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Distribution and Management of Muskellunge in North America: An Overview

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Introduction

This report has been prepared to document current muskellunge (*Esox masquinongy*) distribution in North America as well as summarize and compare management approaches used in various jurisdictions.

This is not the first survey, regarding muskellunge management activities in North America, to be conducted. A similar agency questionnaire was carried out by the North Dakota Game and Fish Department in 1985 (Ragan et al. 1986). The Esocid Technical Committee, Northcentral Division, American Fisheries Society, compiled information on esocid research and management in 1992 (ETC 1992), esocid angling regulations in 1995 (ETC 1997a), and esocid stocking in 1996 (ETC 1997b). I am also aware of a mail survey conducted in 1981 (Miller 1983) but was unable to obtain results from that undertaking.

Information contained in this report was derived from a number of sources including a survey of state/provincial staff (conducted during the fall of 2010), an internet search of muskellunge regulations in various jurisdictions, and a review of published literature. Completed surveys were received from 59 individuals (see Appendix 1) representing 56 different North American jurisdictions. In most instances, a single response was received from an individual jurisdiction. In other cases, several responses were received and combined to form a provincial or state response. Survey responses were not received from Alabama, Delaware, Idaho, Massachusetts, New Jersey, and South Carolina. Much of the outstanding information (e.g., number of muskellunge waters, numbers of fish stocked, etc.) for non-responding jurisdictions was obtained from agency websites.

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Muskellunge Distribution in North America

Native Range

The muskellunge (*Esox masquinongy*) is only found in North America. Muskellunge are indigenous to the Great Lakes region and upper Mississippi drainages of eastern North America (Hubbs and Lagler 1958, MacKay 1963, Berra 2001). Muskellunge are found in all five of the Great Lakes (Superior, Michigan, Huron, Erie and Ontario) and four connecting channels (St. Clair, Detroit, Niagara and St. Lawrence rivers) (Scott and Crossman 1973). In Michigan, muskellunge were originally present in the Great Lakes as well as several inland waters of the upper peninsula (Thomas et al. undated). The original distribution of muskellunge in Wisconsin was believed to have been in the headwater basins of the Chippewa-Flambeau and Wisconsin River systems in the north central portion of the state (Oehmcke et al. 1965). There are more than one hundred muskellunge lakes, from all three drainage basins in the state, in Minnesota (Wingate and Younk 2007). Muskellunge were indigenous to the Ohio and Lake Erie drainages of Pennsylvania (Bean 1908, A. Woomer pers. comm.). In New York state, muskellunge were found in the Allegheny drainage but have been introduced elsewhere (Smith 1985). The native range of muskellunge in West Virginia was confined to the Ohio River drainage (Bean 1908, Miles 1978). The presence of muskellunge in the Tennessee and Cumberland River drainages is among the southernmost in the United States (Parsons 1959). They are not a native species in the New England states (Warye 2002).

In Canada, the muskellunge's original range was limited to the provinces of Ontario and Québec (Scott and Crossman 1973). In Québec, muskellunge were found in the Saint Lawrence River and southern Québec (north and south of the St. Lawrence River). In Ontario, muskellunge are found in the Great Lakes as well as southern and northwestern Ontario (OMNR 1987, Kerr 2001a). There have been some occurrences of muskellunge in the Winnipeg River in the extreme eastern part of Manitoba (Stewart and Watkinson 2004).

A total of 1,866 muskellunge waters in North America were identified during this survey (Table 1). Over 80% (1,527 waters) of these waters containing muskellunge are located in just five jurisdictions (Michigan, Minnesota, Ontario, West Virginia, and Wisconsin).

Muskellunge are absent from a number of North American jurisdictions including Alaska, Alberta, Arizona, British Columbia, California, Colorado, Connecticut, Delaware, Florida, Georgia, Hawaii, Idaho, Kansas, Louisiana, Mississippi, Montana, Nevada, Newfoundland, New Hampshire, New Mexico, Nova Scotia, Oklahoma, Prince Edward Island, Puerto Rico, Rhode Island, Saskatchewan, Utah, and Wyoming. Although muskellunge are sometimes captured in the Manitoba waters of the Winnipeg River (downstream migrants from Lake of the Woods), there are no established muskellunge populations in the province of Manitoba (J. O'Connor pers. comm.).

Table 1. Current distribution of muskellunge in various North American jurisdictions based on responses to a survey conducted in the fall of 2010.

Jurisdiction	Lakes	Rivers	Reservoirs	Total
Canada				
New Brunswick	1	1	3	5
Ontario	302	105[1.]	0	407
Quebec	54	10[2.]	0	64[3.]
United States				
Illinois	41	0	1	42
Indiana	15	0	1	16
Iowa	3	0	5	8
Kentucky	2	12	3	17
Maine	6	3	0	9
Maryland	0	1	0	1
Michigan	82	14	16	112
Minnesota	96	8	0	104
Missouri	3	0	1	4
Nebraska	5	0	7	12
New Jersey	10	2	3	15
New York[4.]	9	15	0	24
North Carolina	0	7	5	12
North Dakota	1	0	2	3
Ohio	0	6	11	17
Pennsylvania	5	13	27	45
South Carolina	0	1	0	1
South Dakota	4	0	1	5
Tennessee	1	11	2	14
Vermont	1	2	0	3
Virginia	4	7	1	12
Washington DC	0	1	0	1
West Virginia	30	70	10	110
Wisconsin	711[5.]	83	0	794
Great Lakes and Connecting Channels	5	4	0	9
Summary	1,391	376	99	1,866

1. Includes upper St. Lawrence River (upstream from Cornwall); 2. Includes lower St. Lawrence River (downstream of Cornwall); 3. May be an underestimate since not all surveys returned; 4. Does not include border waters such as Greenwood Lake (NJ), Delaware River (PA), or Lake Champlain (VT); 5. Includes reservoirs.

Historic Declines in Abundance

Muskellunge abundance had declined in many jurisdictions by the late 1800s – early 1900s. Their decline was attributed largely to overexploitation and habitat destruction (Graff 1986). Historical records indicate that muskellunge were indigenous to several lakes in northeastern Illinois but were extirpated by the early 1900s. In Green Bay, Lake Michigan, muskellunge were decimated by the early portion of the 20th century. The

decline was attributed to pollution, habitat destruction, and overexploitation (Anon. 2010). Once abundant in Lake Simcoe, Ontario, muskellunge had disappeared by the 1930s. Their decline was attributed to habitat destruction, illegal harvest, and the increased abundance of northern pike (MacCrimmon and Skobe 1970). In northwestern Minnesota, there was an abrupt decline in muskellunge catches in the late 1930s (Olson and Cunningham 1989). In Wisconsin, muskellunge declined following the growth of recreational angling after World War II. Declines in muskellunge abundance was recorded in Ohio waters as early as 1850 (Buss 1960, Clark 1964). By 1950, muskellunge in the Ohio tributaries of Lake Erie was almost considered extirpated (Trautman 1957). Muskellunge had been extirpated from North Carolina by the 1950s (Clemmons 1977). In Indiana, native muskellunge had all but disappeared by the 1960s (Jordan 2008). Native muskellunge were extirpated from four Kentucky streams as a result of habitat degradation from coal mining activities (Axon and Kornman 1986). In the St. Lawrence River, the muskellunge fishery declined substantially during the late 1970s-1980s (Farrell et al. 2003).

Introductions and Range Extensions

Stocking has served to expand the distribution of muskellunge in a number of locations beyond its natural range. Forty-six percent (864 waters) of all North American muskellunge waters have resulted from introductions (Table 2).

There are records of non-native muskellunge introductions in 32 different states (Fuller 1999). These programs were intended either to re-introduce muskellunge to an area they once inhabited or to expand their range. In some jurisdictions (e.g., Illinois, Iowa, Missouri), virtually all of the current muskellunge fisheries are the result of introductions (Esocid Technical Committee 1992).

Not all muskellunge introductions were planned. In the province of New Brunswick, muskellunge became established in the St. John River system during the 1970s as a result of downstream migration from a stocked headwater lake (Lac Frontiere) in Québec (Stocek et a. 1999). This same Québec stocking also resulted in muskellunge becoming established into Maine waters of the St. John River watershed (Brautigam and Lucas 2008, J. Dembeck pers. comm.). Muskellunge were not indigenous to South Carolina. In the early 1970s, North Carolina stocked muskellunge into Adger Lake in the Broad River system. In 1984, the first muskellunge was captured at Lockhart, South Carolina, approximately 160 kilometers downstream of the original stocking site. Apparently muskellunge had moved downstream over 5-6 dams during periods of high water (Creel 2004).

There are also several instances where deliberate introductions have failed to establish muskellunge populations. For example, muskellunge were introduced to Georgia waters in the 1950s but never developed a self-sustaining population (Dahlberg and Scott 1971, J. Biagi pers. comm.). In Texas, muskellunge were introduced to nine new reservoirs in the mid-late 1970s. The introductions were intended to control forage fish and expand angling opportunities but no viable populations were established and the program was discontinued (D. Terre pers. comm.). Similarly, in California, muskellunge (from Chautauqua Lake, New York) were stocked in Merced Lake, San Francisco County,

during the 1890s in an attempt to control carp but they failed to become established (D. Lentz pers. comm.). In Alabama, muskellunge were once stocked in the Tennessee and Tallapoosa river systems (www.outdooralabama.com). Muskellunge are no longer stocked in Alabama. Finally, muskellunge were introduced into several lakes in Riding Mountain National Park and Duck Mountain Provincial Park in southwestern Manitoba but failed to establish self-sustaining populations.

Table 2. Origin of muskellunge in various North American waters. Information is based on a survey of North American jurisdictions conducted during the fall of 2010.

Jurisdiction	Indigenous	Introduced
Canada		
New Brunswick	0	5
Ontario	331	76
Québec	28	36
United States		
Illinois	0	42
Indiana	0	16
Iowa	0	8
Kentucky	2	15
Maine	0	9
Maryland	0	1
Michigan	93	19
Minnesota	60	44
Missouri	0	4
Nebraska	0	12
New Jersey	9	6
New York	16	8
North Carolina	7	5
North Dakota	0	3
Ohio	5	12
Pennsylvania	0	45
South Carolina	0	1
South Dakota	0	5
Tennessee	9	5
Vermont	0	3
Virginia	0	12
Washington DC	0	1
West Virginia	44	66
Wisconsin	389	405
Great Lakes and Connecting Channels	9	0
Summary	**1,002**	**864**

Almost 73% of North America's muskellunge waters are sustained by natural reproduction. Muskellunge populations in at least 493 waters are dependent on hatchery supplementation however. Few jurisdictions rely solely on natural reproduction

to provide fisheries (Table 3). Exceptions include the provinces of Ontario and Québec where muskellunge fisheries are managed solely on the basis on self-sustaining stocks.

Table 3. Current reproductive status of muskellunge populations in North American waters based on a survey of management agencies in the fall of 2010.

Jurisdiction	Self-sustaining	Artificial	Unknown
Canada			
New Brunswick	5	0	0
Ontario	407	0	0
Québec	64	0	0
United States			
Illinois	0	42	0
Indiana	0	16	0
Iowa	0	8	0
Kentucky	0	17	0
Maine	9	0	0
Maryland	1	0	0
Michigan	92	20	0
Minnesota	61	43	0
Missouri	0	4	0
Nebraska	0	12	0
New Jersey	0	0	15
New York	9	15	0
North Carolina	8	4	0
North Dakota	0	3	0
Ohio	7	10	0
Pennsylvania	0	45	0
South Carolina	0	0	1
South Dakota	0	5	0
Tennessee	1	13	0
Vermont	1	2	0
Virginia	0	12	0
Washington DC	0	1	0
West Virginia	64	46	0
Wisconsin	619	175	0
Great Lakes and Connecting Channels	9	0	0
Summary	**1,357**	**493**	**16**

Muskellunge Management in North America.

Muskellunge Management Objectives

Various agencies differ in their management philosophy and in what goals and objectives they establish for muskellunge within their jurisdiction.

Muskellunge, for many, are a highly prized trophy fish (Figure 1) As a result, a common management objective for many North American jurisdictions is to provide trophy fisheries for muskellunge (Ragan et al. 1986, Table 4). In Wisconsin, muskellunge management goals are: (i) to maintain an annual harvest of fish > 76 cm (30 inches) at a level not exceeding 27%, and (ii) to maintain a trophy muskellunge fishery (Simonson and Hewett 1999). Minnesota identified a goal of improving opportunities for trophy muskellunge in its muskellunge management plan (Minnesota DNR 2008). Providing trophy fisheries is often accomplished through stocking programs designed to supplement natural reproduction or provide artificial fisheries. Pennsylvania's muskellunge management goal is to maintain or create enhanced sport fisheries through judicious plantings of muskellunge and by implementing management approaches which increase the density of naturally produced and stocked muskellunge (Lorantus and Kristine 2005). Conversely, managing for self-sustaining, rather than artificial trophy fisheries is a management goal in some other jurisdictions. For example, the joint (Ontario-New York) management goal for the St. Lawrence River is to perpetuate the muskellunge as a viable, self-sustaining component of the river's fish community as well as provide quality trophy angling opportunities (Panek 1980, Farrell et al. 2003, 2007).

Figure 1. One of the most common muskellunge management goals in North America is the provision of trophy muskellunge angling opportunities (Michael Butler photo).

Table 4. Muskellunge management objectives identified by various North American jurisdictions. Respondents could identify more than one objective.

Management Objective	Number of Respondents
Provide trophy fisheries	19
Introduce muskellunge to new waters	12
Provide artificial fisheries	10
Supplement natural reproduction	10
Rehabilitate degraded populations	7
Diversity angling opportunities	5
Muskellunge present but not actively managed	3
Conservation - Sustain wild populations	3
Habitat protection	1
Inform anglers about increased muskellunge angling opportunities	1

Some management agencies have developed specific objectives of achieving muskellunge densities at a certain level while maintaining a desired rate of exploitation. For example, Iowa has two clearly stated management objectives for muskellunge: (i) to achieve an adult density of 0.1 – 0.15 fish/acre, and (ii) to provide a catch rate of one fish for every 70 – 100 hours of angling effort (Christianson et al. 1988). Similarly, a key management objective in Missouri is to maintain a density and size structure of muskellunge populations that results in average angler catch rates of one muskellunge, at least 36 inches in length, for every 20 – 40 hours of angler effort (i.e., CUE of 0.025 – 0.050) (Boone 2007, Boone et al. 2007). In Michigan, one of the stated objectives for muskellunge management is to maintain muskellunge densities of at least 0.3 fish/acre while maintaining exploitation rates below 5% annually. The goals for re-establishment of muskellunge in Green Bay, Lake Michigan, are to achieve adult densities ranging from 0.1 – 0.2 adult muskellunge/acre and a catch rate of 0.04 fish/angler hour of effort (Anonymous 2010). The goals established in Michigan's muskellunge management plan include protection of habitat, maintenance of self-sustaining fisheries, provision of a diversity of trophy angling opportunities, and enhanced communications with anglers.

In several jurisdictions, muskellunge are managed as a non-native and/or invasive species. In Maine, for instance, muskellunge are considered as an exotic invasive species which could potentially threaten native fishes such as brook trout and landlocked salmon (Brautigam and Lucas 2008, Lucas 2008). Their management goal is to limit distribution and abundance by allowing unlimited harvest during a year-round open season (Brautigam and Lucas 2008). Similarly, the province of New Brunswick has liberal regulations (e.g., 5 fish per day catch limit, no size limit, etc.) to encourage removal and control on non-native muskellunge (C. Connell pers. comm.).

Finally, although muskellunge may be present, several jurisdictions do not have regulations or management programs for the species. In Washington, D. C., for example, some muskellunge, migrants from further upstream, are found in the non-tidal portion of the Potomac River but there is no management program for the species in that state.

Muskellunge Stocking Programs

Stocking is a management tool which has been used extensively for muskellunge particularly in the United States. Several jurisdictions have well established stocking programs for muskellunge. For example, New York commenced stocking activities in Chautauqua Lake in 1887 (Graff 1986). Cultured muskellunge have been stocked in Wisconsin since 1899 (Nevin 1901, Oehmcke 1969, Margenau 1999). Pennsylvania initiated a muskellunge stocking program in the 1890s which was eventually discontinued but initiated again in 1953 (Graff 1986). Muskellunge in Pennsylvania waters are currently maintained by stocking (Lorantus and Kristine 2005, A. Woomer pers. comm.). Minnesota began propagation and stocking of muskellunge in 1911 (Younk and Pereira 2003). Ohio and Tennessee initiated muskellunge stocking programs in 1953 (Fetterolf 1957, Trautman 1957). Muskellunge were first introduced to Nebraska (Lake Minatare) in 1958 (Morris et al. 1974). Since then, over 70 waters have been stocked with muskellunge but currently only a few waters are managed for the species (Bauer 2007). Iowa initiated a muskellunge management program in 1960 when a small number of fingerlings were introduced to Clear and West Okoboji lakes (Christianson et al. 1988). The stocking program was expanded in the 1970s and eight lakes are now stocked to provide muskellunge angling opportunities (J. Meerbeek pers. comm.). Muskellunge stocking in Virginia commenced in 1963 (Jenkins and Burkhead 1993). Muskellunge were introduced to Pomme de Terre Lake, Missouri, in 1966 (Pflieger 1997). Muskellunge are now present in four Missouri waterbodies and are maintained solely by stocking (ETC 1997b). In North Carolina, muskellunge stocking commenced in 1970 in an attempt to re-establish the species (Monaghan 1985). Indiana initiated a muskellunge stocking program in 1974 and muskellunge were first introduced to Illinois in the late 1970s (ETC 1997b). Introductions of muskellunge in Wisconsin has served to expand its natural range to all three major drainage basins in the state (Simonson and Hewett 1999). It has been estimated that approximately 25% of muskellunge populations in Wisconsin are the result of stocking (USGS 2009). Stocking programs were initiated in 1989 to restore muskellunge in Great Bay of Lake Michigan (Anon. 2010).

The first record of muskellunge being cultured in Canada was believed to be at Rice Lake, Ontario, in 1876 (Kerr 2006). From the 1920s to 1990, muskellunge stocking was conducted in over 260 Ontario waters (Kerr 2001b). Stocking programs resulted in the establishment of muskellunge in 76 new waters. Muskellunge stocking in Ontario was discontinued when the Deer Lake fish culture station was closed in 1990. More recently, stocking has been initiated to restore muskellunge in the Spanish River delta (Lebeau 1996) and to re-introduce muskellunge to Lake Simcoe (Buchanan and Lebeau 2000).

North American jurisdictions stocked almost one million muskellunge into 343 waters in 2010 (Table 5). Although there is evidence that muskellunge stocked at older life stages (i.e, yearlings) survive better than younger life stages (Graff 1986, Margenau 1992, 1999, Kerr and Lasenby 2001), most stocking programs currently involve the use of fingerlings (Figure 2). Overall, fingerlings accounted for 55% of muskellunge stocked in 2010. One notable exception is the state of Nebraska which only stock age-1 (25-35 cm in length) muskellunge in the spring of the year (D. Bauer pers. comm.). Illinois was the only jurisdiction which reported stocking muskellunge as fry in 2010.

Figure 2. Most muskellunge stocking programs in North American involve the use of fingerling-sized fish (MNR photo).

Table 5 . Muskellunge stocked in 2010 by various North American jurisdictions.

		Number of Muskellunge Stocked by Life Stage			
Jurisdiction	**No. Waters Stocked**	**Fry**	**Fingerlings**	**Yearlings or Older**	**Total**
Canada					
Ontario	1	0	3,000	0	3,000
United States					
Illinois	33	407,607	138,903	0	546,510
Indiana	16	0	23,000	0	23,000
Iowa	4	0	0	3,399	3,399
Kentucky	17	0	9,500	0	9,500
Michigan	10	0	19,432	0	19,432
Minnesota	32	0	29,933	1,162	31,095
Missouri	4	0	5,500	0	5,500
Nebraska[1.]	0	0	0	0	0
New Jersey	21	0	14,528	0	14,528
New York	12	0	25,600	0	25,600
North Carolina	4	0	769	0	769
North Dakota	2	0	0	900	900
Ohio	9	0	14,500	0	14,500
Pennsylvania	45	0	149,348	1,518	150,866
South Dakota	4	0	2,071	0	2,071
Tennessee	5	0	4,609	0	4,609
Virginia	10	0	5,896	0	5,896
West Virginia	15	?	?	0	60,000
Wisconsin	106	0	54,829	216	55,045
Summary	**343**	**407,607**	**501,418**	**7,195**	**916,220[2.]**

1. Have an ongoing stocking program whereby fish are stocked in alternate years (none in 2010).
2. Does not include 60,000 fish whose life stage was unknown.

Stocking to supplement an existing population or to provide artificial fisheries were the most common stocking objectives reported (Table 6).

Table 6. Stocking objectives identified by North American jurisdictions currently involved in muskellunge stocking programs. Respondents could identify more than one stocking objective.

Stocking Objective	No. of Responses
Artificial	12
Supplemental	8
Rehabilitation	6
Introductions	5
Coarse fish control	3

Six jurisdictions (Ontario, Michigan, Minnesota, New York, Vermont, and Wisconsin) indicated that they were stocking muskellunge for rehabilitative purposes in waters including Green Bay (Lake Michigan), Lake Champlain, and Lake Simcoe. In some reservoirs, muskellunge are stocked with biomanipulation objectives of controlling coarse fish including gizzard shad, carp, redhorse, and stunted yellow perch.

Annual stocking is required to maintain muskellunge fisheries in several jurisdictions including Indiana, Kentucky and Missouri. In Nebraska, muskellunge are stocked on a rotational basis (i.e., every 2nd or 3rd year)(D. Bauer pers. comm.). Some jurisdictions (e.g., Georgia) indicated that they may consider muskellunge introductions in the future.

Several jurisdictions (Connecticut, Colorado, Idaho, Montana, Utah and Washington) stock tiger muskellunge (*Esox lucius x Esox masquinongy*) to control coarse fish (e.g., carp, suckers, etc.) populations. They utilize only the sterile hybrid in order to prevent their establishment.

Muskellunge Regulations

(a) Open Seasons – Many American jurisdictions have year-round open seasons for muskellunge. In other areas**,** open and closed seasons are generally utilized to protect spawning adults and reduce the period available for exploitation. Open season dates generally reflect seasonal differences based on geography (e.g., latitude). In some larger jurisdictions, such as Michigan and Ontario, there is more than one standard season date to reflect various climatic regimes. In several northern jurisdictions, muskellunge seasons are closed during the spring spawning period (Table 7). Some states and provinces also have winter closures.

While season closures can afford protection to muskellunge during their vulnerable spawning period, it is generally recognized that changes to season length have little effect on fishing effort or harvest (Hoff and Serns 1986, Simonson and Hewett 1999).

Table 7. Muskellunge open seasons in various North American jurisdictions (including Great Lakes and connecting channels).

Jurisdiction	2010 Open Season Dates
Canada	
New Brunswick	• April 15 (rivers) – November 30; May 1 (lakes) – November 30.
Ontario	• 1st Saturday in June – December 15; 3rd Saturday in June – December 15; Friday before 3rd Saturday in June (18th) – December 15.
Quebec	• June 18 - November 30 (Ottawa River); June 18 – March 31 (Inland).
United States	
Illinois	• Open year-round.
Indiana	• Open year-round.
Iowa	• Open year-round (exceptions on three waters having a Dec. 1 – May 20 closure).
Kentucky	• Open year-round.
Maine	• Open year-round.
Maryland	• Open year-round.
Michigan	• Last Saturday in April – March 15 (lower peninsula); May 15 – March 15 (upper peninsula and Great Lakes); 1st Saturday in June – December 15 (Lake St. Clair and Detroit River).
Minnesota	• June 5 (1st Saturday) – December 1.
Missouri	• Open year-round.
Nebraska	• Open year-round.
New Jersey	• Open year-round (with some exceptions).
New York	• 3rd Saturday in June – November 30.
North Carolina	• Open year-round.
North Dakota	• Open year-round.
Ohio	• Open year-round.
Pennsylvania	• Open year-round (April 1 – May 30 closure on brood stock lakes).
South Carolina	• Open year-round.
South Dakota	• Open year-round.
Tennessee	• Open year-round.
Vermont	• Open year-round.
Virginia	• Open year-round.
Washington DC	• Open year-round.
West Virginia	• Open year-round.
Wisconsin	• May 29 – November 30; May 1 – December 31.

(b) Catch and Possession Limits – Catch (bag) limits are commonly used to distribute and restrict the harvest of fish. Recognizing that muskellunge exist at relatively low densities, most jurisdictions have instituted low creel limits (e.g., one fish per day).

Catch limits appear to have remained consistently low (i.e., 1-2 fish) in most North American jurisdictions over the past 25 years. Nineteen jurisdictions currently have a daily catch limit of one fish (Table 8). In Ontario, a daily catch limit of two fish has been in place since at least 1949 (Kerr 1998). Provincially, the limit was reduced to one fish (two in possession) in 1988. In some jurisdictions, such as New Brunswick, Maine, and Washington, where muskellunge are considered an exotic, invasive species, catch limits are much more liberal.

Table 8. Muskellunge catch and possession limits in various North American jurisdictions (including the Great Lakes and connecting channels).

Jurisdiction	2010 Daily Catch and Possession Limits
Canada	
New Brunswick	• Five fish per day.
Ontario	• One fish per day for holders of a regular sport fishing licence; zero fish per day for holders of a Conservation licence.
Quebec	• Two fish per day.
United States	
Illinois	• One fish per day.
Indiana	• One fish per day.
Iowa	• One fish per day.
Kentucky	• One fish per day (two in possession).
Maine	• Unlimited.
Maryland	• One fish per day.
Michigan	• One fish per day.
Minnesota	• One fish per day (some exceptions for catch-and-release only).
Missouri	• One fish per day (two in possession).
Nebraska	• One fish per day (two in possession).
New Jersey	• One fish per day.
New York	• One fish per day.
North Carolina	• One fish per day.
North Dakota	• One fish per day.
Ohio	• One fish per day (with some exceptions).
Pennsylvania	• One fish per day.
South Carolina	• Unknown.
South Dakota	• One fish per day (two in possession).
Tennessee	• One fish per day (two in possession).
Vermont	• Zero (Catch and release only).
Virginia	• Two fish per day (with some exceptions).
Washington D.C.	• Unlimited.
West Virginia	• Two fish per day (four in possession): catch-and-release only on two streams).
Wisconsin	• One fish per day (two in possession).

(c) Size Limit Regulations

Size limit regulations are employed by fisheries managers for a number of reasons which include providing for maximum growth, protecting immature fish until they have had the opportunity to spawn, and restricting harvest until trophy size is reached (Wingate 1986). In some instances, large minimum size limits are used to enhance opportunities for size-based fisheries. Size limit regulations are generally considered to be a more effective means of regulating muskellunge harvest than catch limits and open seasons (Hoff and Serns 1986).

Minimum size limits are commonly used to manage muskellunge fisheries. One of the first muskellunge size limit regulations in North America was a minimum weight of 1.8 kg (4 lb.) instituted by the state of Wisconsin (Petrie et al. 1993). Minnesota first

implemented a minimum length limit of 76.2 cm (30 inches) in 1914 (ETC 1997a). Minimum size limit regulations for muskellunge in Ontario have been in place for well over sixty years (Kerr 1998). The first size limit of 63.5 cm (25 inches) was placed on Tennessee muskellunge in 1954 in an effort to protect dwindling stocks (Parsons 1959).

Most North American jurisdictions have one standard minimum size limit for muskellunge (Table 9). A different approach has been taken by Ontario and Wisconsin. Ontario has established five benchmark values based on growth potential and management objectives (Casselman et al.1999, OMNR et al. 1999): 91.4 cm (36 inch) or 101.6 cm (40 inch) for high density populations; 111.8 (44 inch) or 121.9 (48 inch) for enhanced size

Table 9. Muskellunge size limits in various North American jurisdictions including the Great Lakes and connecting channels (MSL – Minimum Size Limit; FL – Fork Length).

Jurisdiction	Size Limit Regulations
Canada	
New Brunswick	• Minimum length of 10 cm (TL) and maximum length of 100 cm; minimum length of 10 cm and maximum length of 150 cm (TL).
Ontario	• Five benchmark MSLs: 91 cm, 102 cm, 112 cm, 122 cm, or 137 cm.
Quebec	• MSL of 104 (FL) in most waters including the St. Lawrence River; MSL of 127 FL on Ottawa River.
United States	
Illinois	• MSL of 91 cm statewide; MSL of 107 cm and 122 cm on special waters.
Indiana	• MSL of 91.4 cm.
Iowa	• MSL of 101.6 cm.
Kentucky	• Statewide MSL of 76.2 cm; MSL of 91.4 cm on three designated lakes.
Maine	• None.
Maryland	• MSL of 91.4 cm.
Michigan	• Statewide MSL of 106.7 cm; 127 cm MSL on broodstock lakes.
Minnesota	• MSL of 121.9 cm; some exceptions with MSL of 101.6 cm.
Missouri	• MSL of 91.4 cm.
Nebraska	• Statewide MSL of 101.6 cm.
New Jersey	• Statewide MSL of 91.4 cm; some exceptions with MSL of 101.6 cm.
New York	• MSL of 76.2 cm statewide; special regulations ranging from 101.6 – 137.2 cm in some locations.
North Carolina	• MSL of 106.7 cm.
North Dakota	• MSL of 101.6 cm.
Ohio	• None.
Pennsylvania	• Statewide MSL of 101.6 cm.
South Carolina	• Unknown.
South Dakota	• MSL of 101.6 cm.
Tennessee	• MSL of 91.4 cm; MSL of 127 cm in two reservoirs.
Vermont	• N/A (zero catch limit).
Virginia	• MSL of 76.2 cm with some exceptions (106.7 cm).
Washington DC	• None.
West Virginia	• MSL of 76.2 cm; MSL of 101.6 cm on one waterbody.
Wisconsin	• MSLs of 71.1, 86.4, 101.6, 114.3, and 127.0 cm.

fisheries, and 137.2 cm (54 inch) for world class fisheries. Similarly, Wisconsin has designated five minimum size limit standards so that the appropriate regulation can be applied based on characteristics of the waterbody and its muskellunge population. Wisconsin is currently reviewing minimum size limit regulations with the goal of increasing the statewide size limit.

Several studies have indicated a positive response to the imposition or increase in minimum size limits. These include Lake St. Clair, Ontario (MacLennan 1996), Lake of the Woods, Ontario (Mosindy 1996), Bone Lake, Wisconsin (Cornelius and Margenau 1999), the New River, Virginia (Brenden et al. 2007), and the St. Lawrence River, New York/Ontario (Farrell et al. 2007).

Based on a 1985 survey of North American jurisdictions (Ragan et al. 1986), 76.2 cm (30 inches) was the minimum size limit standard in many areas. Since that time, minimum size limits for muskellunge have progressively increased in northern jurisdictions (Kerr 1998, Simonson and Hewett 1999, Farrell et al. 2007, Younk and Pereira 2007, Thomas et al. undated). The changes have been a reflection of an increase in the catch-and-release ethic, more interest in sustaining trophy fisheries, and an overall desire to protect large, productive female muskellunge.

(d) Miscellaneous Regulations

Several other gear-related regulations were identified during this survey. For example, the state of Vermont prohibits the use of live bait while fishing for muskellunge and restricts gear to the use of artificial lures and flies only. New York prohibits the use of gaff hooks for landing muskellunge (ETC 1997a).

In 1985, Ragan et al. (1986) reported that spear fishing for muskellunge was allowed in four states. The only jurisdiction which identified spearing in the 2010 survey was Michigan. Michigan currently allows spearing for muskellunge through the ice on several inland lakes from December 1 – March 15.

Record-Sized Muskellunge

Record muskellunge from various North American jurisdictions are summarized in Table 10. There is currently considerable dispute over the world record muskellunge, however.

The original world record muskellunge (31.7 kg), angled from the St. Lawrence River by Art Lawton in 1957, was officially disqualified in 1992 by both the Freshwater Fishing Hall of Fame (FFHF) and the International Game Fish Association (IGFA). That fish is still recognized by the State of New York as the state record however.

In 2005, the next largest muskellunge, a 31.6 kg fish angled by Louis Spray in Chippewa Flowage, Wisconsin, in 1949, was disqualified by the IGFA. This fish is, however, still recognized by the FFHF as the world record (FFHF 2010). The IGFA currently recognizes the world record as a 30.6 kg muskellunge angled by Cal Johnson from Lake

Court Oreilles, Wisconsin, in 1949 (IGFA 2010). The largest muskellunge reported from Ontario was a 29.5 kg fish angled from Georgian Bay by Ken O'Brien in 1988.

Table 10 . Record muskellunge for individual North American jurisdictions. Some jurisdictions with record-sized fish may no longer have muskellunge present in their jurisdiction.

Jurisdiction	Waterbody	Year Caught	Total Length in cm (inches)	Round Weight in kg (pounds)	Girth in cm (inches)
Canada					
Manitoba	Audy Lake	2002	- (-)	13.6 (30.0)	- (-)
New Brunswick	St. John River system	Unknown	132.0 (51.9)	21.8 (48.1)	68.6 (27.0)
Ontario	Georgian Bay	1988	147.3 (58.0)	29.5 (65.0)	77.5 (30.5)
Québec	Ottawa River	Unknown	140.0 (55.1)	- (-)	- (-)
United States					
Alabama	Wilson Dam tailwater	1972	- (-)	8.9 (19.5)	- (-)
Georgia	Blue Ridge Lake	1957	- (-)	17.2 (38.0)	- (-)
Illinois	Kaskaskia Lake	2002	- (-)	17.6 (38.8)	- (-)
Indiana	James Lake	2002	- (-)	19.4 (42.8)	- (-)
Iowa	Spirit Lake	2000	- (-)	23.0 (50.6)	- (-)
Kentucky	Cave Run Lake	2008	- (-)	21.3 (47.0)	- (-)
Maine	Glazier Lake	2009	- (-)	14.4 (31.7)	- (-)
Maryland	Upper Potomac River	2004	- (-)	12.7 (28.0)	- (-)
Michigan	Torch River	2009	139.7 (55.0)	22.9 (50.5)	- (-)
Minnesota	Lake Winnibigoshish	1957	142.2 (56.0)	24.5 (54.0)	71.0 (27.8)
Missouri	Lake of the Ozarks	1981	125.7 (49.5)	18.7 (41.2)	63.5 (25.0)
Nebraska	Merritt Reservoir	1992	132.0 (52.0)	18.8 (41.5)	- (-)
New Jersey	Monksville Reservoir	1997	- (-)	18.9 (42.8)	- (-)
New York	St. Lawrence River	1957	- (-)	31.7 (69.9)[1.]	- (-)
North Carolina	Lake Adger	2001	124.5 (49.0)	18.8 (41.5)	- (-)
North Dakota	GDU Canal Lakes	2007	137.2 (54.0)	21.1 (46.5)	- (-)
Ohio	Piedmont Lake	1972	128.3 (50.5)	25.0 (55.1)	- (-)
Pennsylvania	Conneaut Lake	1924	- (-)	24.6 (54.3)	- (-)
South Carolina	Broad River	2004	107.4 (42.3)	10.4 (22.8)	50.8 (20.0)
South Dakota	Amsden Dam	1991	124.4 (49.0)	18.2 (40.0)	66.0 (26.0)
Tennessee	Norris Reservoir	1983	- (-)	19.4 (42.8)	- (-)
Vermont	Missisquoi River	2005	132.7 (52.3)	17.3 (38.2)	52.4 (23.0)
Virginia	New River	1997	134.6 (53.0)	20.6 (45.4)	62.2 (24.5)
West Virginia	Stonecoal Lake	1997	133.9 (52.7)[2.]	22.6 (49.7)[2.]	- (-)
Wisconsin	Lake Court Oreilles	1949	- (-)	30.6 (67.5)[3.]	- (-)
	Chippewa Flowage	1949	161.3 (63.5)[4.]	31.6 (69.7)	79.5 (31.3)

1. Still recognized as state record fish despite being disqualified by FFHF and IGFA.
2. Different fish.
3. World record fish recognized by IGFA.
4. Still recognized as state record fish despite being disqualified by IGFA.

None of these fish are recognized as world records by the World Record Musky Alliance (WRMA) (Jerry Newman, pers. comm.). The WRMA recognizes a muskellunge angled by Edward Walden in 1940 as the "honorary" record. They have established a new modern day records program to accurately document muskellunge having a minimum weight of sixty pounds (27.2 kg).

Muskellunge Management Issues

Survey respondents were given the opportunity to identify the most pressing management issues they currently faced in their jurisdiction (Table 11). Several individuals reported more than one management issue.

Table 11. Current muskellunge management issues identified by respondents during a 2010 survey of North American jurisdictions. Some respondents identified more than one issue while other respondents did not identify any issues.

Problem/Issue	Number of Respondents
Habitat destruction	13
Pollution	7
Overexploitation (commercial and/or recreational)	7
Absence/shortage of suitable habitat	5
Invasive/exotic species	4
Diseases/pathogens	4
Lack of interest/acceptance by anglers	4
Hatchery production limitations	3
Low water levels in storage reservoirs	2
Lack of natural reproduction	2
Interspecific competition	1
Insufficient staff/funding to implement a muskellunge program	1
Inadequate forage base	1
Emigration of muskellunge from stocked waters	1
Winterkill	1
Water temperatures (too warm)	1

Habitat limitations and hatchery production capacity were issues which ranked high in both the 1985 and 2010 surveys. Habitat issues have long been recognized as being increasingly important for muskellunge management (Nelson 1978, Dombeck 1986)(Figures 3 and 4).

Figures 3 and 4. In addition to the relative shortage or absence of suitable habitat, pollution and habitat destruction are widespread muskellunge management issues (MNR photos).

For the first time, diseases and pathogens were identified by several respondents as being a muskellunge management issue. This is undoubtedly due to infections of muskellunge in the Great Lakes by piscirickettsia (musky pox) and viral hemorrhagic septicaemia (VHS) over the past decade.

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References

Anonymous. 2010. Green Bay Great Lakes spotted muskellunge management plan (draft). Wisconsin Department of Natural Resources. Peshtigo, Wisconsin. 13 p.

Axon, J. R., and L. E. Kornman. 1986. Characteristics of native muskellunge streams in eastern Kentucky. American Fisheries Society Special Publication 15:263-272.

Buchanan, I. and B. Lebeau. 2000. Muskellunge restoration feasibility study, Lake Simcoe. Ontario Ministry of Natural Resources. Aurora, Ontario. 73 p.

Bauer, D. L. 2007. History of muskellunge management in Nebraska. Environmental Biology of Fishes 79:179-185.

Bean, T. H. 1908. The muskellunge of the Ohio basin. Transactions of the American Fisheries Society 37:145-151.

Berra, T. M. 2001. Freshwater fish distribution. Academic Press. San Diego, California. 604 p.

Boone, M. 2007. Muskellunge in Missouri: A ten year strategic plan. Environmental Biology of Fishes 79:171-177.

Boone, M., M. Anderson, M. Boyer, D. Cornelius, J. Guyot, J. Koppelman, M. Mauck, T. Moore, K. Neubrand and K. Richards. 2007. Missouri's muskie management plan, 2008-2017. Missouri Department of Conservation. Kirksville, Missouri. 49 p.

Brautigam, F and J. Lucas. 2008. Maine muskellunge management plan. Department of Inland Fisheries and Wildlife. Augusta, Maine. 16 p.

Brenden, T. O., E. M. Hallerman, B. R. Murphy, J. R. Copeland, and J. A. Williams. 2007. The New River, Virginia, muskellunge fishery: population dynamics, harvest regulation modelling, and angler attitudes. Environmental Biology of Fishes 79:11-25.

Buss, K. 1960. The muskellunge. Special Purpose Report. Pennsylvania Fisheries Commission. Bellefonte, Pennsylvania.

Casselman, J. M., C. J. Robinson, and E. J. Crossman. 1999. Growth and ultimate length of muskellunge from Ontario waterbodies. North American Journal of Fisheries Management 19:271-290.

Christianson, J. H., J. R. Wahl, and T. W. Gengerke. 1988. Iowa's muskellunge program. Iowa Department of Natural Resources. Spirit Lake, Iowa. 28 p. + appendices.

Clark, C. F. 1964. Muskellunge in Ohio and its management. Publication W-329. Ohio Department of Natural Resources. Columbus, Ohio. 13 p.

Clemmons, M. 1977. Muskellunge wildlife profile. North Carolina Wildlife. North Carolina Wildlife Resources Commission. Raleigh, North Carolina.

Cornelius, R. R. and T. L. Margenau. 1999. Effects of length limits on muskellunge in Bone Lake, Wisconsin. North American Journal of Fisheries Management 19:300-308.

Creel, M. 2004. South Carolina record muskie. Southeastern Outdoors. http://www.southeasternoutdoors.com

Dahlberg, M. D. and D. C. Scott. 1971. Introductions of freshwater fishes in Georgia. Bulletin of the Georgia Academy of Science 29:245-252.

Dombeck, M. P. 1986. Muskellunge habitat with guidelines for management. American Fisheries Society Special Publication 15:208-215.

Esocid Technical Committee (ETC). 1992. Synopsis of esocid research and management. North Central Division. American Fisheries Society. 56 p.

Esocid Technical Committee (ETC). 1997a. A synopsis of angling regulations for esocids in North America. North Central Division. American Fisheries Society. 64 p.

Esocid Technical Committee (ETC). 1997b. The introductory, maintenance, and restoration stocking of esocids. North Central Division. American Fisheries Society. 58 p.

Farrell, J. M., R. Klindt, and J. M. Casselman. 2003. Update of the strategic plan for management of the St. Lawrence river muskellunge population and sport fishery. Phase III:2003-2010. New York State Department of Environmental Conservation. Syracuse, New York.

Farrell, J. M., R. M. Klindt, J. M. Casselman, S. R. LaPan, R. G. Werner, and A. Schiavone. 2007. Development, implementation and evaluation of an international muskellunge management strategy for the upper St. Lawrence River. Environmental Biology of Fishes 79:111-123.

Fetterolf, C. M. 1957. Stocking as a management tool in Tennessee reservoirs. p. 275-284 *In* Proceedings of the 10th Annual Conference of the Southeast Association of Game and Fish Commissioners. Columbia, South Carolina.

Freshwater Fishing Hall of Fame. 2010. Official world and USA state freshwater angling records. Hayward, Wisconsin. 81 p.

Fuller, P. L., L. G. Nico, and J. D. Williams. 1999. Nonindigenous fishes introduced into inland waters of the United States. Special Publication 27. American Fisheries Society. Bethesda, Maryland. 613 p.

Graff, D. R. 1986. Musky management – a changing perspective from past to present. American Fisheries Society Special Publication 15:195-198.

Hoff, M. H. and S. L. Serns. 1986. The muskellunge fishery of Escanaba Lake, Wisconsin, under liberalized angling regulations, 1946-1981. American Fisheries Society Special Publication 15:249-256.

Hubbs, C. L. and K. F. Lagler. 1958. Fishes of the Great Lakes region. Cranbrook Institute of Science. Bloomfield Hills, Michigan. 213 p.

International Game Fish Association. 2010. World record game fishes. Dania Beach, Florida. 408 p.

Jenkins, R. E. and N. M. Burkhead. 1993. Freshwater fishes of Virginia. American Fisheries Society. Bethesda, Maryland. 1079 p.

Jordan, D. 2008. Indiana muskie program producing big payoffs. www.jordanoutdoors.com

Kerr, S. J. 1998. Muskellunge regulations in Ontario: the last fifty (1949-1998) years. Fish and Wildlife Branch. Ontario Ministry of Natural Resources. Peterborough, Ontario. 34 p.

Kerr, S. J. 2001a. Atlas of muskellunge streams and rivers in Ontario. Fish and Wildlife Branch. Ontario Ministry of Natural Resources. Peterborough, Ontario. 17 p.

Kerr, S. J. 2001b. Records of muskellunge stocking in Ontario, 1900-1999. Fish and Wildlife Branch. Ontario Ministry of Natural Resources. Peterborough, Ontario.

Kerr, S. J. 2006. An historical review of fish culture, stocking, and fish transfers in Ontario, 1865-2004. Fish and Wildlife Branch. Ontario Ministry of Natural Resources. Peterborough, Ontario. 154 p. + appendices.

Kerr, S. J. and T. A. Lasenby. 2001. Esocid stocking: an annotated bibliography and literature review. Fish and Wildlife Branch. Ontario Ministry of Natural Resources. Peterborough, Ontario. 138 p. + appendices.

Lebeau, B. 1996. Muskellunge reintroduction feasibility study, Spanish Harbour Area of Concern. p. 11-18 *In* S. J. Kerr and C. H. Olver [eds.]. Managing Muskies in the '90s. Workshop Proceedings WP-007. Southern Region Science and Technology Transfer Unit. Ontario Ministry of Natural Resources. Kemptville, Ontario.

Lorantus, R. and D. Kristine. 2005. Muskellunge and tiger muskellunge management and fishing in Pennsylvania. Pennsylvania Fish and Boat Commission. Bellefonte, Pennsylvania.

Lucas, J. 2008. Maine muskellunge management plan. Department of Inland Fisheries and Wildlife. Augusta, Maine. 16 p.

MacCrimmon, H. R. and E. Skobe. 1970. The fisheries of Lake Simcoe. Fish and Wildlife Branch. Ontario Department of Lands and Forests. Toronto, Ontario. 140 p.

MacKay, H. H. 1963. Fishes of Ontario. Fish and Wildlife Branch. Ontario Department of Lands and Forests. Toronto, Ontario. 292 p.

MacLennan, D. 1996. Changes in the muskellunge fishery and population of Lake St. Clair after an increase in the minimum size limit. p. 19-28 *In* S. J. Kerr and C. H. Olver [eds.]. Managing Muskies in the '90s. Workshop Proceedings WP-007. Southern Region Science and Technology Unit. Ontario Ministry of Natural Resources. Kemptville, Ontario. 169 p.

Margenau, T. L. 1992. Survival and cost effectiveness of stocked fall fingerling and spring yearling muskellunge in Wisconsin. North American Journal of Fisheries Management 12:484-493.

Margenau, T. L. 1999. Muskellunge stocking strategies in Wisconsin: The first century and beyond. North American Journal of Fisheries Management 19:223-229.

Miles, R. L. 1978. A life history study of the muskellunge in West Virginia. American Fisheries Society Special Publication 11:140-145.

Miller, M. L. 1983. The status of muskellunge in North America: results of a mail survey conducted during the fall of 1981. Division of Wildlife. Ohio Department of Natural Resources. Columbus, Ohio.

Minnesota Department of Natural Resources. 2008. Long range plan for muskellunge and large northern pike through 2020. St. Paul, Minnesota.

Monaghan, J. P. 1985. A study of riverine muskellunge populations and habitat in North Carolina. North Carolina Wildlife Resources Commission. Raleigh, North Carolina. 32 p.

Morris, J., L. Morris, and L. Witt. 1974. The fishes of Nebraska. Nebraska Game and Parks Commission. Lincoln, Nebraska. 98 p.

Mosindy, T. 1996. Recent trends in the Lake of the Woods muskellunge fishery. p. 105-114 *In* S. J. Kerr and C. H. Olver [eds.]. Managing Muskies in the '90s. Workshop Proceedings WP-007. Southern Region Science and Technology Unit. Ontario Ministry of Natural Resources. Kemptville, Ontario. 169 p.

Nelson, W. R. 1978. Implications of water management in Lake Oahe for the spawning success of coolwater fishes. American Fisheries Society Special Publication 11:154-158.

Nevin, J. 1901. The propagation of muskellunge in Wisconsin. Transactions of the American Fisheries Society 30:90-93.

Oehmcke, A. A. 1969. Muskellunge management in Wisconsin. Fisheries Management Report No. 19. Wisconsin Department of Natural Resources. Madison, Wisconsin. 22 p.

Oehmcke, A. A., L. Johnson, J. Klingbiel, and C. Wistrom. 1965. The Wisconsin muskellunge. Publication No. 225. Wisconsin Department of Natural Resources. Madison, Wisconsin.

Olson, D. E. and P. K. Cunningham. 1989. Sport fisheries trends shown by an annual Minnesota fishing contest over a 58 year period. North American Journal of Fisheries Management 9:287-297.

Ontario Ministry of Natural Resources. 1987. Atlas of muskellunge lakes in Ontario. Fisheries Branch. Toronto, Ontario. 35 p.

Ontario Ministry of Natural Resources, Ontario Federation of Anglers and Hunters, Northern Ontario Tourist Outfitters, and Muskies Canada Inc. 1999. Size limit regulations for Ontario muskellunge: a new approach. Peterborough, Ontario. 12 p. + appendices.

Panek, F. M. 1980. Strategic plan for management of the muskellunge population and sport fishery of the St. Lawrence River. New York State Department of Environmental Conservation. Watertown, New York.

Parsons, J. W. 1959. Muskellunge in Tennessee streams. Transactions of the American Fisheries Society 88:136-140.

Petrie, C., B. Knops, M. C. Martin and B. Vaughn. 1993. Fishing Wisconsin's top 50 muskie lakes. Fishing Hot Spots. Rhinelander, Michigan. 255 p.

Plflieger, W. L. 1975. The fishes of Missouri. Missouri Department of Conservation. Jefferson City, Missouri. 343 p.

Ragan, J., T. Steinwand, and G. Van Eeckhout. 1986. A synopsis of results from a questionnaire on muskellunge resource agency survey. American Fisheries Society Special Publication 15:370-372.

Scott, W. B. and E. J. Crossman. 1973. Freshwater fishes of Canada. Bulletin 184. Fisheries Research Board of Canada. Ottawa, Ontario. 966 p.

Simonson, T. D. and S. W. Hewett. 1999. Trends in Wisconsin's muskellunge fishery. North American Journal of Fisheries Management 19:291-299.

Smith, C. L. 1985. The inland fishes of New York state. New York State Department of Environmental Conservation. Albany, New York. 522 p.

Stewart, K. W. and D. A. Watkinson. 2004. The freshwater fishes of Manitoba. University of Manitoba Press. Winnipeg, Manitoba. 276 p.

Stocek, R. F., P. J. Cronin, and P. D. Seymour. 1999. The muskellunge (*Esox masquinongy*), distribution and biology of a recent addition to the ichthyofauna of New Brunswick. Canadian Field Naturalist 113(2):230-234.

Thomas, M., J. S. Diana, and K. Smith. Undated. Management plan for muskellunge in Michigan. Michigan Department of Natural Resources. Ann Arbor, Michigan. 35 p.

Trautman, M. B. 1957. The fishes of Ohio. Ohio State University Press. Baltimore, Maryland. 683 p.

U.S. Geological Survey (USGS). 2009. Nonindigenous aquatic species. U.S. Department of the Interior. 6 p. http://nas.er.usgs.gov

Wayre, R. 2002. Muskie! The premier waters of North America. Fishing Hot Spots Inc. Rhinelander, Wisconsin. 243 p.

Wingate, P. J. 1986. Philosophy of muskellunge management. American Fisheries Society Special Publication 15:199-202.

Wingate, P. J. and J. A. Younk. 2007. A program for successful muskellunge management: a Minnesota success story. Environmental Biology of Fishes 79:163-169.

Younk, J. A. and D. L. Pereira. 2003. An examination of Minnesota's muskellunge waters. Investigational Report 498. Minnesota Department of Natural Resources. St. Paul, Minnesota. 31 p.

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