u>

The extent and effect on lake sturgeon populations of current legal harvest in the licensed sport and tribal fishery is unknown, but thought to be minimal. Illegal harvest of lake sturgeon cannot be estimated accurately, but there is potential for substantial harm to populations that concentrate in rivers to spawn (Auer 1995). A strong caviar market could increase the incentive to poach or harvest sexually mature fish.

Schorfhaar and Peck (1993) studied by-catch in Michigan state-licensed trap net fisheries in Lake Superior from 1983-1989. Of the 48 lake sturgeon collected in trap nets, none were observed dead. Monitoring surveys of small mesh commercial gill net fisheries in Wisconsin and Michigan suggest that by-catch mortality of lake sturgeon is minimal, but additional monitoring is necessary in locations where lake sturgeon densities are higher, and should continue as lake sturgeon populations expand (Richard Schorfhaar, MIDNR, 488 Cherry Creek Road, Marquette, MI 49855 and Mike Toneys, WIDNR, Sturgeon Bay, Wisconsin, personal communications).

Physical obstacles for migrating fish

Some man-made barriers have altered river substrates and flow regimes in areas critical to lake sturgeon spawning. Barriers, which are often constructed in high gradient reaches with suitable lake sturgeon spawning substrate, block spawning migrations and impound what was likely favorable spawning substrate. The net result is a loss in available spawning habitat. Historical spawning tributaries with man-made barriers include the Ontonagon and Sturgeon Rivers, Michigan; the White River, Wisconsin (a tributary of the Bad River); the St. Louis River, Minnesota; and the Black Sturgeon, Wolf, Nipigon, and Michipicoten Rivers, Ontario. Some water level control structures have been built at natural barrier sites, such as the St. Louis River, Minnesota/Wisconsin).

Physical impacts on spawning and nursery areas

The operation of hydroelectric facilities has been documented to negatively affect anadromous fish populations by disrupting migratory behavior; de-watering habitat; stranding eggs, larvae, and adults; and by altering the annual hydrograph (Olson et al. 1985). Hydroelectric facilities that operate in a peaking mode destabilize daily flows. High flows are used to generate power during peak demand periods and low flows are present at all other times. This mode alternately de-waters and flushes river reaches on a daily basis, and has been shown to directly affect recruitment processes of stream fishes (Bain 1988). Also, entire river reaches may be bypassed or seasonally dewatered to increase the available head pressure of impoundments, resulting in a direct loss of habitat and increased opportunities to poach lake sturgeon.

The conversion of peaking hydroelectric facilities to run-of-river flows (where instantaneous inflows equal instantaneous outflows) has been shown to increase the ripeness of spawning sturgeon; decrease the length of the spawning period; increase the number of large adults in the spawning run; and decrease the potential for egg and larvae loss due to rapidly changing discharges that lead to desiccation or flushing (Auer 1995). These factors increase the potential for natural recruitment.

Lake Superior tributaries have and continue to be influenced by poor land use, contaminants, and water pollution. Logging, mining, agriculture and urbanization have contributed to excessive inputs of fine sediment and sand, removal of large woody debris from river channels, changes in stream hydrology, and inputs of saw log and other wastes into river mouths and coastal shoreline reaches. Inputs of fine sediment may bury spawning and nursery habitat. Sediments may remain in some tributaries because of low stream power (combination of low gradient and stable flows). Throughout the Great Lakes basin, the removal of old growth forests initially led to a destabilization of the hydrograph by increasing runoff and reducing baseflows. When followed by settlement and agriculture development, these events increased fine sediment and sand inputs into river systems which buried spawning substrates. Some recovery is occurring as second growth forests mature and stream banks stabilize, but many Lake Superior tributaries still carry heavy sediment loads.

The conversion of forests from old growth to secondary growth has likely reduced nutrient input into some watersheds. Nutrient loss results from the loss of the humus layer through fire events. Furthermore, secondary forests have faster growing characteristics and bind up more nutrients than old growth forests (Vitousek and Reiners 1975).

Discharge of saw log wastes may reduce or eliminate river mouth and shoreline habitat used by lake sturgeon (Anonymous 1888). The addition of large amounts of sawdust causes extremely high biological oxygen demand and low dissolved oxygen concentrations in these locations (Sanders 1981). These conditions resulted in a reduction in the diversity and abundance of benthic organisms. Low oxygen levels and absence of benthic food organisms likely reduced available habitat for juvenile lake sturgeon. Efforts to rehabilitate lake sturgeon populations may be enhanced if these areas are restored to more natural conditions.

Mining has caused localized water quality and quantity problems in some drainages due to excessive inputs of fine sediment and sand, disturbance of substrate and sediment transport, and inputs of heavy metals (Gore 1985). Rehabilitation of these sites may also restore their productivity for lake sturgeon.

Limited knowledge of life history and abundance

Restoration and protection of habitats critical to lake sturgeon requires an understanding of the habitat requirements during all stages of their life history. Knowledge of the habitat requirements of lake sturgeon, particularly of juveniles, is limited. Current estimates of abundance are also lacking for all but one spawning population in Lake Superior. Increased assessment efforts will be required to determine if self-sustaining populations exist in historic spawning tributaries and to document their current level of abundance.

Potential loss of genetic stocks

Increased assessment efforts may determine if stocks exist or have been extirpated from historic spawning tributaries, thus indicating the preservation or loss of stocks that may have adapted to particular environments. Ongoing research at Ohio State University into the genetic variability of Great Lakes lake sturgeon stocks, which includes genetic material from the Bad River, Wisconsin, and Sturgeon River, Michigan, may provide managers with information that will assist with future management decisions.

Predation by sea lampreys

The impact of sea lampreys on lake sturgeon is not well documented. Scott and Crossman (1973) reported the capture of a large lake sturgeon in the Bay of Quinte, Lake Ontario, that carried 15 adult sea lampreys and scars from previous attacks. In 1990, 1992, and 1994, incidence of lamprey marks (species not identified) on lake sturgeon captured in the Sturgeon River, Michigan, ranged from 4.4 to 9.0% (Nancy Auer, Michigan Technological University, 1400 Townsend Drive, Houghton, Michigan 49931, personal communication). Since current sea lamprey control methods have reduced sea lamprey abundance by 90% from pre-control levels, it is likely that predation on lake sturgeon has also been reduced. Continued control of sea lamprey may be important to restoration of lake sturgeon to near historic levels.

AREAS OF CONCERN

Toxic chemicals

In recent years, the discovery of toxic chemicals in fish tissue raised concern over long-term human health issues and overall effects on all life history stages of fish populations. Bottom feeding and long-lived fish species are known to accumulate toxic chemicals in their tissues (Larsen 1988; MIDNR, Surface Water Quality Division, Lansing, MI, unpublished data). The impacts of toxic chemicals on lake sturgeon reproduction and recruitment are unknown and remain a concern to restoration efforts.

Sea lamprey control

Since the 1940's, efforts have been made to control sea lamprey populations in the Great Lakes. Although the control of sea lampreys is critical to rehabilitation efforts for the Lake Superior fish community. Two components of the integrated control program are concerns to lake sturgeon rehabilitation efforts: barrier dams and lampricide treatments. The problems associated with barriers have been previously discussed. The Wolf River, Ontario, is the only historical lake sturgeon spawning tributary in the Lake Superior basin with a sea lamprey barrier (Ed Iwachewski, Ontario Ministry of Natural Resources, Lake Superior Programs Office, 1194 Dawson Road, Thunder Bay, Ontario P7B 5E3). However, in tributaries where rehabilitation efforts may occur, any sea lamprey barrier should be provided with appropriate fish passage for lake sturgeon if necessary.

Lake sturgeon are more tolerant to the lampricide 3-trifluoromethyl-4-nitrophenol (TFM) than sea lampreys (Johnson and Weisser 1993). However, TFM can be toxic to lake sturgeon. Since 1989 the sea lamprey treatment policy has been to identify streams used by lake sturgeon and avoid treatment during spawning or incubation times. Using improved treatment techniques (Klar 1993), the USFWS can more accurately measure and apply treatment concentrations that are not lethal to lake sturgeon. These efforts reduce the risk of lake sturgeon mortality due to lampricide treatments. However, the lack of knowledge regarding the distribution of juvenile lake sturgeon in spawning tributaries during lamprey treatments remains a concern.

Commercial sale of sturgeons

The commercial sale of sturgeons not endemic to the Great Lakes region through the tropical fish market could have negative impacts on lake sturgeon populations. The accidental or purposeful release of exotic sturgeons into the basin could expose native populations to an infectious disease or bacteria and they could compete for food and habitat. An iridovirus-like agent from white sturgeon was recovered from lake sturgeon exposed to the infection (Hedrick et al. 1992). White sturgeon juveniles have been sold through tropical fish outlets in Michigan. Exotic sturgeons could also potentially interbreed with native lake sturgeon, jeopardizing the genetic integrity of native stocks.

Stocking of exotic piscivores in lake sturgeon spawning streams

Larval lake sturgeon drift downstream after most of their yolk sac has been absorbed (Kempinger 1988; LaHaye et al. 1992; Nancy Auer, Michigan Technological University, unpublished data). The duration and extent of this drift, and the degree of predation that stocked, non-native piscivores may inflict on drifting larval lake sturgeon is unknown. Increasing the number of non-native predators into a lake sturgeon spawning stream during the time of larval drift may negatively affect recruitment through predation of larval lake sturgeon by stocked fishes.

RESEARCH AND MANAGEMENT NEEDS

The following research and management needs, listed in order of priority, have been identified as being useful to ongoing and future rehabilitation efforts for lake sturgeon in Lake Superior.

1. Determine the current population status of lake sturgeon in historic spawning streams and estimate their abundance.

2. Describe the nursery habitats and habitat requirements of juvenile lake sturgeon and describe the movements of larval lake sturgeon and the time period that juveniles utilize spawning tributaries.

3. Describe the genetic variability of lake sturgeon within and among populations in the Great Lakes, the Lake Superior basin, and other populations in North America.

4. Estimate historic and present standing stocks of lake sturgeon.

5. Describe the annual movements of adult lake sturgeon in and out of spawning tributaries and nearshore waters. Adult fish, thought to concentrate and begin spawning aggregations in the fall, will be subject to fishing pressure and exposure to pollution problems. Areas of these aggregations will need to be excluded from fishing pressure at this time of year to reduce stress on the fish. Ice fishing and spearing during winter months may be targeting pre-spawning fish, especially in the Sturgeon River, Michigan.

6. Evaluate the impact the stocking of lake sturgeon may have on remnant stocks, and consider the amount of stocking that should be done. Quantify and document the results of lake sturgeon fry stocking in the St. Louis River, Minnesota.

7. Determine whether or not lake sturgeon imprint to spawning tributaries and if so, at what life stage.

8. Identify suitable techniques of capturing juvenile lake sturgeon that limit mortality of non-target fishes.

9. Quantify the mortality of lake sturgeon due to entanglement in commercial gears and illegal harvest.

10. Quantify predation on drifting lake sturgeon larvae by stocked non-native salmonids.

11. Evaluate the impact of toxic substances on lake sturgeon reproduction and survival.

12. Increase public awareness and education about lake sturgeon.

RECOMMENDATIONS

1. Relicensing criteria for hydroelectric facilities should provide: 1) run-of-river flows in riverine reaches; 2) adequate flow for lake sturgeon use in bypassed river channels; and 3) an appropriate annual water regime for lake sturgeon where the annual hydrograph is now altered by hydroelectric operations.

2. Comparable genetic analysis should be completed on as many Lake Superior lake sturgeon populations as possible. Until genetic analysis is conclusive, lake sturgeon stocking should be with fish of Lake Superior origin. Wild brood stock should be bred following principles designed to maximize the genetic variability of the progeny and minimize genetic drift and inbreeding, as described in Ryman and Utter(1987).

3. Self-sustaining populations of lake sturgeon in the Bad River, Wisconsin, and Sturgeon River, Michigan, should be protected through harvest regulation and habitat protection and restoration (where needed, see Table 2).

4. Lake sturgeon populations should be restored in tributaries that once had significant populations by use of habitat protection and restoration, judicious stocking, and harvest regulations. Specific tributaries include, the Pigeon River, Minnesota; St. Louis River, Wisconsin/Minnesota; Ontonagon and Tahquamenon Rivers, Michigan; and the Black Sturgeon, Nipigon, Pic, Michipicoten, and Goulais Rivers in Ontario.

5. Treatment for sea lamprey in tributaries known to contain lake sturgeon should be scheduled to limit contact with adult and juvenile lake sturgeon.

6. Watershed and stream rehabilitation will be necessary to restore the former processes and functions and to fully recover the productivity of these habitats. Tributaries that are identified for lake sturgeon rehabilitation should be evaluated regarding their degree of imparity. If necessary, sediments stored in the stream channel should be removed and old growth forests and subsequent large woody debris should be restored to these watersheds.

7. All point sources of pollution in watersheds containing lake sturgeon stocks should be evaluated on a watershed basis.

8. When possible, all lake sturgeon stocked into Lake Superior should be marked with an identifiable external mark.

9. A marking database should be established and maintained at one location where all agencies have access to it.

10. Agencies should standardize assessment techniques and records for interjurisdictional comparisons.

11. Natural resource agencies should work with county, city and state departments of transportation to encourage that road, bridge and other stream repair projects be delayed until larval sturgeon have drifted past the site.

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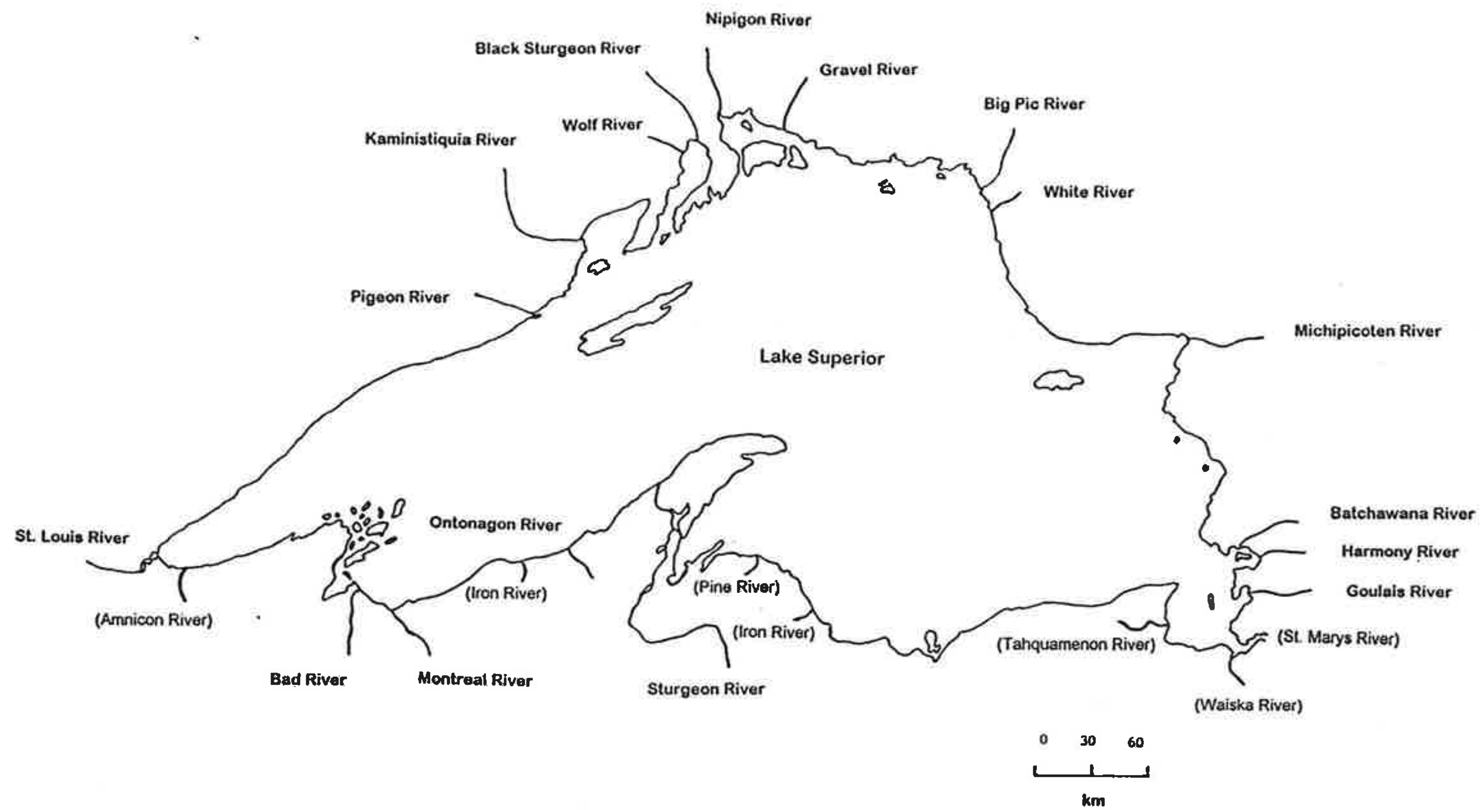


Names of rivers in parentheses indicate at least one lake sturgeon has been observed in the river or near the river mouth.

Figure 1. Lake Superior tributaries in which lake sturgeon have or currently are known to spawn.

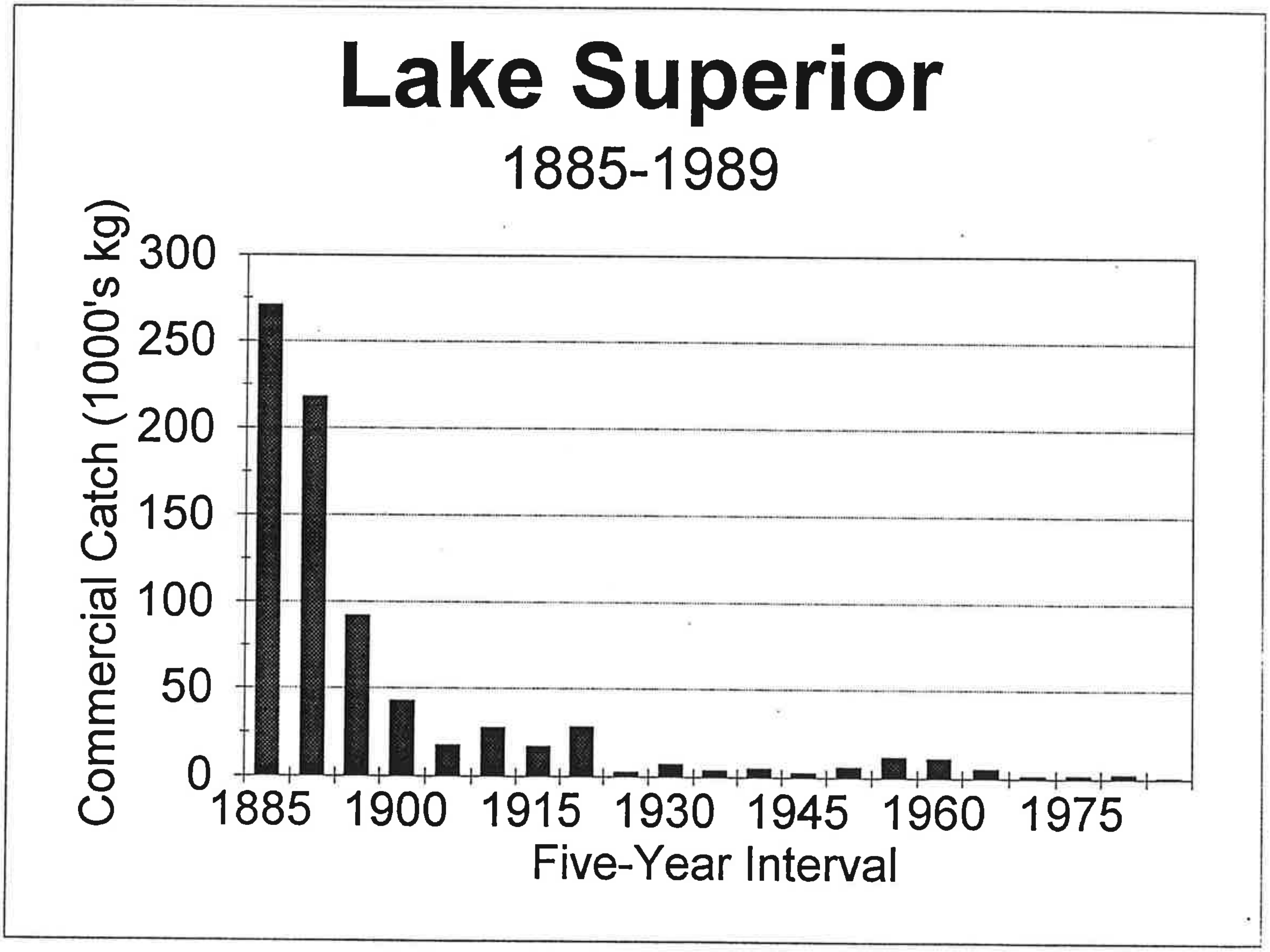
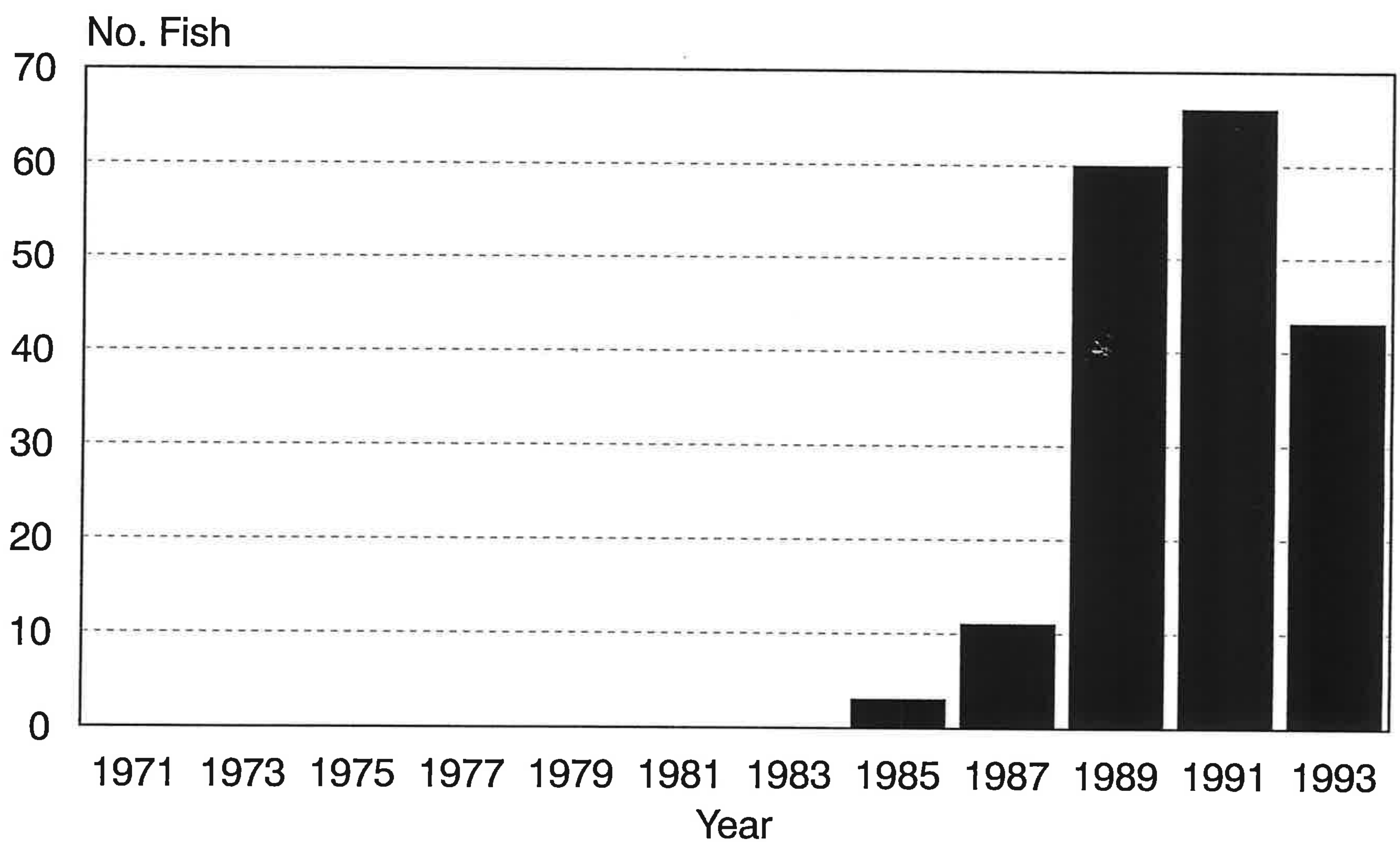


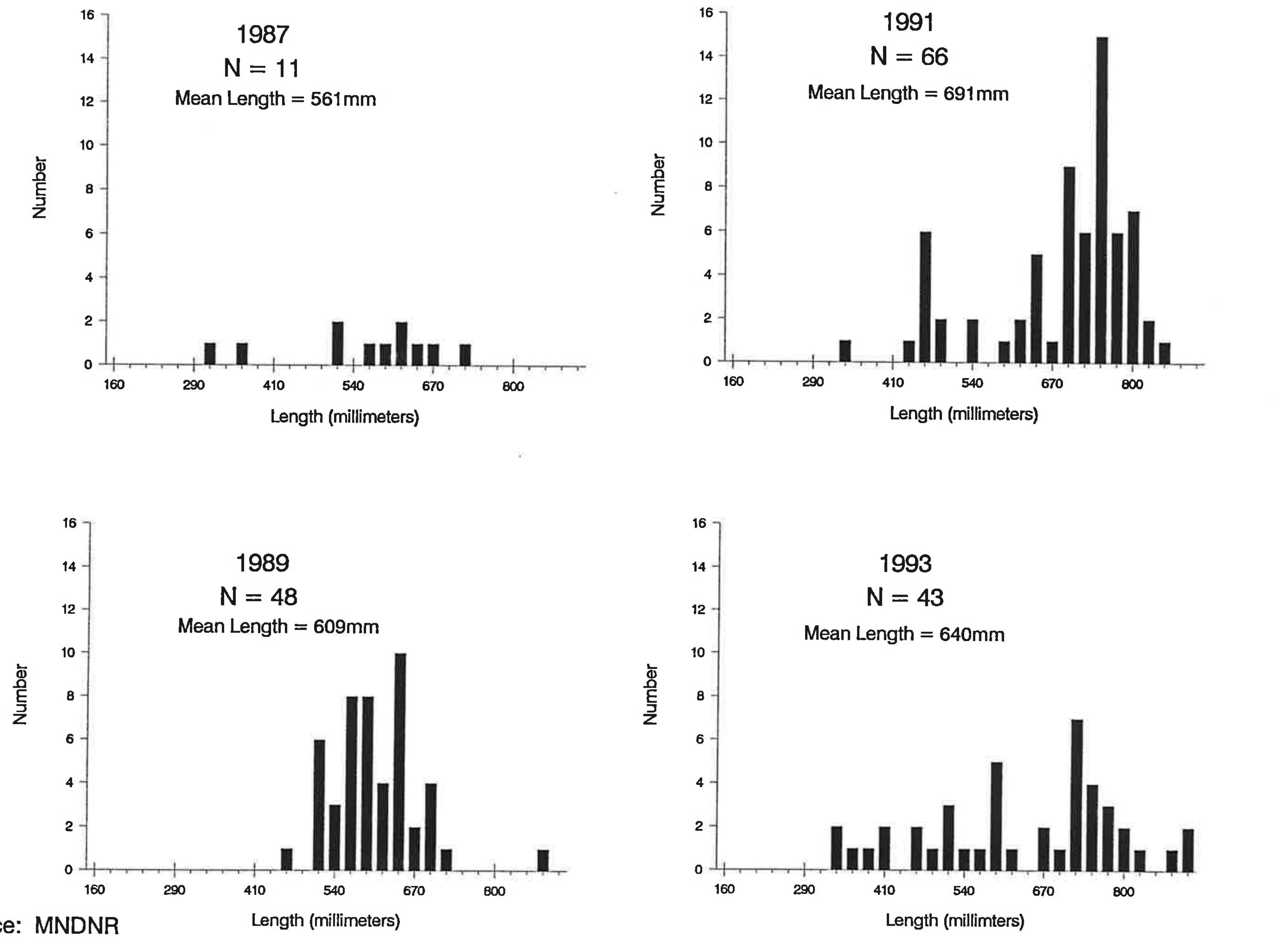
Figure 2. Total commercial catch of lake sturgeon from all Lake Superior waters 1885 to 1989.

Figure 3. Lake sturgeon catch in graded mesh summer assessment nets from western Lake Superior, 1971-1993.



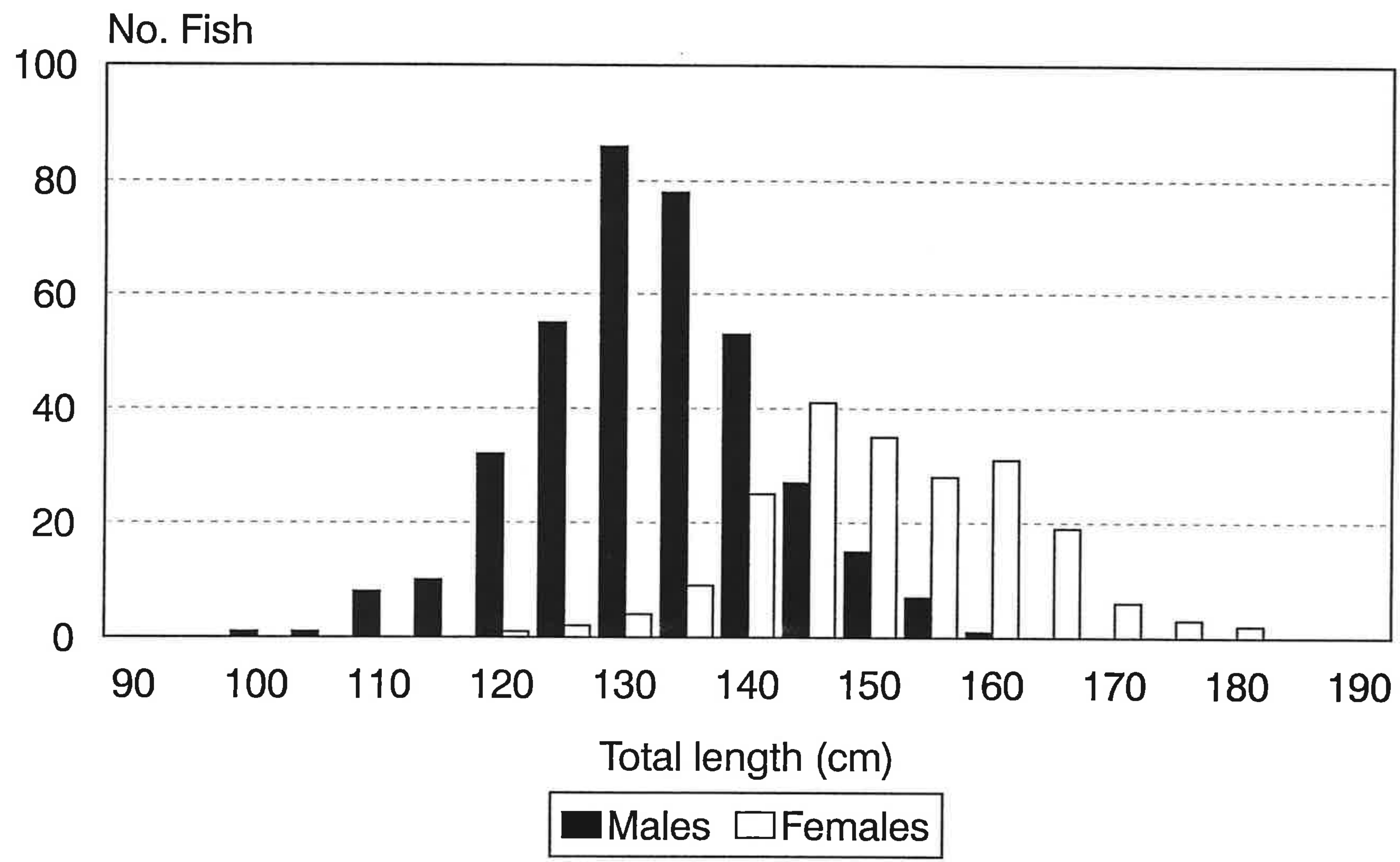
Source: WIDNR

Figure 4. Length frequency of lake sturgeon captured in Wisconsin DNR gillnet assessments along the south shore of Lake Superior, 1987-1993.



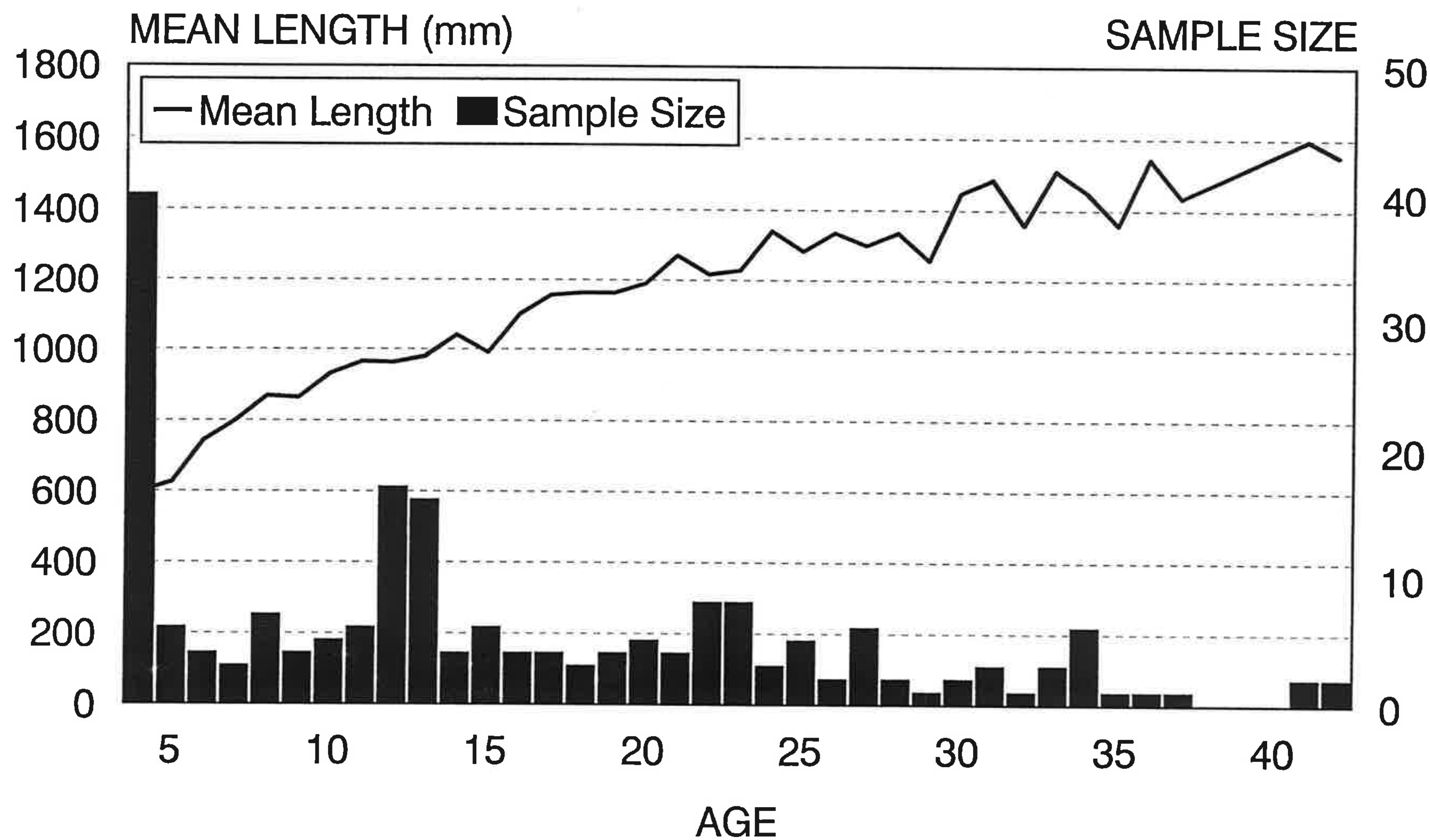
Source: MNDNR

Figure 5. Length frequency distribution of Sturgeon River lake sturgeon, 1987-1994.



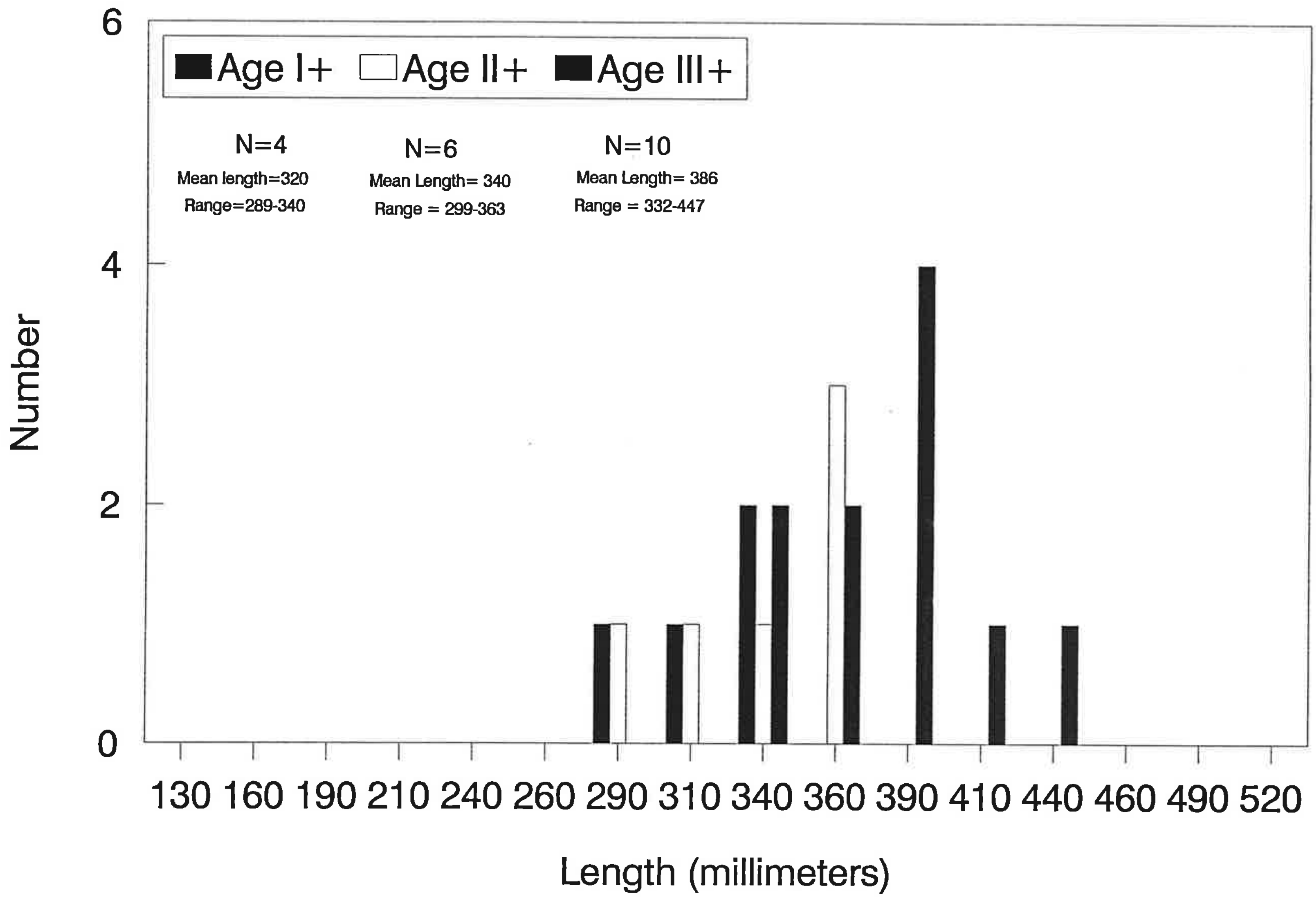
Source: Auer 1995

Figure 6. Total length and number of lake sturgeon sampled by age group in Chequamegon Bay and western Lake Superior, 1988-1993.



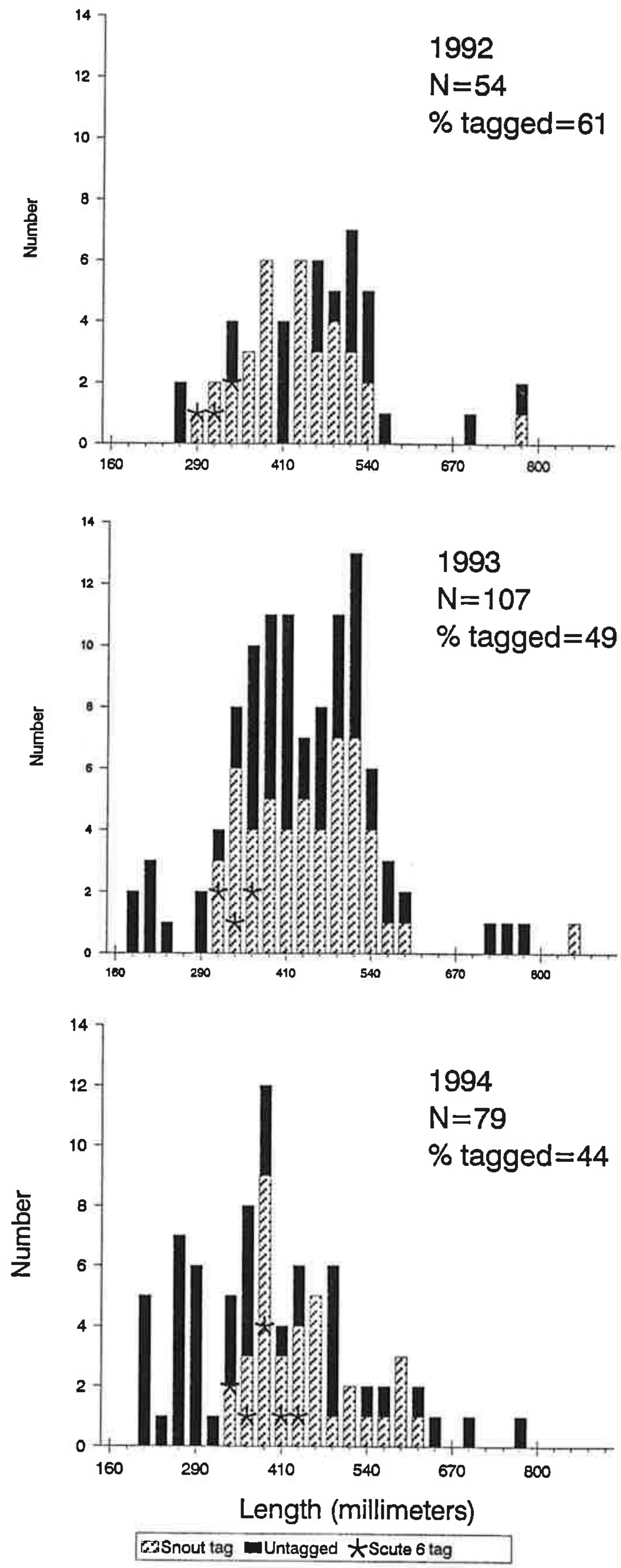
Source: WIDNR

Figure 7. Length frequency, mean length and length range of marked 1991 St. Louis Bay lake sturgeon cohort recaptured at ages I+, II+ and III+.



Source: MNDNR

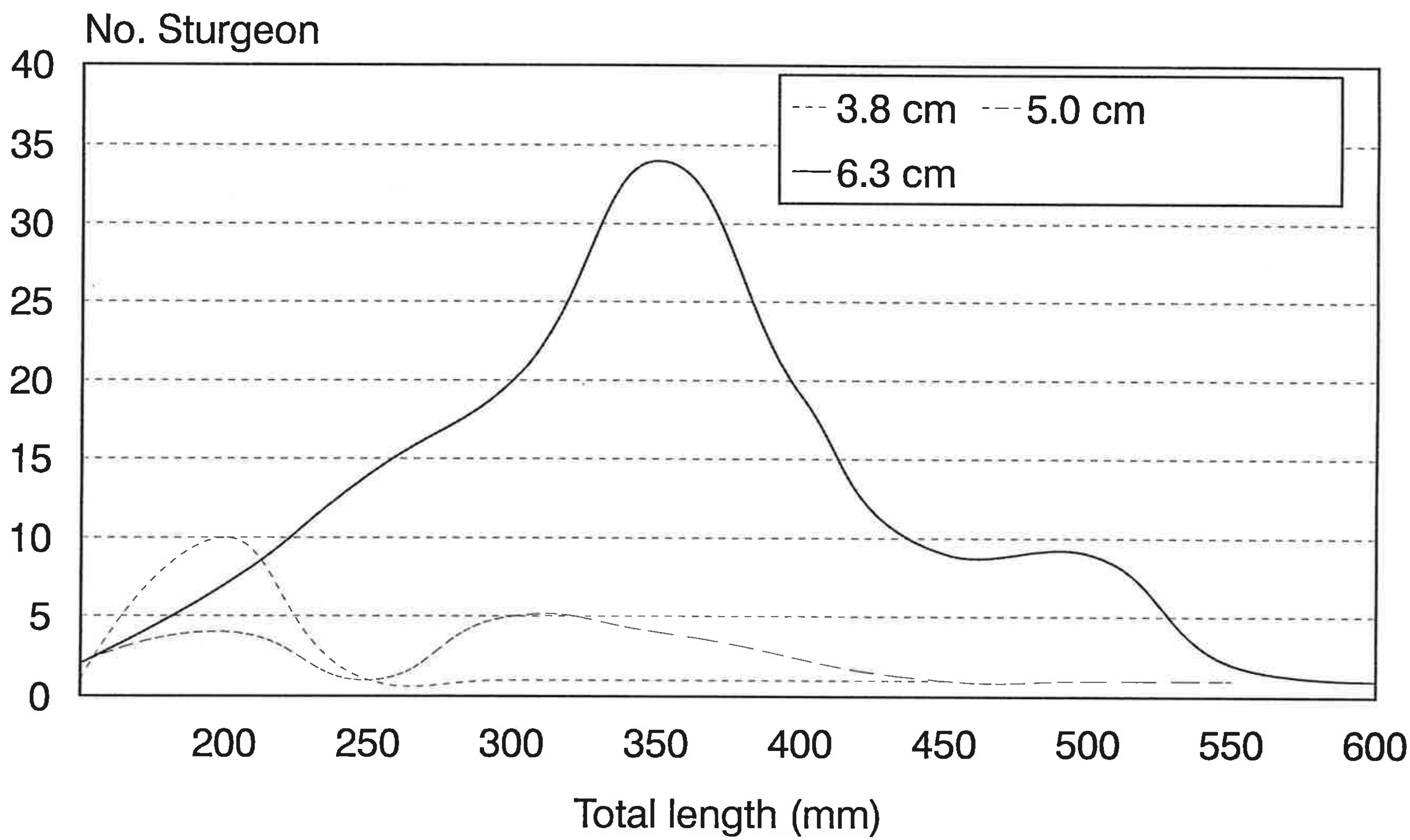
Figure 8. Length frequency and tag incidence for St. Louis Bay lake sturgeon, 1992-1994.



Source: MNDNR

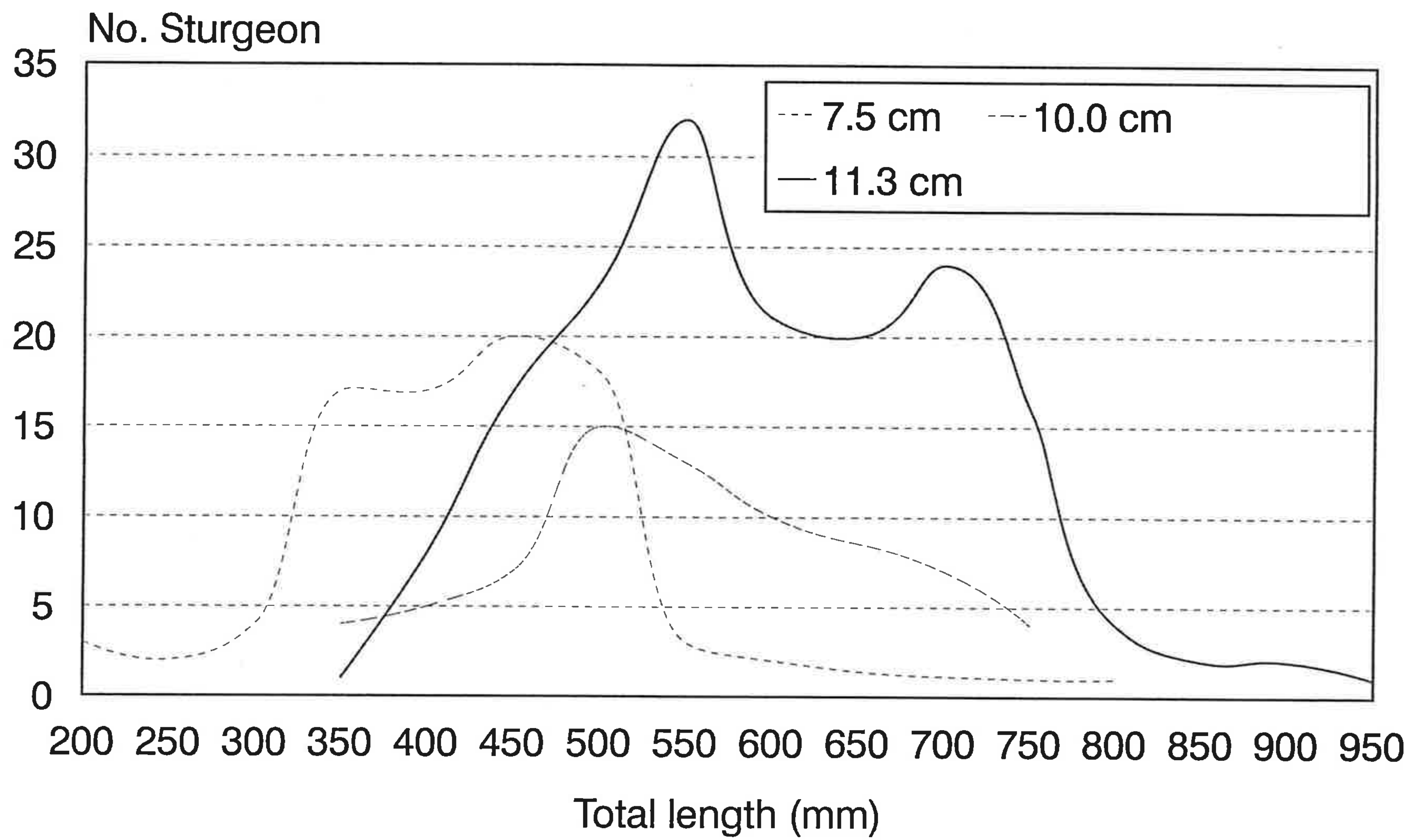
Appendix A

Gillnet selectivity curves for lake sturgeon (stretch-mesh)

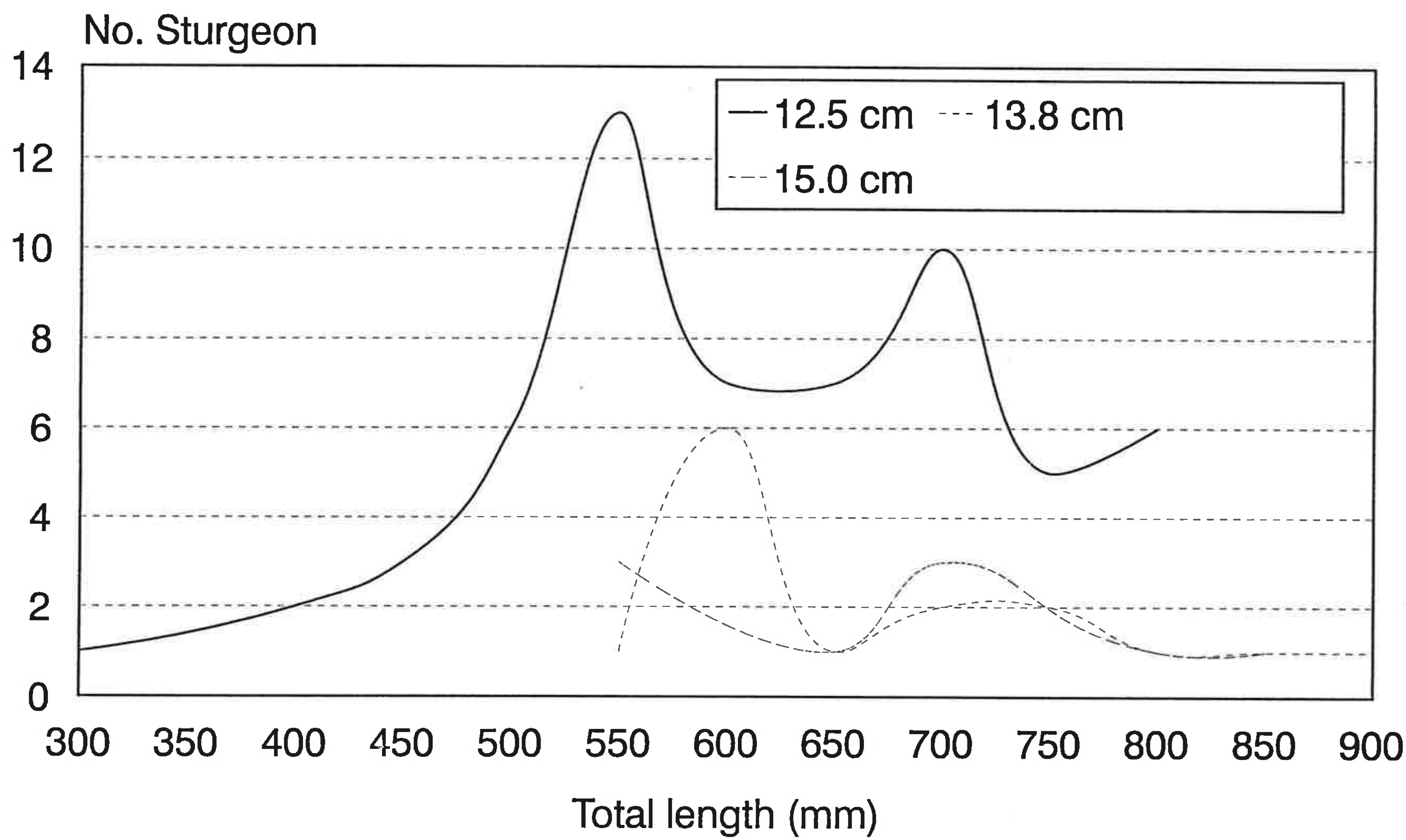


Source: WIDNR, MNDNR, and USFWS data, compiled by WDNR

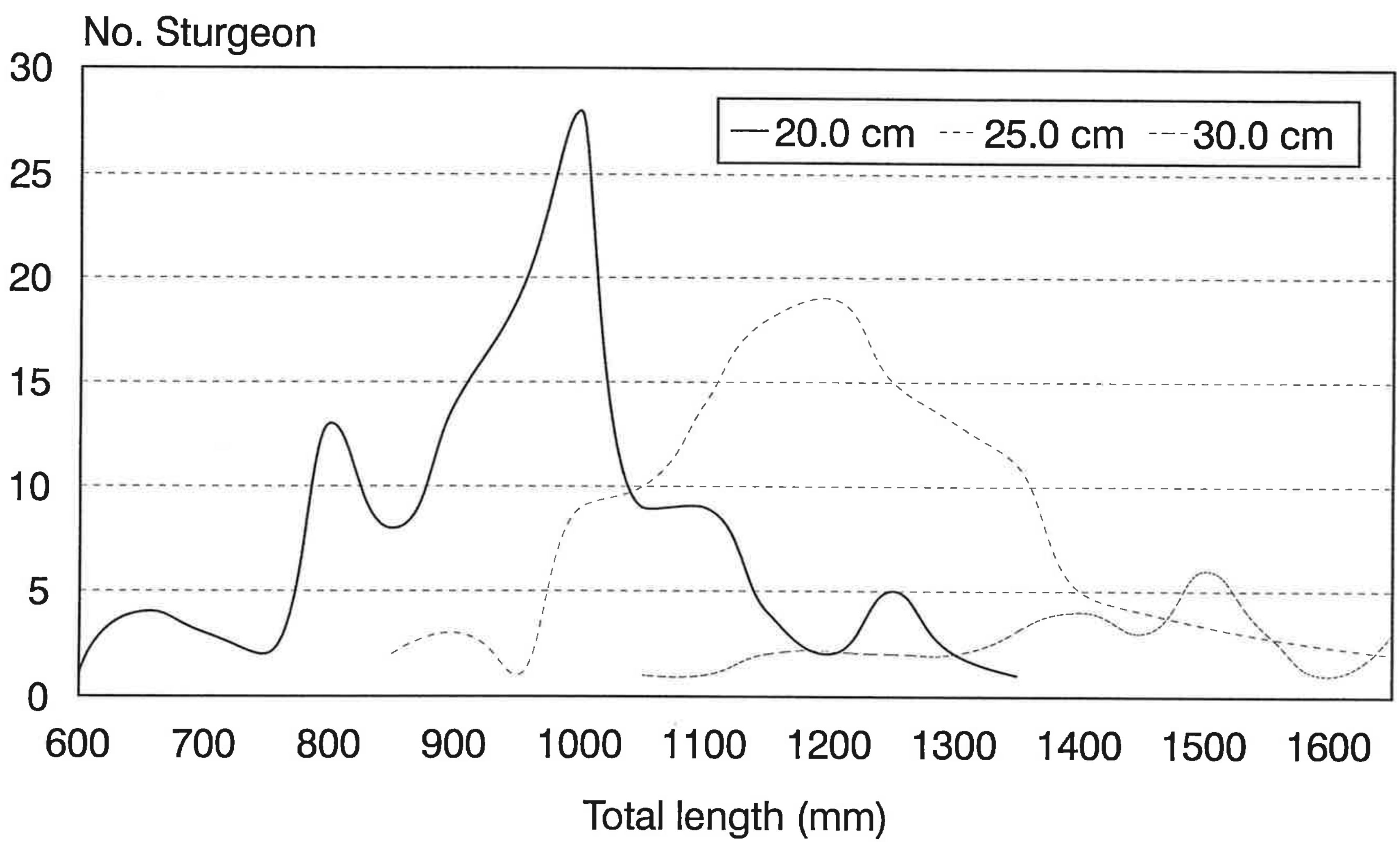
Appendix A (cont.)



Appendix A (cont.)



Appendix A (cont.)



APPENDIX A (cont.)

Mean total length of lake sturgeon captured in various gillnet mesh sizes (stretch-measure).

Mesh size (cm)	Total length (mm)	Standard deviation	Sample size
3.8	271	86.1	16
5.0	326	110.5	19
5.6	345	31.5	2
6.3	373	85.6	117
7.5	448	96.6	88
8.8	472	117.5	6
10.0	561	105.9	65
11.3	614	124.1	178
12.5	653	131.4	61
13.8	707	98.8	15
15.0	679	118.8	9
16.3	787	110.0	5
17.5	928	130.9	5
20.0	985	144.8	124
25.0	1218	144.8	126
30.0	1442	163.6	28